CHALMERS

Development of a generic gear shifter for the truck industry

Master of Science Thesis in the Master Degree Program, Industrial Design Engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg Sweden, 2014

Department of Product and Production Development
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ABSTRACT

There is an on-going paradigm shift from mechanically operated shifters to “by wire” systems in the automotive industry. This change also applies to the heavy truck industry, where Kongsberg Automotive has identified a potential market for a generic “by wire” shifter, that is interchangeable across vehicle types and platforms.

The aim of this master thesis project was to explore the potential for developing an “off the shelf” shifter for the heavy truck industry. The goal was to introduce a design proposal for a generic shifter, capable of achieving various positions within the truck cockpit.

Knowledge regarding users and the use context was acquired through interviews with truck drivers, observations and study visits to resellers. A usability test was conducted for further insight regarding different shift patterns, and numerous concepts were developed and evaluated both theoretically and practically through workshop sessions.

The final concept is a generic shifter offered in two versions. It is designed to provide a good user experience regardless of the type of truck or field of operation, and can easily be integrated into different interiors. The concept can be bought “off the shelf”, minimising development time and costs for the vehicle manufacturer.

Keywords: Shift by wire, off the shelf shifter, truck industry, product development

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Sebastian Dreijer

Isak Wahnström

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01

INTRODUCTION

This chapter introduces the project´s starting point and describes the background, purpose and goals that were established at the beginning of the project.

1.1 BACKGROUND

A paradigm shift is on going within the automotive industry, where mechanically operated shifters are replaced with electronically controlled “by wire” systems. Development of shifters has traditionally been driven by the OEMs (original equipment manufacturer) and the need for mechanical linkage between shifter and transmission has made it difficult to make a shifter compatible with different platforms. When introducing shift by wire said limitations does not apply anymore and OEMs are starting to look for “of the shelf”-shifters to reduce time to market and save development cost. To support this trend Kongsberg Automotive (KA) will develop a generic shifter mechanism aimed to be reusable between vehicle types and platforms.

An industry that is supposed to be particularly interested in this kind of solutions is the heavy truck industry, where the driver interface in general are not as prioritized as in personal vehicles.

As KA traditionally is a company that develop products out of given specifications, knowledge in fields as ergonomics, semantics and user-experience are lacking and this is why this project was initiated.

1.2 PROJECT

1.2.1 Purpose

The purpose of the project is to examine the possibility of developing an off the shelf-shifter for the heavy truck industry. The project will study what aesthetic and semantic attributes as well as what functionality that should be applied to the shifter in order to satisfy the drivers. The final concept aims to facilitate KA in selling a generic shifter.

1.2.2 Goal

The goal of this project is to develop a design proposal of a generic shifter that is feasible for various positions within a truck cockpit and applicable for different types of trucks. The shifter shall be intuitive, ergonomically pleasant and be customizable in order to fit different brands.

1.2.3 Delimitations

- The final concept of this project will use a by KA already developed shifting mechanism.
- The project will only discuss a number of shift pattern predefined by KA.

1.2.4 Deliverables

The main deliverable of this master thesis project is an academic report describing the process and all relevant results including recommendations. Basic visualization of early concepts will be delivered, showing a wide range of ideas that can be used in further development for KA. The final concept will be represented with rendered pictures showing material suggestions and a physical functioning prototype that could be used as a demonstration tool for the company.

1.2.5 Project and Report Outline

The project comprises six main phases (image 1.1) that have been executed using an iterative process. This means that although the phases are described separately in this report, they have been processed several times and in parallel with each other.

Each chapter starts with an introduction of what the chapter will discuss. The process, main results and conclusions are then presented continuously.

Throughout all phases, input and guidance have been given mainly from Andreas Persson, Concept Design Engineer at Kongsberg Automotive. Along the project he has also involved employees with relevant expertise in order to support the development and make decisions. The proceedings of the project have been done in consensus.

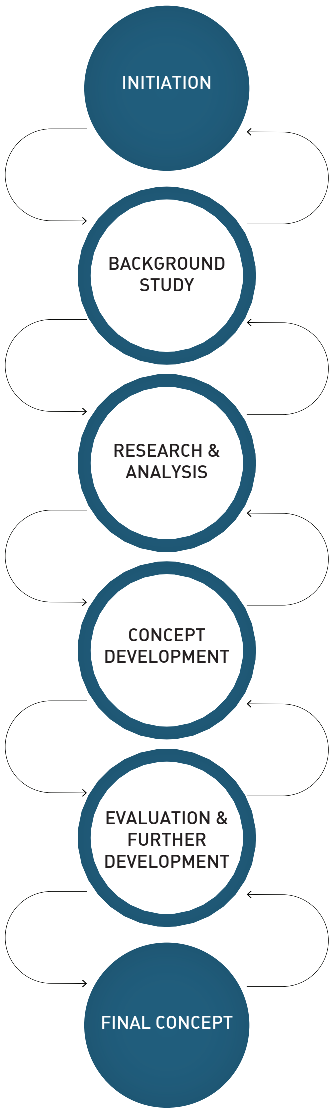


Image 1.1. The project´s six main phases in chronological order.

02

THEORY

The following chapter describes relevant technical theory as well as chosen design theories that formed the theoretical basis for this project.

2.1 TECHNICAL THEORY

2.1.1 Shift-by-wire overview

In a Shift by wire system, (image 2.1) the gear selector is connected to the gearbox electronically in contrast with traditional technology where the gear selector and gearbox are connected mechanically with a cable or rod. This enable a more or less free positioning of the gear selector since the only constraint is to provide an interface to the vehicles electronic network. Removing the mechanical link does also give freedom to select the right shift force and movement in order to develop suitable haptics. (Bickerstaffe, 2011)

The gear selector allows the operator to select gears and modes through movement. The most common modes are Park (P), Reverse (R), Neutral (N), Drive (D), and a manual mode (M), (see chapter 2.1.2). A gear selector does often also include a sport and an economy mode. Information from the gear selector is sent to a controller that executes commands and communicates with the gearbox. The controller is usually connected to other vehicle systems such as the brake pedal and the dashboard display to collect and send information related to the gear shifting.

2.1.2 Functions

Automatic mode

When using the automatic mode, the shifting is made automatically. The driver however still needs to interact with the gear selector and change driving modes when needed. The most common modes are:

Park (P):	By locking the gears, the vehicle is prevented from moving.
Reverse (R):	The vehicle will be driving backwards.
Neutral (N):	The transmission is disconnected from the engine.
Drive (D):	The vehicle will be driving forward.
Manual (M):	Gears can be selected manually in se quential order.

Shift lock

Most gear selectors features a release button connected to a shift lock in order to prevent accidental shifting. Traditionally this button has to be pressed to move the gear selector and thereby change mode/gear. To prevent illegal shifting (for instance going to R when the vehicle is moving forward in high speed) the button is mechanically locked. Shift by wire systems can feature a similar electronic release button. In mono stable gear selectors (see chapter 2.1.3) it is in general possible to tilt the gear selector without pressing the release button, even though this would not give any result when trying to make illegal shifting.

Break pedal lock

In excess of the shift lock the driver is also in general required to press the brake pedal in order to prevent unintentional movement of the vehicle. This can be the case for instance when releasing the park mode.

2.1.3 Shift patterns

The layout of the gear selector´s function is called shift pattern (image 2.2). Gear selectors can have different types of stability when manoeuvring these patterns, mainly multi stable and mono stable (image 2.2). In a multi stable system, the gear selector stays in the position it is put in, and each gear has its distinct location (this is traditionally the most common solution). In a mono stable system the gear selector moves like a joystick in one dimension. It will thus tilt back to its starting position after it has been triggered. Note that a mono stable gear selector can feature several unstable positions (usually indicated by a haptic "click") in each direction, enabling shifting for instance from R to D in a single movement. A pattern with two unstable positions is referred to as a "single-step" (SS) pattern and one with four unstable positions as a "double-step" (DS) pattern in this report. Some automatic shifters also provide the possibility of a manual mode. This is normally entered either with tipping the shifter or pressing an external button. (image 2.2)

Worth noticing is that R is placed in the front of the sequence while D is placed in the back. In order to make the vehicle move forward, the shifter should consequently be tilted backward. This is a questioned issue from a usability perspective and the way of movement is often not intuitive for a non-experienced user. This order has however always been used, and the vehicle manufacturers are afraid of potential accidents that could occur due to a change of a accustomed movement. (Persson, 2013)

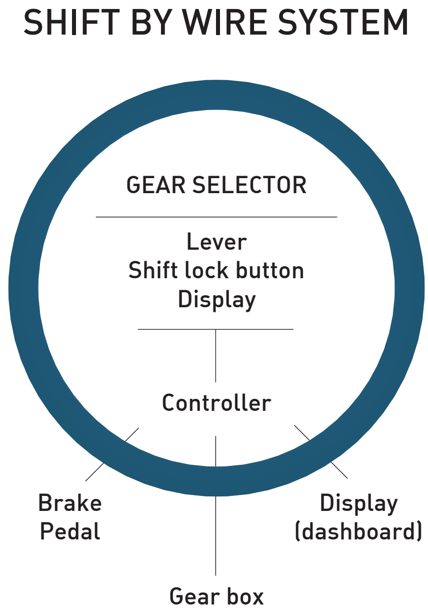


Image 2.1. A shift by wire system.

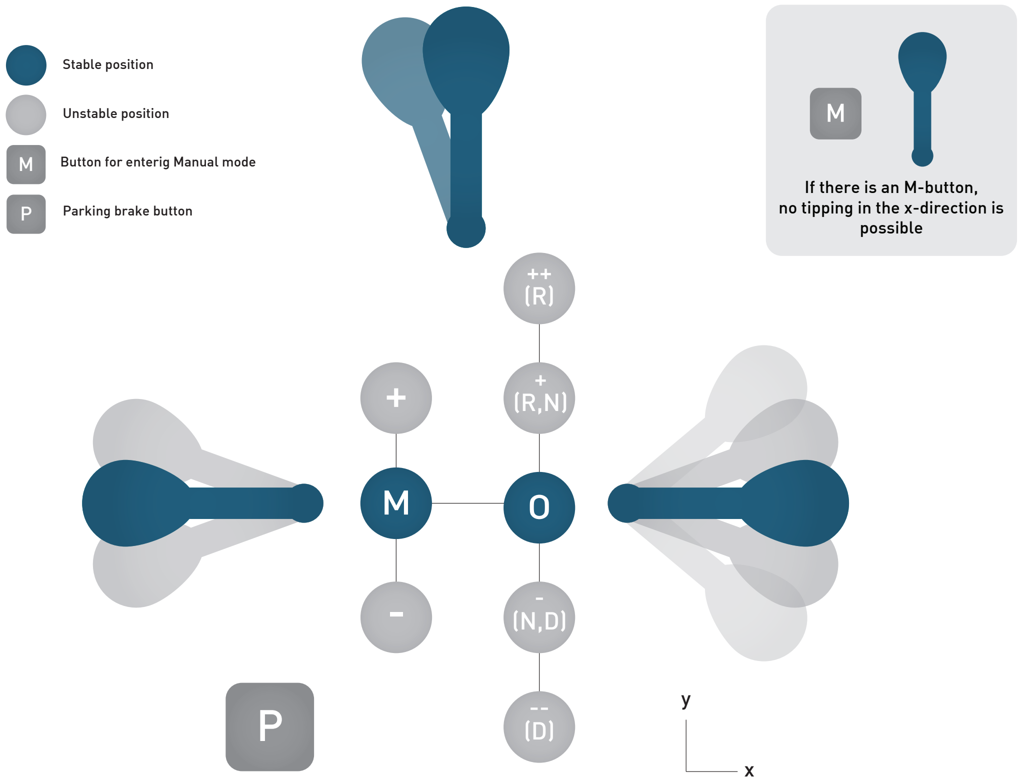


Image 2.2. Description of mono stable shift pattern.

2.1.5 Transmission

A Shift by wire system can be applied to different kinds of transmissions. Automatic Transmission (AT), Automated Manual Transmission (AMT), Dual Clutch Transmission (DCT), Constant Variable Transmission (CVT) and Electric Vehicles (EV's). For the truck industry, AT and AMT is however the most used techniques. (Transmission 2013)

2.1.6 Rules and regulations

Law regulates the design of a gear selector. The Electronic Code of Federal Regulations (eCRF) is applicable on a shift by wire system. In summary, the relevant regulations can be formulated in the following bullet points:

- Shift positions, including the positions in relation to each other and the position selected, have to be displayed in view of the driver. (eCRF §571.101)
- Neutral position has to be positioned between forward and reverse drive. (eCRF §571.101)
- The engine starter shall be inoperative when the transmission shift position is in a forward or reverse drive position (eCRF §571.101) (eCFR, 2014)

2.2 DESIGN THEORY

2.2.1 User experience

A user experience is a user´s perception and response resulting from an interaction, or anticipated interaction with a product, system or service. The affective response created by a human-product interaction are defined by Desmet and Hekkert (2007) as the Product experience and divided into the three different levels; aesthetic pleasure, attribution of meaning and emotional response (image 2.3). The aesthetic pleasure refers to the sensory experience of the product, the attribution of meaning describes the interpretations and associations linked to the product, and the emotional response describes the feelings and emotions that the product elicits. The three different components are closely linked to, and often dependent on, one another and the overall experience are the combined set of psychological effects that the product have on a user (Schifferstein & Desmet, 2007).

The user experience refers to all the possible interactions connected to the product, and not only the actual use of it. These interactions could be occurring with different users in different stages of the product's lifecycle and therefore a differing base for the user experiences are created. Hence there is of great importance that the full customer journey is considered as it "... encompasses every moment from the second when someone has a need for a certain product or service through the purchase and even onto aftercare or repurchase" (Ruth, 2011).

2.2.2 Usability

The ISO-definition of usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction (image 2.4) in a specified context of use" (ISO 9241-11, 1998). Usability is a fundamental part of the user experience during the actual use of the product and is determined by the interplay between the user, context, product and task (Jordan, 1998). To widen the understanding of usability Jordan (1998) has complemented the ISO-definition with five additional measurable factors:

Guessability - Usability for first-time users
Learnability - Usability for a user who already has used the product
Experienced User Performance - Usability for more skilled and experienced users
System Potential - The maximum potential of usability that the system possesses
Re-usability - Usability for users who has not been using the product for a long time

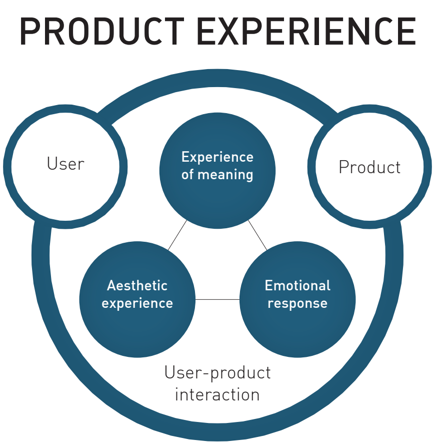


Image 2.3. An interpretation of Desmet and Hekkert´s product experience model.

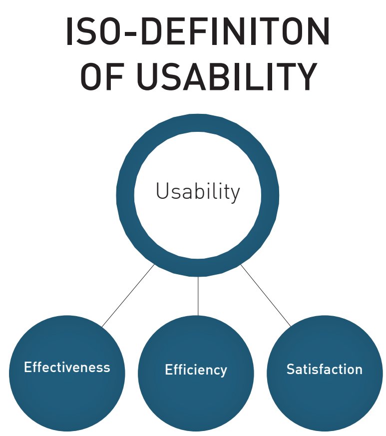


Image 2.4. The ISO-definition of usability.

2.2.3 Product semantics

Semantics is one of the two factors that define product language according to the conceptual model of the Offenbach Theory of Product Language (Gros, 1976). Product semantics is here defined as the bearers of meaning and divided into "indicating functions" and "symbol functions", making a distinction between sign and symbol. Indicating function play an important role when it comes to the product's recognition, usability and self-explanation and indicate the more practical functions of a product, while symbol functions are more related the user's imagination associated to the product and derive from cultural and social traditions and conventions. (Steffen, 2010)

2.2.4 Brand identity

The visual dimension of design plays a significant role in the consumer's initial interpretation and evaluation of a product's properties. It is the visual features that often catch the consumer's attention and direct the perception and product associations. A successful design consistency can result in a solid and unmistakable brand, with a strong differentiation and advantage over competing brands. The visual aspects of design creating a visual brand identity can be expressed through a combination of features such as forms, colours, materials, surfaces and textures, as well as graphical elements and logotypes (Karjalainen, 2007). The visual features must also be true to the inherent functionality of the product, creating a coherent product experience throughout the whole interaction as well as the complete customer journey (Roscam, 2010).

2.2.5 Lateral and vertical transformation

It exists two different types of transformations that could be used to generate form, lateral and vertical. Lateral transformation is mainly used in the early stages of the process and is associated with a more unstructured form generation where there is a movement from one idea to another. Vertical transformation is on the other hand occurring during the refinement and more detailed design phases. During the vertical form generation more precise alterations are applied to the new concepts. When using the vertical form generation method it is favourable to produce a larger group of ideas and concept variations. (Purcell, 1998)

2.3 PHYSICAL ERGONOMICS

2.3.1 Overview

Hands are complex in both function and ability, and that is why products handled by hands need to be considered from a number of different aspects. Efficient power transmission is substantial, as well as comfort. Furthermore, it is important that the user feels in control over the product and that the product expression is signalling how it should be held and used. (Bohgard et al, 2008)

It is naturally also necessary to consider the placement of the shifter since this is affecting the ergonomics and the design as well. What strength that is needed to manipulate the shifter in different posture is dependent both of physiology and for reasons of simple mechanics. What is an acceptable reach is dependent on whether the task involves gripping by the hand, finger pinch grip or fingertip operations. (Pheasant, 2003)

2.3.2 Guidelines

Freivalds (1987) highlighted four main anatomical concerns regarding handle design in addition to effectiveness of the tool itself. These are; avoidance of awkward wrist and finger postures, static muscle loading, repetitive finger action and tissue compression. Pheasant (2003) emphasize these concerns by forming a number of guidelines for handle design that steams as much from common sense as from scientific investigation. Here are the guidelines that seemed relevant for this particular project:

1. Force is exerted most effectively when the hand and the handle interact in compression rather than shear. This means that it is better to exert a thrust perpendicular to an axis than along the axis. If the latter is necessary, a knob on the end will improve the grip.

2. Avoid sharp edges and other surface features that cause pressure hot spots when gripping the handle. This includes things as finger shaping, edges of raised surfaces (e.g., for application of labels or logos), and 'pinch points' between moving parts.

3. Surface texture should neither be so smooth as to be slippery, nor so rough as to be abrasive. The frictional properties are complex due to that they are changing when the hand gets wet or when gloves are used.

2.3.3 Anthropometry

Using anthropometrical data is an efficient way to find out what dimensions that suite a population. It is conventional to aim to fit 90 % of the population and therefore use data between the 5:th and the 95:th percentile.

Two anthropometric measurements are especially important for the product that is being developed in this project. These are the length and the breath of the hand (image 2.5). As 96 % of all transport workers in Sweden are men (SCB 2011), and we can assume that this is similar in other countries. The result is shown in table 1.

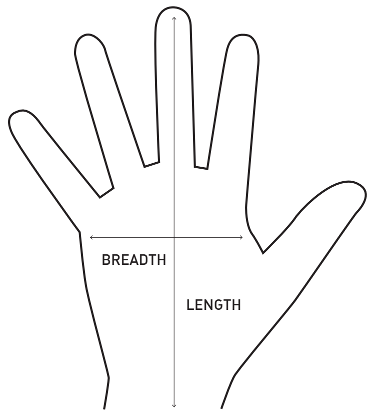


Image 2.5. Hand measuremets

	Men				Women			
Dimension	5th %ile	50th %ile	95th %ile	SD	5th %ile	50th %ile	95th %ile	SD
Hand length	173	189	205	10	159	174	189	9
Hand breadth	78	87	95	5	69	76	83	4

Table 1. Hand measurements of Swedish men and women.

03

METHODS

This chapter outlines the methods utilised, and how these were implemented through the project.

3.1 PLANNING

3.1.1 Gantt Chart

A Gantt chart is a tool where the time committed to a certain task is represented in a matrix. Tasks are listed vertically and the stretch of the horizontal blocks symbolizing each task shows its time consumption and their chronological position in the project. (Ulrich, 1995).

The Gantt chart method was used to easily get an overview of the time plan for this project. It was both useful in the early stages of the project structuring the upcoming activities, as well as throughout the project where it worked as a checklist to ensure the project´s position and direction (appendix I).

3.2 DATA COLLECTION

3.2.1 Literature Studies

In order to get more insight and background information regarding a certain subject a literature study can be carried out. The relevant literature can be articles and books as well as checklists and regulations, both found online and in physical publications. (Bohgard et al., 2008).

In this project literature studies was especially used in the early stages of the project providing the project team with a necessary knowledge base and an understanding for the subject of the thesis.

3.2.2 Interviews

Interviews are the most fundamental method for gathering information about people's opinions and thoughts. The data from an interview can be regarded as mostly qualitative, when knowledge about a person's experiences and values, as well as insights of his or her reasoning are collected. An interview can be either structured, semi-structured or unstructured. (Bohgard et al, 2009).

For this thesis project, mainly semi-structured interviews were performed. Using a semi-structured setup allowed for discussions regarding issues that evolved as especially interesting and created an more informal and somewhat relaxed context for the interview. For the improvised interviews throughout the project a more unstructured setup was used.

3.2.3 Observations

Observations are used to understand how people actually behave in a specific situation and to get knowledge regarding things that the observants are not always aware of. Observations are a good complement to interviews, and can preferably be recorded for further analysis. (Bohgard et al., 2009).

Observations were used in the early stages of the project to get an initial knowledge regarding the usage of shifters and later in order to analyse gripping of knobs.

3.2.4 Benchmarking

Benchmarking is a method used to gain insight and knowledge from analysing other companies within the same segment and to investigate the differences and trends on the market. Benchmarking is primarily used to compare processes and procedures but can also be applied for a comparison between products. (Bohgard et al., 2009).

Benchmarking was used throughout the whole project. It was conducted to identify trends within the area of the thesis and to learn more about what products and solutions that existed on the market.

3.3 ANALYSIS TOOLS

3.3.1 Clustering

When structuring large amounts of data, clustering can be an efficient and effective way to identify common elements and to sort out relevant and useful aspects.

Clustering facilitated the sorting of the content from the literature study as well as the analysis of the data from the interviews. It was also used to find interesting form elements and promising ideas to continue with during the idea generation phase.

3.4 CREATIVITY METHODS

3.4.1 Personas

A persona is describing a fictive person that is using a certain product or service. A persona should clearly mirror the information gathered from the data collection and correspond to relevant needs and requirements. Several different personas can be created in order to cover a full target group. (Österlin, 2010).

For this project, personas were used as a communication tool both internal and external and were a way of combining and compiling user aspects and other relevant information in an inspiring way.

3.5 VISUALIZATION METHODS

3.5.1 Sketching

Sketches can be made with a very differentiated level of detail, depending on what it is proposed to communicate. Sketching can be made in either two or three dimensions, and different types of sketches are more suitable in different stages of a project. (Österlin, 2010).

Sketching was the main method used in the early idea generation and was thereafter used throughout the project. Mainly to communicate ideas within the project group.

3.5.2 Mock-ups (Physical models)

Making mock-ups or physical models are a quick, easy and cheap way of examine the three dimensional form and building structure of an idea or concept. With a physical model it is also possible to get the haptic experience of a shape. (Österlin, 2010).

Numerous different physical models were made in this project, both used for communicating ideas internally and for the form evaluation in the KA workshop and the more unstructured user tests.

3.5.3 CAD-modelling

Computer Aided Design (CAD) can preferably be used in order to visualize a model before making a physical model. CAD tools can also facilitate calculations and movements of mechanical systems. (Johannesson et al., 2004).

The models of the final concepts made in ureol were made digital using the online version of the software 123d-catch. This resulted in a polygon mesh possible to use as an underlay when creating class-A surfaces in Alias Automotive.

3.5.4 Function Modelling

The purpose of making a function model is to test operations and tasks that the product is ought to be able to perform. The focus is to explore the functionality rather than the visual aspects of the product. (Österlin, 2010).

In this master thesis project function models was used to explore the functionality and haptic sensation as well as the usage of the product. The functional models made the usability tests possible and enabled deeper discussions during the interviews.

3.5.5 Rapid Prototyping

Rapid prototyping is a quick way of printing CAD models and turning them into physical objects. When using this type of method no machining is needed, making the process of trying out and experiencing different designs fast and easily accessible. (Johannesson et al., 2004)

For this project rapid prototyping was used in the later stages of the project, to get a physical experience of the final concept and to analyse how well the scanned-in ureol models had been transformed into digital surface models. The printer used in this project uses a technique where a plastic string create layers that are melted together, forming the desired shape.

3.6 EVALUATION METHODS

3.6.1 Usability test

In a usability test a number of test participants conduct a series of tasks with a representation of a product in a certain environment. The result from the tests enables an evaluation of different relevant aspects connected to usability. The measured parameters can be both qualitative and quantitative. (Jordan, 1998).

To enable an analysis of the different shift patterns possible to be used in this project a usability test were conducted. This resulted in information useful for the further development of the product.

3.6.2 Kesselring

A Kesselring matrix enables a ranking of different concepts. Several pre-defined criteria are weighted and multiplied with how well the concepts fulfil the different criteria and then added up resulting in a total score. (Johannesson et al., 2004)

A Kesselring matrix was used to evaluate the workshop concepts in order to choose what concepts to proceed with into the last stage of the project.

04

RESEARCH AND ANALYSIS

The following chapter summarizes the insights regarding users, use context, and current solutions that were generated during the research phase.

4.1 COLLECTION OF DATA

4.1.1 Literature Studies

Literature studies supported the project throughout the entire research phase. Initially these studies were used in order to build up an understanding for the shift by wire technology, existing shifting solutions as well as rules and regulations regarding the subject. This was done primarily by reading journal articles and studying previous projects carried out in the subject. The literature study was also used to deepen the knowledge in existing design theory, mainly through books and journal articles related to ergonomics and user experience. The findings founded a theoretical basis that was substantial in order to understand the technology and functionality as well as enable the project group to form the subsequent user studies.

4.1.2 Study of truck interiors and shifter placement

With the intention of understanding the context of the future product the interior of different truck brands were analysed. This was done by studying digital marketing materials from 16 truck brands represented globally and document type and placement of the shifter. This was helpful in order to realize how this product should be designed to suit a large variety of truck interiors. The result of this analysis is described in chapter *4.2.3 Existing shifter solutions and placement in trucks*.

4.1.3 Study visits - Reseller of personal vehicles

To gather inspiration and experience of current shifter solutions a couple of study visits at resellers of personal vehicles was carried out. The 30th of August unstructured observations of various brands were done mainly to see what exists on the market of personal vehicles, and what potentially could be implemented in a truck. Later on, the 2nd of October, focused observations of specifically mono stable shifters in personal vehicles was done. The shifters in Volvo C30 Electric, Mercedes SL + SLS, BMW 3-series, and Audi R8 were analysed mainly regarding form and haptic feedback. The Volvo C30 Electric was also test driven for an hour to analyse the shifter over time.

4.1.4 Study visits - Reseller of trucks

Study visits were made at Volvo trucks reseller in Gothenburg the 4th of September 2013, Volvo Demo Centre in Torslanda the 5th of September, Mercedes trucks reseller in Gothenburg 10th of September, and Scania trucks reseller in Gothenburg 10th of September. The objectives with these initial visits were to gain real life experience of trucks, and how it feels driving this type of vehicle. The visits also aimed to understand the additional functionality that is used in trucks compared with personal vehicles and acquire knowledge to be able to design relevant upcoming interviews.

4.1.5 Interviews with truck drivers

Interviews were conducted at Halléns Transport in Gothenburg the 25th of September 2013, Schenker AB in Gothenburg the 26th of September, Mattssons Åkeri in Gothenburg the 30th of September, Haga-Mölndal Lastbilcentral in Mölndal 1st of October, and Carlsberg in Karlstad 5th of October. In total 20 truck drivers were interviewed. The interviewees worked in different fields; local and regional distribution, long-haulage and construction, thereby they used a large variety of truck models. More information about the different fields can be found in *4.2.1 Different types of transportation with trucks.*

The intention with the interviews was to get an understanding of the truck drivers work situation and what is appreciated and not appreciated with current shifting solutions. Moreover the interviews aimed to evaluate whether a mono stable shifter would be appropriate to use in a truck, what shifting-patterns that would be best suited, what, if any, additional functionality that could be implemented in the shifter, and what kind of grip that would be preferred. Besides, the interviews aimed to develop an understanding of the main objectives, needs and preferences of the truck drivers.

One shifter-rig equipped with a single-step shift pattern and a tip function was brought to the interviews. In addition, three highly differentiated grips were used as mediating objects in order to create a discussion about form and ergonomic values.

4.1.6 Usability test

Based on the information received from the company regarding interesting and realizable shift patterns, four patterns were identified as applicable. Due to the setup of the usability test it was though regarded as enough to try out three of the patterns (SS with tipping for manual mode, DS with tipping for manual mode, SS with button for manual mode) and still obtain information for all the interesting possible pattern variations (see chapter 4.3.2 Shift-pattern Kongsberg). The test were performed on the 4th and 5th of November 2013 in the usability lab at PPU, Chalmers. The test included in total 18 participants, all being students at Industrial Design Engineering with a diverse experience of using automatic shifters. The number of participants was chosen with regard to that the three different patterns allowed six possible internal orders and if each order would be used an equal number of times, unnecessary sources of error would be avoided.

To enable a test of the three patterns two function models (image 4.1) were needed. These were manufactured by the company and then installed with a small tool on which micro switches were attached, so that the shifter-rigs were made interactive. The switches were soldered on to cable connected to a five-button computer mouse. The use of a computer mouse and a program called X-mouse simplified the communication between the shifters and a computer. A flash program was built in order to visualize the current gear.

One shifter was used for representing the single-step pattern and the other one the double-step pattern. The single-step shifter was customizable being able to represent two different shift patterns, one with the tip function and one with a button for entering the manual mode resulting in three different patterns altogether. Both of the rigs were equipped with the same, somewhat generic, grip to avoid that this would affect the test to a great extent.

A short scenario was created for the test, representing a possible but compressed gearshift sequence (appendix II). This sequence were read out loud, one gear at the time, to the participant by the member of the project group located inside the test room, while the other one was in charge of recording the test from inside the adjacent control room. At the same time as the participants carried through the shift sequence with their right hand, they were asked to play a simple computer game (Papi River) with their left hand (image 4.2). The test was designed like this in order to simulate that gear shifting is a secondary task when it comes to driving. The game was though regarded as simple enough to not affecting the wanted measure values, so that the participant's simultaneous capacity would distort the result.

Each pattern was tested twice for the same shift sequence allowing analysing possible improvements when using the pattern over time. The participants were able to try each pattern out before it was tested to briefly get familiar with it. After the three different patterns had been tested, the participants were asked to fill out a questionnaire (appendix III) where they weighted the single-step feature against the double-step feature, and the tilt function against a button for entering the manual mode. These were done in three respectively four different scales, including experienced time, safety, intuitiveness and which one they preferred. The participants were also asked to more qualitatively describe what function they preferred and why, complementing the information gathered from the scales.

Video recordings were used to analyse each test in retrospect, where the time and error frequency for each participant and sequence were measured and registered (appendix IV).

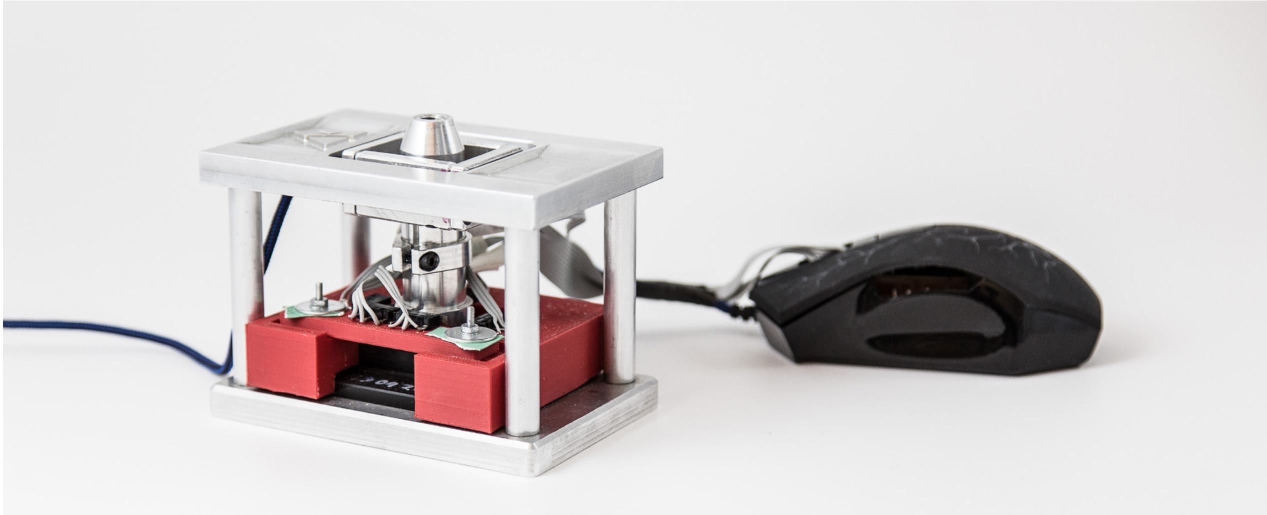


Image 4.1. The interactive rig used in the usability test with no grip attached

Image 4.2. Photo of one of the participants during the usability test.

4.2 CONTEXT AND USER DESCRIPTION

4.2.1 Different types of transportation with trucks

As the project aims to develop a generic gear shifter, the concept should suit different kinds of trucks for different types of transportation. The types of transportation that is considered to be most relevant and thereby in focus for the project scope are local and regional distribution, long-haulage, and construction. As these types of transportation differ in many aspects, they also put diverse requirements on the product. (image 4.3)

Local and regional distribution

Transportation of goods that can be done during a workday is often called distribution. Distribution that is done within an area of a city including suburbs is termed local distribution, while regional distribution is operated within a radius of up to 300 kilometres.

Trucks for distribution are generally smaller than for instance long-haulage trucks in order to be more manoeuvrable in traffic. This does also result in a smaller cockpit where the driver seldom moves around but rather reaches for papers or gadgets placed in the passenger seat.

In local distribution a number of 30 stops per day is not unusual, and in most cases the truck is backed into a loading dock. This causes relatively much interaction with the shifter, which is the reason why AT and AMT transmission is often used in this type of vehicles.

According to most interviewees, the field of distribution is rather stressful. The drivers are expected to keep up with many stops per day and are often driving within intensive traffic. This puts high demands on the shifter to be intuitive and fast. Furthermore the shifter needs to be easily accessed but not be in the way.

Long-haulage

Long-haulage trucks and the way these are used differ from distribution in several aspects. First and foremost long-haulage trucks are designed to allow sleeping possibilities and are therefore equipped with a larger cockpit. The drives does usually run for several days or weeks, which mean that the cockpit becomes almost like a home for the driver. Furthermore does this type of driving include very few gearshifts since most time are spent on highways.

Due to the small amount of interaction, the drivers interviewed did not put particularly high demands on the shifter regarding accessibility and speed of interaction. Instead it is of great importance that the shifter is not in the way and does not worsen the possibilities to move inside the cockpit. Several drivers termed that they would appreciate to use buttons for shifting in a long-haulage truck since that would occupy a minimal amount of space.

Construction

The third category is trucks used in construction. This includes vehicles such as crane trucks, loading trucks for construction materials etc. These trucks are generally used in dirty and rough environments that also affect the interior.

Trucks used in this field are often driven out of tarmacked roads that are bumpy and heavy to manoeuvre, which puts high demands on the driver. According to most interviewees, manual shifting is often preferred in these situations in order to maximise control. It is also of great importance that operating devices in these situations has an appropriate sensitivity and provide good feedback.

Image 4.3. Different types of trucks.

4.2.2. Personas

CHRISTER, 61

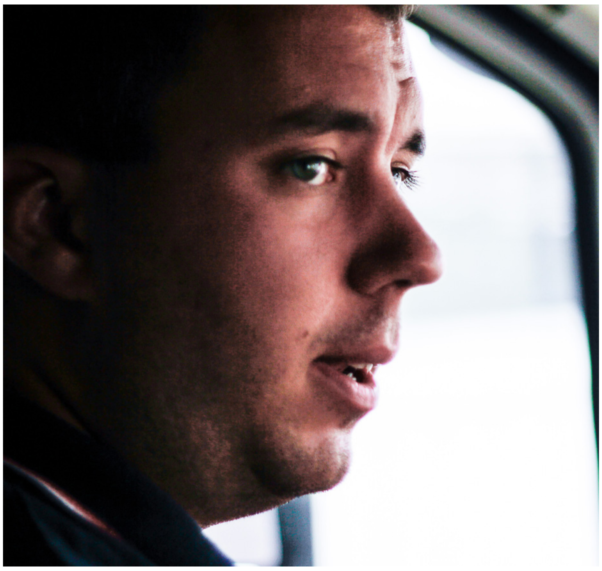
Christer is 61 years old and has been a truck driver for 35 years. During his career he has worked for several different trucking companies but has for the last 15 years been doing pick-up and delivery for one of the bigger trucking companies in Gothenburg. He is almost only driving shorter distances within the Gothenburg region and is doing around 20-30 stops per day.

Ever since he started driving trucks, Christer has enjoyed his job and is feeling that he is contributing to the society. He is social and appreciates the short and often jokey conversations with customers as well as with his colleagues in the coffee room at work.

During the years Christer has been driving several different trucks with a great variety of gear shifters. His current truck is equipped with a shifting lever behind the steering wheel, but Christer does not like this solution very much. The lever is too small and difficult to handle and Christer sometimes gets really frustrated when the shifter does not react to a gear change. This can be very stressful, especially in the intense inner city traffic.

Christer thinks that everything inside the cockpit should be easily accessible and that the different levers and buttons should provide good feedback with a feeling of quality. Christer is opened for changes, as long as they are simplifying his working situation and he believes that one get used to new things quite fast.

He thinks that the automatic gearbox suits the inner city traffic well. In more difficult conditions, like during the winter, Christer though feels that he needs to control the shifting himself, and therefore thinks that a manual mode is a must.



JOHAN, 28

Johan is 28 years old and a dedicated truck driver. He has always loved all types of vehicles and got his own workshop in the garage at home. He studied the automotive program at the upper secondary school and has been working as a truck driver ever since.

In the beginning of his career, Johan worked with local distribution, but due to Johan's personality, this type of transportation did not suit him at all. He is a calm and laid back type of person and a stressed environment with people putting pressure on him resulted in an impossible work situation. Johan has instead been doing long-haulage transportation for the last 8 years. The longer distances the better he thinks, and appreciates that no one tells him what to do during the drive.

Due to that the truck is Johan's home for long periods of time, Johan feels that it is of great importance that it is kept clean inside the cockpit. He even keeps a pair of crocks just inside the driver's door because no shoes are allowed inside. The curtains that the older drivers persist having in their trucks are however not his cup of tea.

Johan thinks that it is very important that the truck that he is driving is up to date and that the interface inside the cockpit is providing easy understandable controls. Previously Johan drove a truck with a manual shifter sticking up between the seats, on which he tripped several times when he was about to get back to his bed for a rest. Today Johan's truck is equipped with an automatic gear shifter, which result in very few shifts when doing long-haul transportation. Due to these reasons, Johan feels that it is really important that the shifter is small and not in the way when he wants to move around in the cockpit.

4.2.3 Existing shifter solutions and placement in trucks

In the western world, the use of manual gearboxes in trucks are decreasing in favour of AT and AMT's. The operating devices used to control these AT/AMT's could be divided into three groups; more or less classical levers, levers behind the steering wheel, and key sets. Images describing these three solutions are found in image 4.4.

To get an understanding of where and how shifters are placed inside different cockpits today, a number of international brands were studied. The results showed that the leavers almost exclusively were mounted on a more or less horizontal surface and that four main groups of placements existed; Centre console (CC), Dashboard (DB), Beside seat (BS) and Behind the steering wheel (BSw). As the mechanical design of the type of mono stable shifter developed in this project is not suited for a solution located behind the steering wheel, horizontal placement in CC, DB and BS are the locations that are discussed in this project (image 4.5).

Image 4.4. Volvo´s I-shift beside the seat, Scania´s opticruice behind the steering wheel, and the key set in Volvo FE.

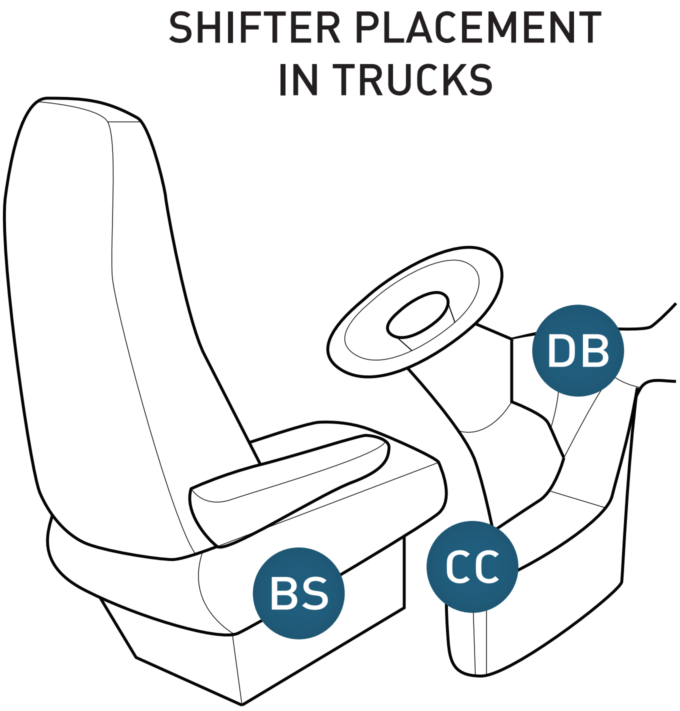


Image 4.5. Description of Beside seat, Centre console and Dashboard

4.3 SCOPE SPECIFIC RESULTS

4.3.1 General opinions from the drivers' perspective

Due to the quantity of interviews, a rather representative picture of truck drivers was created. It was however apparent that opinions and point of views differed clearly in certain respects within the interview group.

Most of the interviewed drivers were positively disposed towards AT/AMT shifting in general. The majority considered shifting as a secondary task that they did not need to control fully, but instead trusted the vehicle to make the selection of gear in most situations. The exception to this was drivers with no experience of AT/AMT that rather meant that manual shifting was the "real way" of driving a vehicle. A number of drivers referred to that they had such mind-set until they were forced to drive an AT/AMT truck, and that they ever since wouldn't go back to a manual vehicle. Aged drivers also described how their arms and shoulders were hurt due to resting their hand on a vibrating manual shifter through many years, and that these problems did not prevail when using a shift by wire solution.

The ability of using a manual mode was indispensable to in principle all interviewees. Even though modern AT's and AMT's has become fast and accurate in choosing suitable gears, the gearbox´s controller can still not replace the driver´s competence in all situations (Nordin, 2013). The manual mode is mainly used in wintertime when the roads are icy and slippery and when there is a risk of being bogged down. It is also used when driving in narrow spaces and sometimes when going uphill. The manual mode can also be used for engine braking.

No general conclusions could be drawn regarding the interview group´s willingness to adopt new technology and operation methods. Instead, this differed clearly between individuals. As mentioned above, some interviewees would not even accept a transition from manual shifting, while others claimed that using any kind of lever in order to change gear was out-dated. It was however prominent that the interview group were able to absorb changes (e.g. operating methods within the interior) fast due to that the interaction often is made continuous many times per day and therefore soon becomes a habitude.

A mono stable solution was generally well received. As the interviewees interacted with the rig, they found it intuitive and appreciated the feedback. The interviewees found this solution rather similar to Volvo´s I-shift and were not concerned about knowing which gear that was active due to the single stable position. Most drivers that were currently using Volvo´s I-sync argued that the mono stable concept seemed to be a better solution due to the simple interface with just a tiltable lever that did not require that much fine motor ability.

Whether the drivers care about the truck interior design was diversified as well. Some drivers thought of the truck as their second home while others just considered it as a tool they had to use for work. According to Andreas Nordin, one can also see differences regarding the importance of the interior design depending on if the purchaser intends to drive the vehicle, or if a company is investing in several trucks at ones for their employees. In the latter case the matter of interior design is commonly low prioritised. (Nordin, 2013)

What generally mattered the most to the interviewees regarding the interior design was the operating devices capacity of providing clear feedback and a feeling of quality. Most drivers formulated that they disliked manoeuvres that require fine motor abilities to a great extend and are too sensitive. Instead they preferred robust details that are easily found and operated also in stressed situations.

Image 4.6. Evaluation of early concept

4.3.2 Shift pattern Kongsberg

From previous research, Kongsberg had identified five different shift patterns (image 4.7) applicable for the type of shifter developed in this project. The patterns had been ordered on a cost scale based on the estimated mechanical and electronic functionality needed as well as development costs for each solution. All patterns had just one stable position in the automatic sequence, making them mono stable in accordance to the project definition. From estimated as cheapest to develop to most expensive the following patterns were presented: Single-step with a button for entering the manual mode, Double-step with no manual mode, Double-step with a button for entering the manual mode, Single-step with tilt function for entering the manual mode and Double-step with tilt function for entering the manual mode. All the patterns were also equipped with a parking brake button.

According to KA, the reason for using a button for entering the manual mode was mainly economical. Applying mechanical locks for the tip functionality would require extra costs. The event of a tipped shifter when trying to start the car (after a motor failure for instance) could also cause problems. Some manufacturers do not simply allow the vehicle to start with a tipped shifter, which could cause hazardous situations and even danger of life. This could though be solved with a motorized redirection of the shifter every time the vehicle is switched off, but this would of course demand for greater costs.

Out of the five possible patterns presented by the company four patterns were identified as suitable for further analyses. The one with no manual mode was considered as unsuitable for this project, based on the findings from the initial studies.

4.3.3 Shift pattern Truck driver Interviews

Since only a single-step shifter was brought to the truck driver interviews, the comparison between a single-step and a double-step shifter could only be made theoretically. When theorizing about a double-step shifter, many interviewees were worried to slip and move one step too far in the shift pattern. Others however thought that a feature like that could make shifting more efficient. Altogether the ones preferring single-step was a few more compared with the ones preferring double-step.

The comparison between a button or tip function for entering the manual mode also had to be made theoretically due to that the tip function was the one represented on the rig. Probably this affected the result where everyone, except one, preferred the tip function. The tip function was nevertheless largely appreciated and the respondents liked that it provided a clear and distinct manual position of the shifter.

4.3.4 Shift pattern Usability test

Measurements

The double-step pattern was twice as fast compared with the single-step pattern when shifting from R to D (or vice versa). The mean value of a number of shifts showed that moving two steps with a single-step shifter took 4/10 seconds in contrast to 2/10 for the double-step shifter. These are however measures done on just two gear steps, and when measures are done on a whole sequence of shifts, the differences are not that clear. This also became clear in the usability test where no significant differences in time needed to complete the entire shift sequence could be identified. The single-step shifter with the tip function was slightly faster in the tests compared with the single-shifter equipped with a button, but there were no large variances. One thing that could be noted was that the participants that

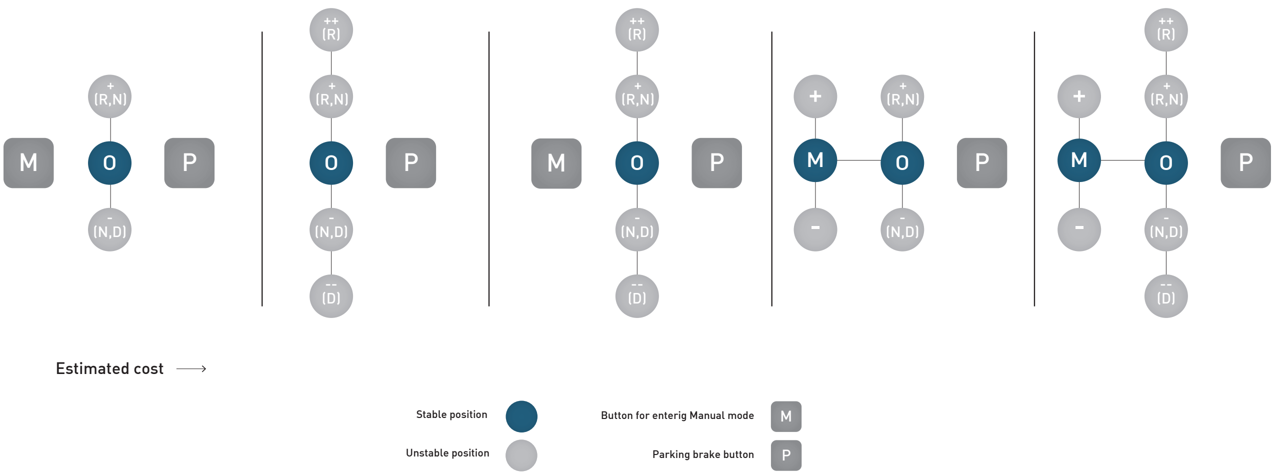


Image 4.7. The five initial shift patterns

tested the double-step pattern after the single-step pattern always performed the fastest time with this one.

Neither the error frequency differed severely between the different patterns. An equal amount of mistakes was for instance done by the participants when trying to enter, or leave, the manual mode. Independent whether they were testing the shifter with the tip function or the one with the button. The most frequent error made was moving in the wrong direction in the pattern, both in the automatic and the manual mode. This was made by all participants at some point and 92 times all together, which correspond to almost 5 % of all shifting. The error when the user by mistake stepped past the N gear and made a double-step instead of a single one were registered in 4 % of the times when it was possible to be made using the DS shifter.

Subjective opinions

Many participants found the internal order of the gears, R forward and D backwards, to not be intuitive. The same thing applied to the plus and minus in the manual mode.

Regarding the DS and SS feature the majority of the participants perceived the single-step feature as most safe, providing a greater control. Even though some of the participants found no divergence regarding safety between the two patterns and found the position of the double-step shifter to be distinct enough for a safe experience. A few participants preferred the double-step feature due to that one did not have to count the steps when moving between D and R, because "it is just simply pulling and you will end up in the desired gear" as one participant put it. Referring to that it did not matter what gear that is active when making a "double-move" in the right direction, because one end up in the intended gear. Furthermore thoughts about that one could possibly become frustrated over time when using a single-step shifter was expressed and some participants imagined the double-step feature to be even more preferable when one got used to it.

Almost all participants preferred the tip function in favour of the button and perceived it as both faster, safer and a more intuitive way to enter the manual mode. The fact that the shifter was physically put in another position and that one did not have to let go of the knob with the tip feature was something that was perceived as positive. Pressing a button was experienced as a different type of movement compared with how the lever is handled and was therefore difficult to connect to shifting according to some participants. One participant expressed that "manoeuvring a car with buttons does not seem very safe."

Conclusions and sources of error

Rather than showing a clear time difference between the different patterns the results instead indicated an improved time for each completed sequence. It was almost always the last or second last shift sequence that was measured as the fasted one.

The same thing applied for the error frequency, which for all participants decreased in time with the test. Most errors were consequently often made during the participants' very first try. Even though some of the participants made more mistakes with the single-step featured shifter, it was still perceived as safer than the double-step shifter, possibly because of that is what the common sense indicates. The results from the tests did not indicate a high level of errors where the user accidently stepped past N when using a DS shifter, which in beforehand had been an area of concern.

The tip function was regarded as safer than the button when the participants intended to enter the manual mode, but according to many comments the button was safer concerning avoiding mistakes and an unwanted activation. Regarding the comparison between the two ways of entering the manual mode, it was bit of an unequal refinement of the two features, which affected the experience, possibly in the buttons disadvantage.

Further factors linked to the test setup that affected the results was the fact that it was done in a usability lab with no vibration or acceleration, nor other movements that appear in a normal truck cockpit. With the acceleration, for instance, the order of the gears, with D in the back and R in the front, would maybe have appeared more natural, due to that the acceleration of the truck pushes the driver backwards.

Some of the participants viewed the test as a competition and the concentration aimed at the game compared with the gear display varied quite a bit, and consequently sometimes distorted the result with faster times and increased errors.

It is however important to keep in mind that the purpose of the usability test not necessary was to name and proceed with one winning shift pattern, but instead investigate and identify if any of the tested solutions proved to be less suitable, and hence should be discarded.

Image 4.8. Results from the usability test.

4.3.5 Additional functionality

A potential way of improving the accessibility of operating devices and enhancing the driving experience could be to integrate more functionality to the shifter and the underlying panel. This is becoming common in the personal vehicle industry and might be a way for KA to add value to the product.

In order to find out what functions that could be suitable to place in this position in a truck, the interviewees were asked to refer to functions they thought were related to shifting. Generally the drivers were not very interested in adding functions to the shifter, instead the majority expressed that they would prefer it as simple as possible. The functions that were mentioned by the drivers and considered as realistic are listed in table 2.

It was however shown that several potential functions are specific for different vehicles, and that functions that are controlled with buttons in some vehicles could be automatically controlled in others.

	Possible additional functionality
1	Park-break
2	Sport/Eco-mode
3	Rocking control
4	Limp (Maneuver mode)
5	Cruise control (interval)
6	Engine brake on/off (Highway mode)
7	Boggi pressure
8	Exhaust break
9	Hazard warning lights
10	Reverse camera

Table 2. Possible additional functionality.

4.3.6 Knobs and movement

There are a vast variety of opinions regarding knob shapes. During the interviews with truck drivers it was apparent that drivers of manual vehicles preferred classic large knobs, while other drivers had a more open mind regarding size and shape. A possible reason for this is that a manual shifter generally requires a higher force and is operated in four directions unlike a automatic shifter that mainly is moved forward and backward. All drivers did however express the importance of solidity of the knob and clear feedback during movement.

When truck drivers tested early knob concepts, it was discovered that the models were gripped in several unexpected ways that were different variations of top, side and finger grips. This was due to that many drivers had clear preconceptions of how a shifter should be held and handled, but probably also due to lack of clear semantics of the concepts.

The unstructured analyses that were made on personal vehicles with mono stable shifters resulted in important input to the development process. A problem that was experienced with most shifters was how pressure hot spots were created due to sharp edges located where force were applied. As this felt uncomfortable already after a couple of minutes of intense testing, it is likely to cause problems after years of repetitive use.

It was clear that several knobs were designed for one type of grip only. This can be considered to be acceptable in a car where the shifter has its defined location. It however became obvious that a grip that will be placed in different locations have to permit various ways of gripping.

4.4 SHIFTERS IN PERSONAL VEHICLES

It is a significant difference between the interior of trucks and personal vehicles (PV's). The PV industry is many years ahead, not at least from a design perspective. This is apparent also when it comes to shifters. Traditionally a shifter lever consists of a lever arm sheathed with a spat, and with a one-piece moulded knob mounted on top. This is still often the case when it comes to trucks while the PV industry has moved further (Persson, 2013).

In modern PV's the shifter design is often more refined. Today, the shifters are often designed with several materials in more advanced ways. Many shifters have become shorter and in AT/AMT shifters the spat is often removed in favour of a cleaner look. As a shifter in an AT/AMT vehicle is mainly moved in two directions the shape does not have to be optimised for pulling and dragging in the traditional four directions. This has created opportunities for new shapes and proportions.

LED-lightning is commonly used to display the shift pattern in todays modern PV's. Furthermore buttons are often integrated on the shifter or on the underlying panel to be easy accessible.

Image 4.9. Analysis of shifter knob in PV.

Image 4.10. Analysis of shifter knob in PV.

Image 5.1. Ideation

05

CONCEPT DEVELOPMENT

This chapter describes the path from the research results to ending up with eight different concepts.

5.1 IDEATION PREMISS

5.1.1 Existing mechanics

As this project is being executed, KA has not fully defined the shifter mechanics. A functional concept was however given to the project group, which served as a base for the development process. The functional concept mainly consists of a rod that is connected to a structure including mechanics and electronics that enable and register the shifter movement.

When assembling the shifter, a locking ring and the knob is skewered onto the rod. The locking ring is thereafter twisted in order to lock the parts together (image 5.2).

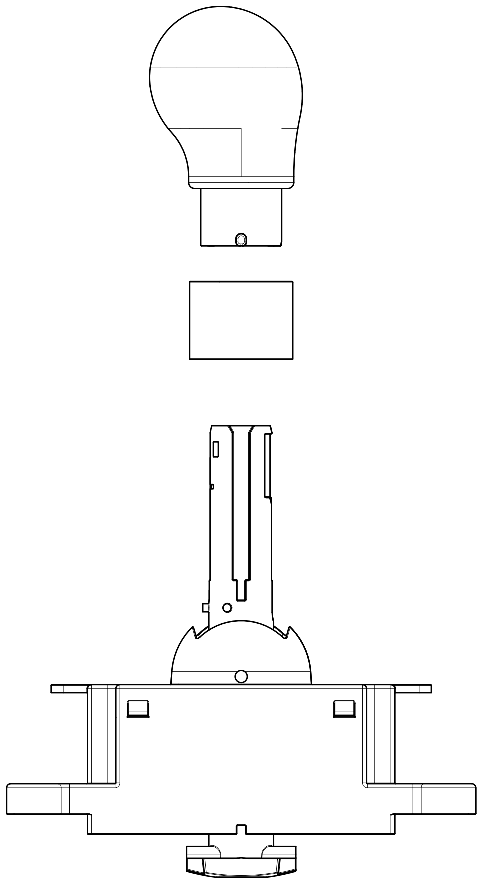


Image 5.2. Existing mechanics

5.1.2 Visual appearance

As KA traditionally is a company that develops products out of given specifications they do not have an own visual brand identity. Nor did they have any specific guidelines for the visual appearance for this concept. Instead, the project group got full scope regarding this issue.

As the concept aims to be installed in different trucks it was however stated that the visual design should suit a generic truck cockpit of today. The design should also be at the forefront in the truck industry and be perceived as modern.

5.1.3 Requirements list

To concretise the requirements from KA and what was found during the research part a brief list of requirements were made (table 3). The list is not complete and includes several subjective parameters that cannot be measured during this project. It does however picture important issues to be treated in the development process. The background for each requirement is stated in italic.

5.2 IDEA GENERATION

5.2.1 Inspiration

In order to stimulate the idea generation a collection of pictures were gathered to create an inspiration board. The pictures were both aimed to trigger ideas regarding the form and the experience of the shifter as well as to understand how to differentiate the new shifter from existing ones.

5.2.2 Form ideation

The form ideation started of with both quantitative and qualitative sketching sessions. Sometimes on one's own accord but more often in a group to keep a stimulating environment and to share ideas with one another. It was however quite early understood that this method was not enough, even in the early stages. The haptic sensation of the type of product that was developed was considered very important, and together with the size of the product the use of materials such as styrofoam was perceived as useful for the idea generation. The qualities of this material made it easy and time efficient to create physical models and a three dimensional experience of the early concepts. However, styrofoam has a disadvantage regarding how changes in the form can be reversed, which is something that clay provides. When wanting to create organic shapes clay is also a preferable material to work with and due to that it is hands that acts as tools when working with clay the fitting to the hand, when gripping the shifter in this case, comes more naturally. These three tools were therefore perceived as complementing each other's weaknesses and used in parallel throughout the idea generation.

In the beginning, all types of ideas were sketched or created with styrofoam or clay without any criticism in order to create a big base of forms to use for the upcoming stages. It was perceived as important to have diversity among the early ideas. To achieve this some of the idea generation was made with different aspects in mind. Examples of aspects used to stimulate diversity as well as to ensure the quality and relevance of ideas was; how the shifter could take up as little space as possible, how it could fit in different positions in the best way, how it could provide many different gripping possibilities, how it could differentiate itself from other shifters and how it could indicate the tip function in an intuitive way.

5.2.3 Semi-structured tests

Semi-structured tests was continuously performed with the different early ideas to get a feeling of how the size of the shifters was perceived by people with different hand sizes and how well they worked in different cockpit positions. This resulted in that some ideas were discarded while others had to be modified in different ways. Performing these tests on people with different hand sizes made it possible to design the concepts to better suit the broad intended target group.

1. Ergonomics		
1.1	Be comfortable to handle a workday with 40 stops in intense city traffic *An estimation of maximum usage based on user studies*	**Demand**
1.2	Allow different gripping *User studies demonstrated a variety of preferred hand positions*	**Preference**
1.3	Allow manoeuvring using only fingers *Preference from KA as this is seen as an upcoming trend*	**Preference**
1.4	Allow hand resting *A preference gained from user studies and KA*	**Preference**
1.5	Provide clear feedback *An issue that was communicated by almost all interviewees*	**Demand**
1.6	Require a suitable force to be manoeuvred *All interviewees expressed the importance of that the shifter should not require too high nor too low force*	**Demand**
2. Function		
2.1	Include a manual mode *A manual mode was substantial almost all interviewees occasionally*	**Demand**
2.2	Suit different shift patterns *The usability test showed that several shift patterns were more or less equivalent in performance. The OEMs might be able to choose from several predefined patterns.*	**Demand**
2.3	Include at least 4 conformable buttons *KA want to add functionality and added value to the shifter. This is also seen as a trend in the PV industry*	**Demand**
3. Integration		
3.1	Fit existing mechanical structure concept *Demand from KA*	**Demand**
3.2	Maximum panel area of 200x100 mm *In order to fit in different positions in the interior without occupy too large area. Demand observed in benchmark studies*	**Demand**
3.3	Maximum height of 120 mm *To not trench the interior. Demand observed in benchmark studies*	**Demand**
3.4	Allow placement on dashboard, centre console and beside seat *The three main positions for trucks according to the benchmark study*	**Preference**
3.5	Withstand a harsh and dirty environment *The environment in some contemplated interiors according KA and user studies*	**Demand**
4. Aesthetics		
4.1	Possess a design that suit a generic truck interior *Demand from KA*	**Demand**
4.2	Allow customisation to suit different brands *Demand from KA*	**Demand**
4.3	Possess a design that is at the forefront in the truck industry *Demand from KA*	**Demand**

Table 3. Requirements list.

5.3 CONCEPT GENERATION

5.3.1 Categorization of concepts

In order to structure the different ideas from the form generation some kind of categorization was needed. This categorization was thought to work as a sort of insurance so that the ideas were fulfilling the identified needs and requirements as well as that the ideas together showed a diversity and provided a wide range of different thoughts to pick from, something that was clearly requested by KA. Similar ideas or thoughts were clustered together to narrow down the selection of concepts ought to be used for the upcoming workshop (table 4).

The five factors used for the categorization was selected with the internal variance of the factor in mind and naturally derived from the findings in the data collection. The first factor chosen was Size, which was divided into three different distinct options (S, M, L). This was included partly due to that many different preferences regarding a shifter's size exists. The second factor was possible Placement (DB, CC, BS) that together with the third factor Grips (Finger, Top, Side) (img. 5.3) thought to represent the adaptability of the concepts, which has been one of the most important things to consider in this project. The fourth factor was degree of innovation and was scaled from 1-5 and the fifth factor related to in what way (if any) current gear or Shift pattern should be displayed (yes on shifter, yes on panel, no). Worth noticing is that the current gear would be showed in some sort of external display in all three cases. The two last factors thought to facilitate the evaluation when providing an indication of what level of technical and form-related degree to apply to the final concept.

5.3.2 Creation of workshop concepts

The categorization table was made partly based on the different concepts from the ideas that came up during the ideation phase, while other parts of the categorization table instead were formulated due to an anticipated need and then created in hindsight.

During the work of creating the workshop concepts, it was early understood that ten concepts was too many, both due to the time limit of development and the evaluation time during the workshop. Concept number 7 and 10 showed no really unique features or advantages and was therefore discarded. The eight remaining concepts were considered enough to create the wanted diverse concept sample needed.

After establishing the categorization table the concepts were refined in order to acquire the wanted shapes and expressions. Modifications to make all concepts theoretically manufacturable were also applied at this stage.

When the basic design features were set, detailed digital sketches were made in Photoshop and physical ureol-models were created. Bolts were glued into the bottom of the models, which enabled mounting on the shifter rig. Together, the sketch communicated the visual sensation while the physical model provided an realistic haptic experience and demonstrated the physical interaction (image 5.4).

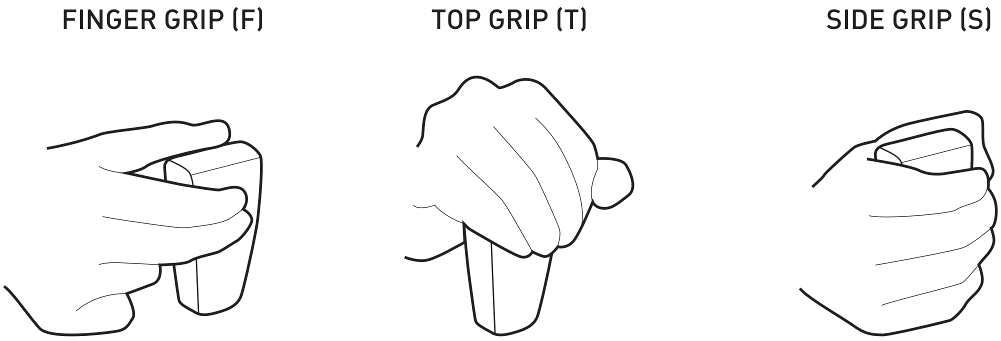


Image 5.3. Different types of grips.

Image 5.4. Workshop concepts including sketches and physical models.

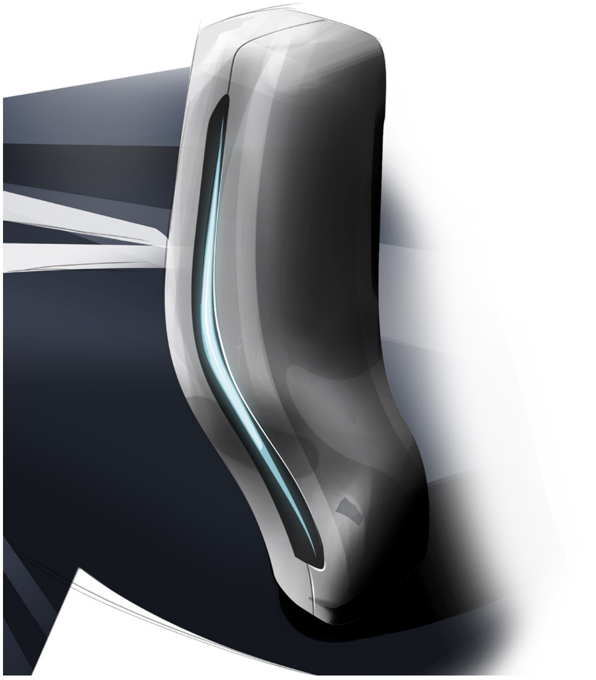
	Concept	Size	Placement	Grip	Innovativeness	Shift pattern
1	Thumb	S	DB (CC)	F	4	NO
2	Mini	S	DB (CC)	F T	2	NO
3	Joystick	S/M	DB CC	F S	4	PANEL
4	Curve	M	DB CC MS	T S	3	PANEL
5	Polygon	M/L	DB CC BS	T S	4	SHIFTER
6	Chubby	M/L	(DB) CC BS	T S	3	SHIFTER
7	Whale	S/M	DB CC BS	T S	4	SHIFTER
8	Flash	M	DB CC	S	5	NO
9	Box	M	DB CC	F T S	2	PANEL
10	Rocket	M	DB CC	T	5	SHIFTER

Table 4. Categorization of concepts.

5.3.3 Workshop concepts

Flash concept

The flash concept was developed to differentiate from existing shifters and express innovation. Using a side grip, the hand can rest on the curved shape. The concept was mainly designed for placement in centre console and dashboard.



Box concept

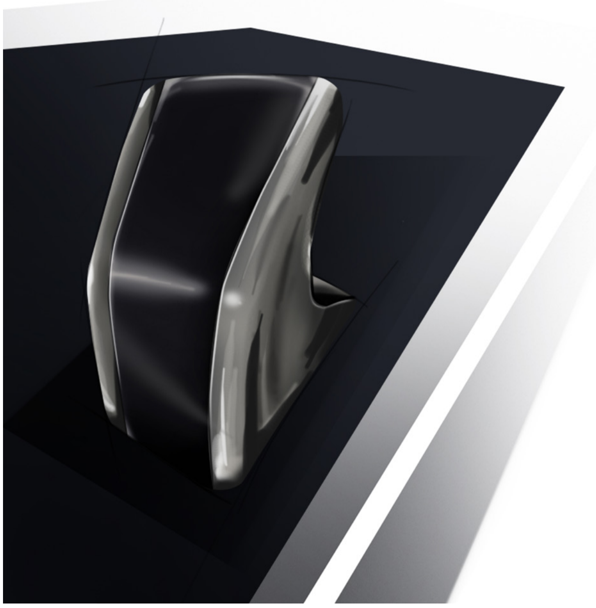
Simplicity and basic shapes were the starting point of the box concept. The large front area created the possibility of placing several fingers here when using a side grip as well as a top grip. The thinness did also allow a finger grip. Centre console and dashboard were the intended locations of placement.

Polygon concept

The polygon concept was designed to provide a comfortable top grip as well as a side grip. With sweeping surfaces and sharp edges the knob got a contemporary expression. Using a flat top surface, a LED shift pattern could easily be integrated. The concept was designed for dashboard as well as for the centre console and beside seat.

Thumb concept

As the name indicates, the thumb concept was designed to be manoeuvred using the thumb together with one or two fingers. The small size made it especially suitable for placement on the dashboard.



Joystick concept
With its elongated shape, the joystick concept was optimised for a side grip. The shape did also make tipping into manual mode natural and gave a futuristic expression. Centre console and dashboard were the intended placements.

Curve concept
The curve concept was designed to provide a comfortable top grip as well as a side grip. Using an unsymmetrical shape, the knob also indicated tipping in the side direction. The knob was designed to be placed on the dashboard, centre console as well as beside seat.

Chubby concept
Knobs in modern PV's inspired the shape of the chubby concept. The shape gave a steady grip from the top as well as the side. The intended positions were the centre console, dashboard and beside seat.

Mini concept
The mini concept was designed to be small but still allow usage of multiple fingers primarily from a side grip. The concept was first and foremost developed to be placed on the dashboard or in the centre console.

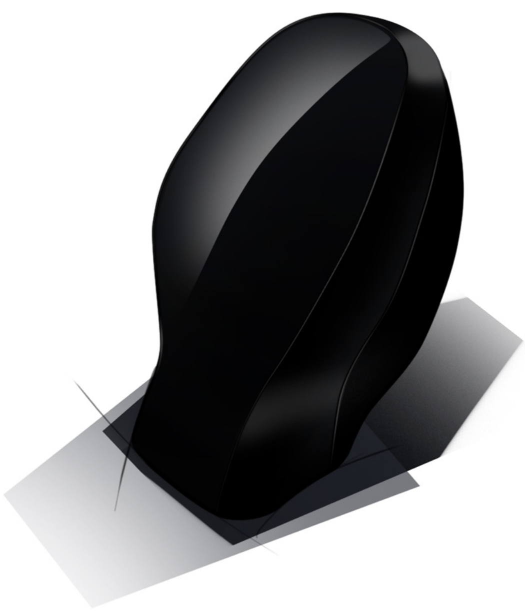


Image 6.1. Evaluation at KA

Concept	P1	P2	P3	P4	P5	Total
Flash	2	3	1	1		**7**
Box						**0**
Polygon				3	3	**6**
Thumb	1	1	2	2	2	**8**
Joystick						**0**
Chubby	3					**3**
Curve			3		1	**4**
Mini		2				**2**

Table 5. Score table from KA workshop

06

EVALUATION AND FURTHER DEVELOPMENT

IIn the following chapter, the different evaluations are described as well as the refinements that were made for the final result.

6.1 KA WORKSHOP

6.1.1 Description of KA Workshop

To evaluate the concepts and gain feedback from professionals, a workshop was carried out with five KA employees in Mullsjö the 3rd of December 2013. Two mock-up truck interiors was built including a seat and shifter rigs placed in the three identified positions (Beside seat, Centre console and Dashboard). Each concept model was then mounted in the various positions so that the participants got to test the concepts in all three positions (image 6.1).

An open discussion climate prevailed, and the participants were encouraged to clearly communicate both positive and negative criticism during the whole workshop. The project group were continuous observing the participants way of interacting with the concepts and asked attendant questions. In order to complement the discussions and concretise opinions as well as improvement proposal, a questionnaire, appendix V, were completed by the participants.

The workshop was wrapped up with a group discussion were the participants got to grade the concepts and give grounds for identified advantages and drawbacks of the concepts.

6.1.2 Outcome from KA Workshop

The KA workshop resulted in important input and new insights for the following concept development. A summary of the participants' comments on each concept is found in appendix VI and the scores are found in table 5.

The participants had a surprisingly positive attitude towards the more uncommon concepts such as the Flash and Thumb concept. A tiredness of existing knob designs might be the reason for that, which might not be representative for the target group. The relatively small sizes of the knobs were appreciated by the majority and were found to suit a modern shifter.

The sharp edges that could be found in several concepts were in most cases disapproved from an ergonomic point of view since they were considered as uncomfortable. For some concepts e.g. the Polygon, some participants expressed a concern whether one would be able to rest the hand on the shifter without tilting it forward due to its forward angled design.

From the score table and the workshop discussions, the Box, Joystick, Chubby and Mini concept could be rejected. These ideas were neither more evaluated nor further developed.

6.2 UNSTRUCTURED EVALUATIONS

Further semi-structured evaluations were carried out by the project group on its own and together with other design students to gain further insights. The four remaining concepts were intensively tested in different positions. In this way, the comfortability could be evaluated over time. In what way the mounting angle influenced the different design proposals could also be investigated. These evaluations resulted in a number of improvement proposals mainly regarding comfort and more balanced forms.

By including design students in these evaluations, the project group gained ideas for aesthetic improvements and could also further evaluate how people with different hand sizes perceived the knobs. Somewhat surprising, the hand size had minor influence on how comfortable the forms were experienced.

6.3 THEORETICAL EVALUATION

The four concepts that were chosen from the KA workshop were theoretically evaluated against the requirements list using a Kesselring matrix. This was done in order to ensure that all the relevant factors would be taken into consideration (table 6).

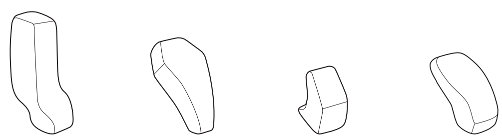
Since there is no existing solution to be replaced, the concepts were only compared to each other. The criteria were selected to include all requirements and were weighted to represent the importance. Since all shift patterns do not include tipping for manual mode *Indicate tipping* got 2. *Allowing Several gripping possibilities* were considered important, as the knob will be gripped from different angles dependent on position, further it is ergonomically favourable to vary grip during use, hence 4. *Placement possibilities* were weighted 5, as this is a fundamental condition for the concept to be generic. Novelty was considered to be important for KA and new product development in general, hence 4. Since the shifter will be used several times per day for many years and *Comfort* is one of the key parameter for a successful shifter, this was considered to gain highest weight. To enable varied placement, not being in the way nor trenching the vehicle´s interior *Space efficiency* got 4. Finger manoeuvring is rather a preference than a demand, hence 3.

As seen in table 6, the Poly, Curve, and Thumb concept received almost equal high scores, while the Flash concept got extensively adverse results. The unfavourable scores were mainly due to the large size that limited opportunities of placement and the weak possibilities for diversified grips.

6.4 CONCEPT CHOICES

Since the Polygon and Curve concept were relatively similar regarding size, gripping possibilities and composition, but still had different strengths and weaknesses, they were combined to one design (hereafter referred to as Poly/Curve concept) including the advantages from both. As the Thumb concept was highly appreciated during the KA workshop and gained good results in the theoretical evaluation, it was decided to develop both these concepts in order to create the variation KA was requesting. The differences in these two concepts were considered to complement each other in a sufficient way.

As the flash concept differed extensive, it could hardly be combined with any of the others. Due to the time limit, this concept was left to KA for further development.



Criteria description	W	Ideal (W)	Flash	Polygon	Thumb	Curve
Indicate tipping (for M-mode)	2	10	8	4	2	10
Several gripping possibilities	4	20	8	16	12	16
Placement possibilities	5	25	5	20	15	20
Novelty	4	20	20	12	20	16
Comfort	5	25	20	20	20	15
Space efficiency	4	20	4	16	20	16
Possibility for finger manouvering	3	15	6	9	15	9
Total		**135**	**71**	**97**	**104**	**102**
Ranking			**4**	**3**	**1**	**2**

Table 6. Kesselring evaluation of the four remaining concepts.

6.5 FINAL CONCEPT DEFINITION

6.5.1 Poly/Curve

The Poly/Curve concept was aimed to be the slightly bigger one of the two final concepts and more fitted for a BS and CC placement. It was thought to keep the asymmetry of the Curve concept to clearly indicate the tipping function for entering the manual mode. The top part would be significant and of a slightly curved surface. The top surface would have a distinct chamfer as the Polygon concept that would meet the bottom part, which would be of a softer and more rounded shape. The top and bottom part would have approximately the same thickness viewed from the side. The combined concept was thought to have roughly the same size as the Polygon concept.

6.5.2 Thumb

Aimed to fit well for a DB placement, the Thumb concept would be of a smaller size than the Poly/Curve concept. The profile of the Thumb concept was thought to be approximately the same in the refined version. The curved inside and the foot was going to be kept, while some modifications were going to be made on the edge where the two surfaces on the front side met, making the transition a bit softer. The top part of the concept, providing the two finger grip, would retain quite thin, and the overall size would be slightly increased in the refined Thumb concept.

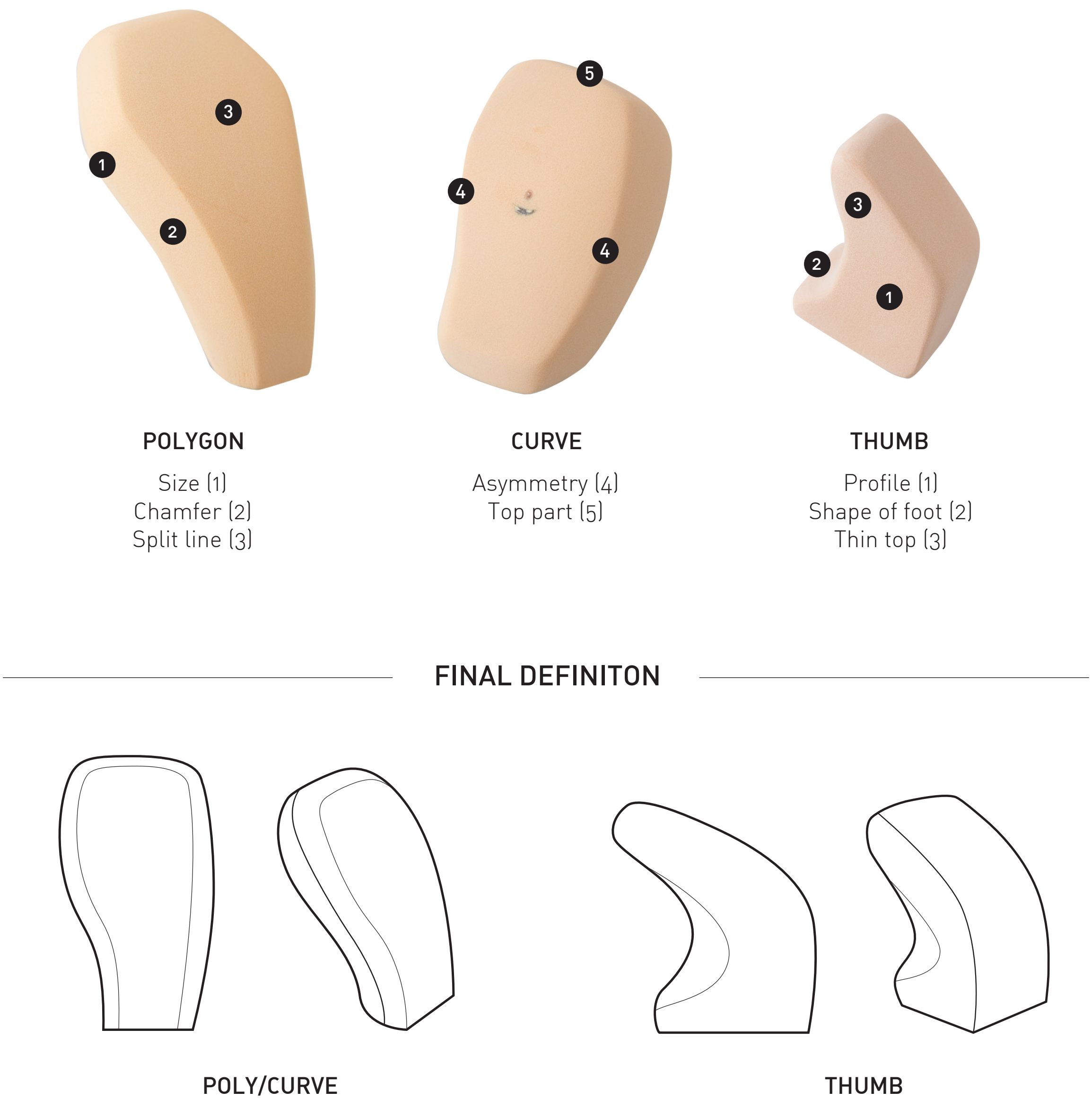


Image 6.2. Features for the final concept.

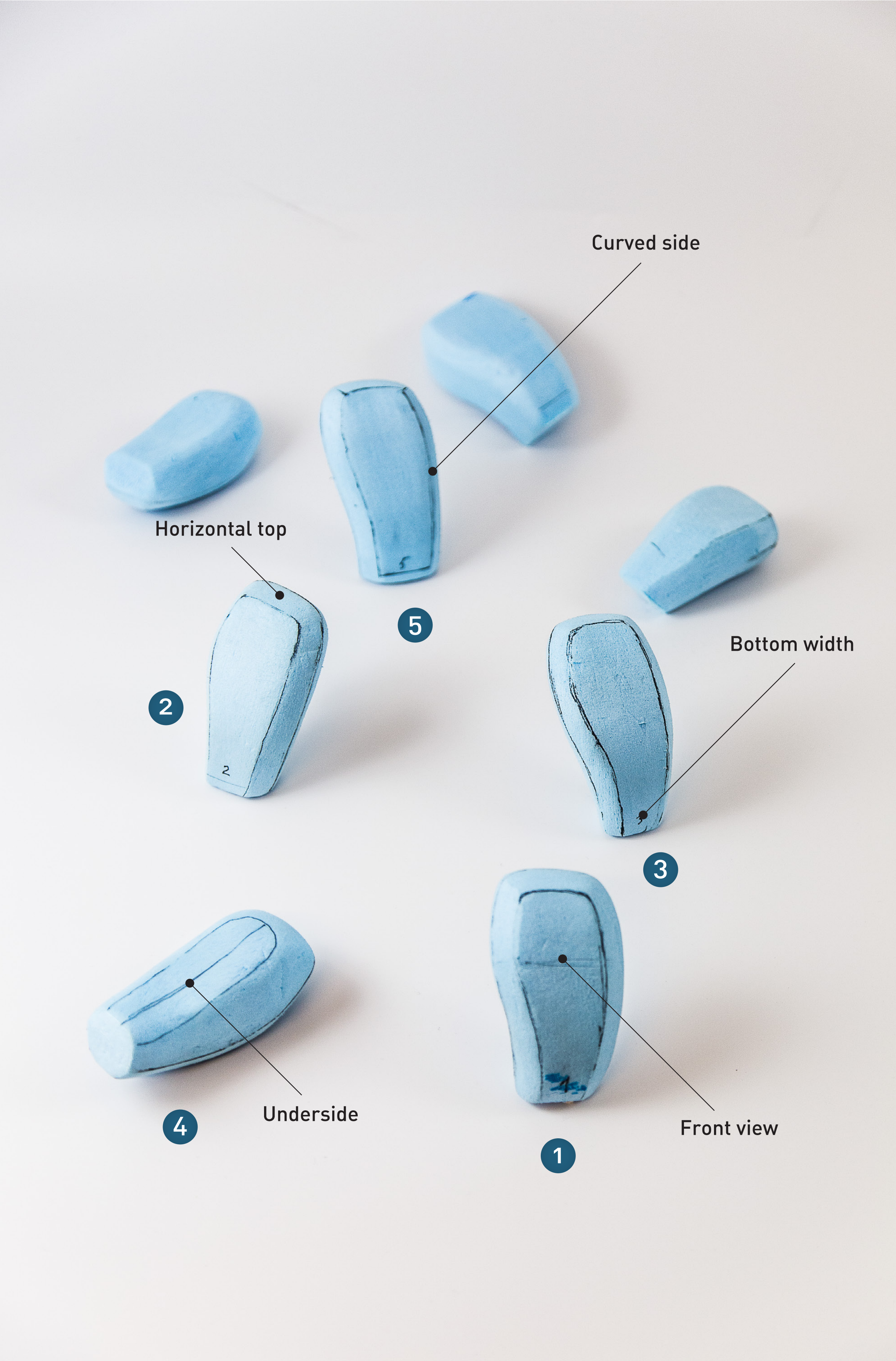
6.6 VERTICAL FORM GENERATION

A vertical form generation were initiated when the final concepts had been defined. The main target was to produce a quantity of models in clay, styrofoam and ureol.

6.6.1 Poly/Curve concept

Styrofoam was used for the vertical form generation of the Poly/Curve concept. The front and side view defined in *6.5.1 Poly/Curve* were used to cut out several base forms and then different diversifications were made on the forms regarding the amount of asymmetry, the angle and size of the chamfer, its vertical stretch and the thickness for instance. This resulted in a fair amount of different concepts from which different form elements were picked out to form the final concept.

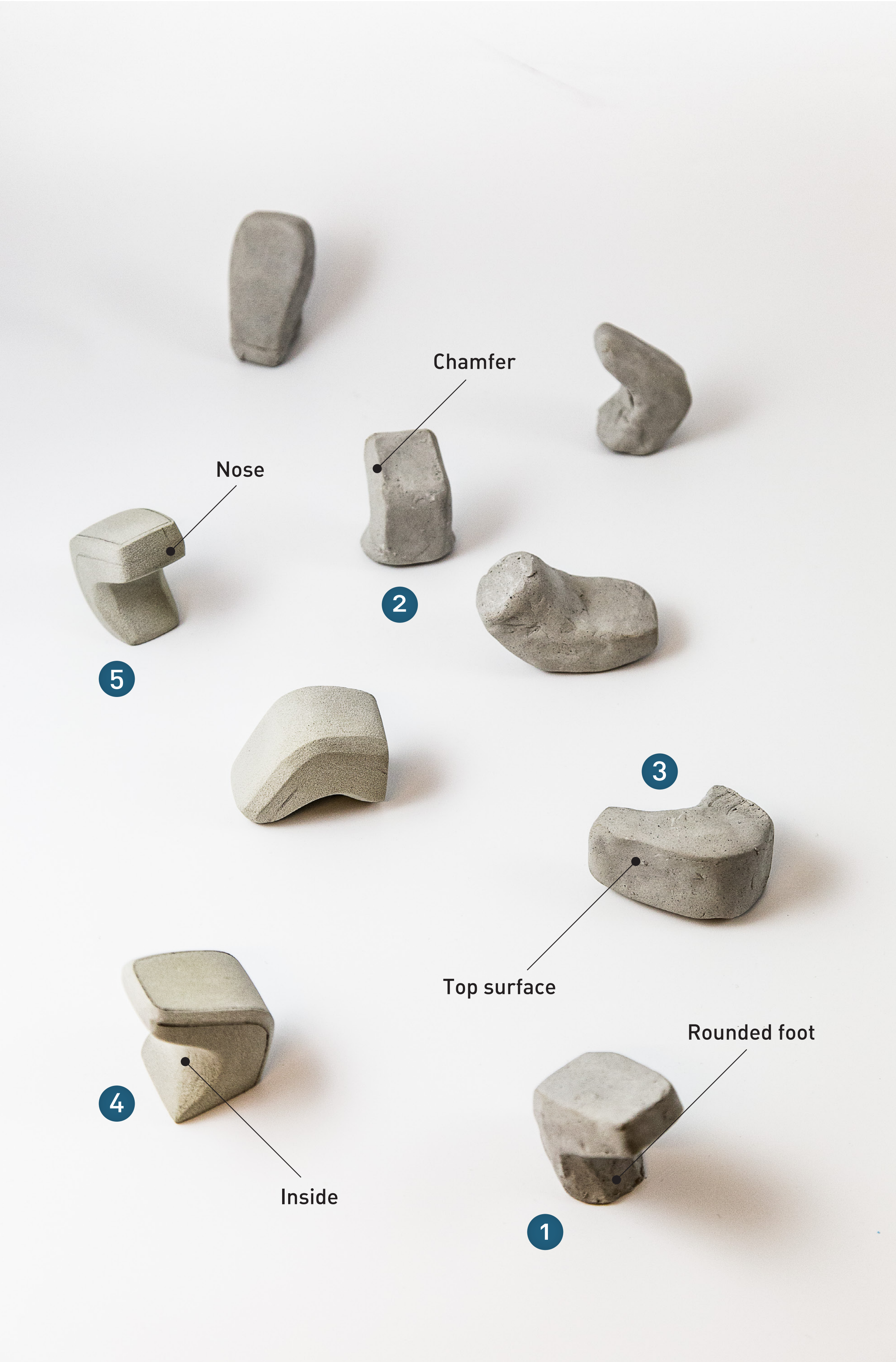
The front view of concept representation 1 was perceived as the most successful one regarding the wavy form on the left hand side, providing a comfortable grip and at the same time a firm and modern expression. The almost horizontal top of concept representation 2 was chosen to hold the wanted angle and its chamfers were also perceived to be the most balanced ones both regarding expression and comfortability. The bottom width of concept representation 3 was thought enough to still provide a solid look while not being too voluminous. The underside of concept representation 4 was chosen because of its balanced roundness and the line on the right hand side of concept representation 5, when viewing it from the front, was considered to counterbalance the more wavy and soft left side in a preferable way.


Curved side
Horizontal top
5
2
Bottom width
3
4
Underside
1
Front view

6.6.2 Thumb concept

Clay modelling was thought to be most suited method for the early vertical form generation of the Thumb concept due to its concave shape. More detailed and sharp forms were difficult to achieve with clay and some models in ureol were therefore produced as a complement.

The rounded front side of the foot visible in concept representation 1 and this concept's front view was perceived to be most similar to the wanted shapes for the final concept. The chamfer on concept representation 2, also seen added to concept representation 4, were something that was chosen to proceed with since this connected it to the Poly/Curve concept and also made the grip more comfortable while still keeping a professional look with straight and distinct lines. The surface on which the thumb would be placed using finger manoeuvring was thought to be best illustrated in concept representation 3 and the inside (or underside) where the other finger would be placed using this type of grip was regarded to be most successfully expressed in concept representation 4. The almost vertical surface of the nose was considered best expressed in concept representation 5, while the waist of the final concept, viewing it from the front, were thought to be appropriate to attain a form somewhere between concept representation 4 and 5.


Chamfer
Nose
2
5
3
Top surface
Rounded foot
4
Inside
1

6.7 PANEL DESIGN

Something that had been requested by KA but not prioritised due to the time limit and workload of the project was the development and design of a panel to integrate the shifter concepts with. Some thoughts regarding this had been discussed in earlier stages but it was not until this stage it was considered to be sufficiently useful for the project. The panel was aimed to provide the shifters with the right context and to add credibility to the final concepts.

Quick sketches of the basic form and what elements and parts that should be included initiated the somewhat intense form generation of the panel design. The findings regarding additional functionality from the pre-study was considered when integrating buttons on the panel. Measurements in cars, complemented with mock-up testing, provided the right dimensions for the different regulators of the panel. When the basic form of the panel had been decided a full-scale version was created with clay (image 6.4). This enabled for the shifter concepts to be tried out with the panel to get the right experience of the full concept and the dimensions.

The outer shape of the panel was thought to resemble the shape of the shifter concepts and especially the Thumb concept. This together with the concave chamfer of the panel aimed to create a coherency. The concavity of the chamfer would also provide a better feeling of integration when the panel would be mounted into a truck interior.

6.8 CONCEPT FINALISATION

The final ureol models of the two concepts were made digital with use of the 123d-catch software that generated a polygon mesh, which could be used as an underlay when creating surface models in Alias Automotive. Some changes were made during the 3D modelling of the concepts to get the wanted functional form and achieve the right expression. When the surface models were finished the two concepts were made into physical models using rapid prototyping (image 6.3) so that the haptic and spatial experience could be better analysed. One additional iteration was hereafter made to the surface models in order to achieve a satisfying result. The finished surface models were sent to KA for mechanical design and preparation for prototype manufacturing.

Image 6.3. Rapid prototyping of concept.

Image 6.4. Ideation of panel design.


KONGSBERG
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TCS
KONGSBERG
SWIFT

07

FINAL RESULT

This chapter describes the final concept and how it is fulfilling the requirements stated.

7.1 CONCEPT

7.1.1 Concept idea

G Swift and C Swift are two concepts of mono stable shifters for the truck industry. By using shift-by-wire technology, the shifters can be bought "off the shelf" and implemented in all trucks with supporting automatic transmission, in order to minimise development time and costs for the vehicle manufacturer. This contributes to a more economical sustainable product.

The concepts are designed out of requirements and preferences from Swedish truck drivers and aim to provide a good user experience regardless of the type of truck and field of operation. By being offered in two versions, the product can be better suited for specific demands and more easily be integrated in different interiors. The concepts can be implemented with different shift patterns, specific recommendations are found in chapter *7.3 Shift-pattern*.

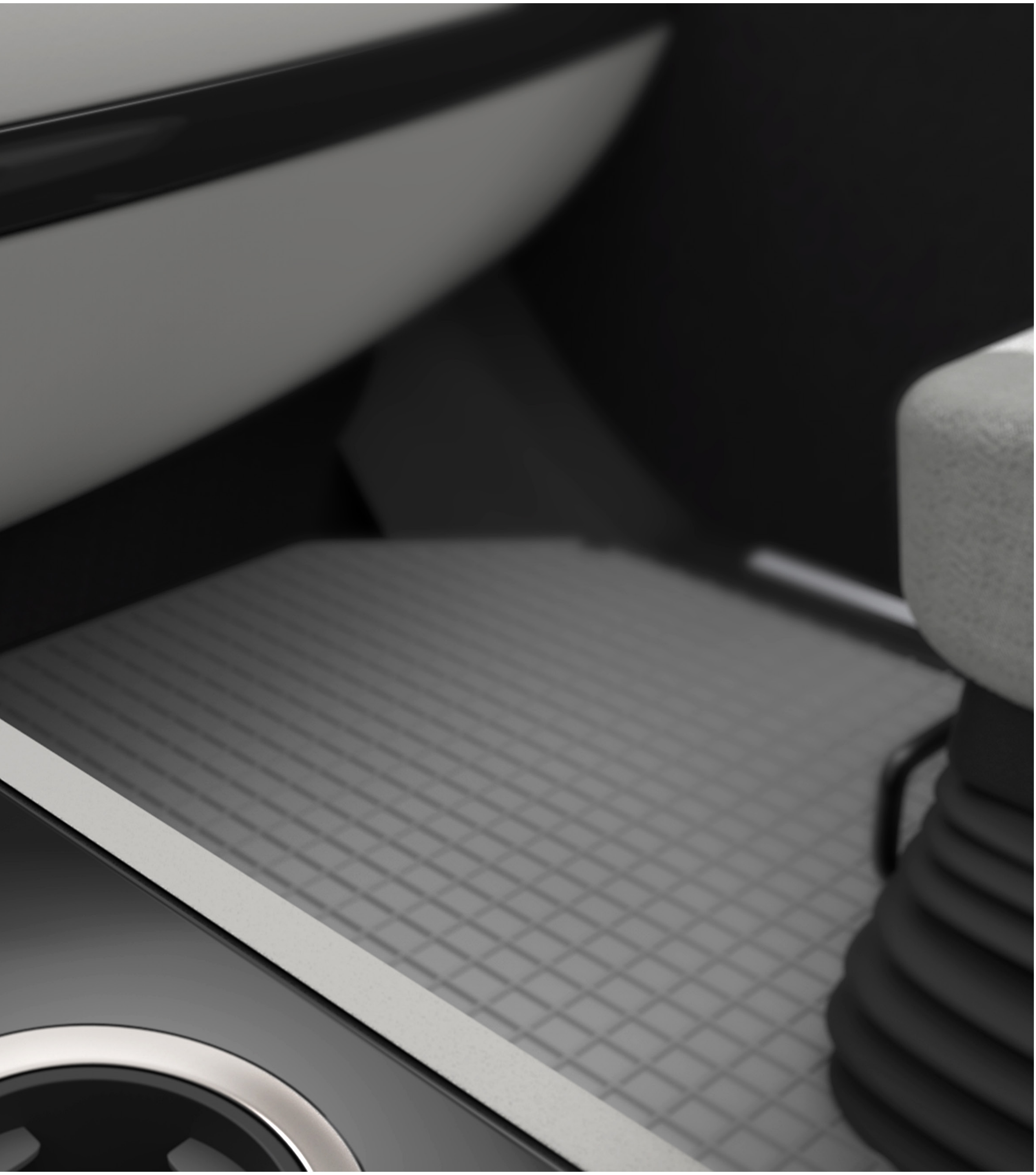
7.1.2 Ergonomics

Both knobs are designed to enable placement in various positions and to fit hand sizes from 5:th to 95:th percentile men and women. The G Swift provides a comfortable experience regardless of if it is gripped using a top or side grip. The thinness also enables finger manoeuvring for even better variation possibilities. The C Swift is designed to provide a sturdy finger grip both from the top and from the side. Both knobs holds even shapes that will not create pressure hot spots during use.

G Swift and C Swift can easily be handle in diverse positions. The forms provides good gripping possibilities if they are placed beside the seat, in the centre console as well as on the dashboard. The small size does however make the C Swift optimal for placement on dashboard.

The functionality of the underlying panel is easily accessible through its design. As all buttons are placed behind the knob, these can easily be manipulated regardless of position.


100 YARD DASH
CAM
TEL
MEDIA
NAV
TEMP
TEMP
R
N
D
-
M
+
TCS



7.1.3 Aesthetics and Semiotics

G Swift and C Swift are also designed to suit a large variety of interiors regarding aesthetics and semantics. The expression aims to be modern and in the leading edge compared with what exist in trucks of today. It is however not intended to be as cutting edge as seen in some of today's personal vehicles since that would hardly match any truck interior the upcoming years.

Both knobs are built up of sweeping surfaces intersecting in small radii. Through a smart placement of these intersections and by using chamfers, the concepts can hold a partly edgy expression without feeling uncomfortably edgy during gripping.

The semi glossy upper part creates a contrast to the rugged under part and gives the knobs a more dynamic and interesting expression. In these concepts, both the upper and lower part are 100% black in order to be perceived as generic as possible. The colour can however be changed by the OEM in order to better fit a specific brand or interior.

The hollow shape of the panel emphasise the expression of integration with the interior, and by using a similar texture on the panel´s buttons as the knob's under part, a balanced wholeness is created. The five push buttons on the panel can be configured by the OEM and will therefore possess different symbols. The central round button is however differentiated and can be used for important actions such as entering the manual mode. A button for parking brake is located rearmost. This is pulled upwards for activation of parking break and pushed down for release.


PC-ABS top cap
TPU grip surface
PC-ABS locking ring
Load carrying structure
KONGSBERG

7.2 MATERIALS AND MANUFACTURING

Both knobs are composed in a similar way, but the components are specific for each of them. Starting from the inside, the knobs are built up by a load carrying structure of glass fibre reinforced polyamide. Using double shot injection moulding, this structure is partly covered by a softer, almost rubbery thermoplastic polyurethane (TPU), which make up the inside/underside of each knob. In this way, the knob gets very solid as this becomes one component.

The upper part is made of an injection moulded polycarbonate-ABS blend (PC-ABS), a polymer that is frequently used in the automotive industry. The PC-ABS gives the component both high strength and toughness, and the surface does not need to be painted in order to achieve the semi glossy surface. This upper part has a material thickness between 1-2 mm, and is mounted to the load carrying structure using built in snap buckles.

The locking ring and the base of the panel are also manufactured of injection moulded PC-ABS. In this concept, these parts are varnished with a chrome colour.

By making all components of polymer, the colour can relatively easily be changed. This is favourable for the product to be generic.

7.3 SHIFT-PATTERN

As mentioned earlier, different shift patterns can be implemented in both concepts in order to meet the OEMs´ needs. The project group does however recommend to use a DS pattern with tipping for manual mode in G Swift and a DS pattern with push button for manual mode in C Swift.

A DS pattern is used in both concepts as this is considered to give the most efficient experience. Even though the nominal time difference from a SS pattern is minimal, the perceived time difference will most probably be substantial for an everyday user. The fact that the driver can pull or push the shifter two steps regardless if it is needed or not to access the intended gear, will most likely be appreciated, as a minimal cognitive exertion is needed.

Since both the field studies and the usability test indicated that tipping the shifter for manual mode is favourable, this functionality is used for G Swift. The asymmetric and tapered shape of this knob also helps in expressing this functionality. C Swift does however use a pushbutton instead because of its low profile and since the form less obvious give clues about tipping possibilities.

08

DISCUSSION

The following chapter elaborates on the process of the project as well as the final result and how this could be improved further.

8.1 METHODS AND PROCESS

8.1.1 Overview

The ambition from the start of the project has been to stay within the assigned time frame of twenty weeks according to the initial Gantt chart (Appendix I). The planning has been followed well and all planned activities have been given the time required.

Well-recognised methodology for product development and design has been used during the whole process, but only a few specific methods have been executed properly by the book. Instead, ways of thinking found in different methods has been implemented and methods have been tailored to fit this specific project. One could argue that a more strict approach towards the methods would give more useful results. On the other hand, tailored methods are time efficient and by being shaped specifically for the current project, the results most likely are more relevant, and with that also more useful.

8.1.2 Data collection

A theoretical base could rapidly be formed from the literature studies and conversations with KA, which made it possible to perform user studies in a relatively early stage of the project. Weather it was an advantage or not to carry out these studies in such an early stage can be discussed. On one hand it was profitable to get a deeper understanding of the use situation and the users' preferences at this point. On the other hand, more insightful information might have been gathered and more relevant concept testing could have been fulfilled in a later stage.

Performing interviews with the target group was more difficult than expected. Several questions and evaluation procedures that were prepared in advance could not be performed due to time limits and interviewees' unwillingness to discuss. Instead, the interviews had to be adjusted and improvised during the execution. A general sentiment of not being able to influence the vehicle interior by the target group also limited the outcome. To observe the users during driving could have resulted in other insights, such procedure was however not prioritised.

The absence of direct contact with any OEM might have resulted in overlooked demands and preferences on the product. Instead KA has been the contact for such aspects whose opinions are substantial for the product to be successful from a business perspective.

8.1.3 Usability test

Preparing and performing the usability test claimed a fair amount of time, especially designing and manufacturing the hardware and software to make the rig interactive. One could discuss whether this should have been prioritised or not since this set up still differed from a real life driving experience in many ways. The most influencing differences were probably that the participant did not have to worry about making mistakes to the same extent in the test that they would do in reality. This is a likely reason for the relatively large number of mistakes done. Furthermore the shifting sequence that was executed were more intense than an ordinary driving situation, which gave the participants less time to think and created a rather extreme driving situation. It is however most probable that the findings from the usability test are much more trustworthy than what a theoretical evaluation would have resulted in.

The selection of participants for the usability test consisted of design students instead of truck drivers as this saved a large amount of time for preparation. One could argue that this group are not representative for the target group and that the results thereby might be distorted. These participants are however presumably better in understanding the representation and map this to a real life driving situation, in contrast to experienced drivers who most probably would have had difficulties with the generalisations that were made.

8.1.4 Concept generation

Working with several different materials in parallel during the ideation and concept development phase was a key element in order to generate realistic concepts. It is however undetermined if this led to a lack of extreme concepts, as the ideas continuously were tested against aspects like comfort and manufacturing. More innovative solutions might have triggered KA's ideas even more, but there is still a greater risk that said concepts would end up as just ideas with a need for modification to be used further.

8.1.5 Evaluation

As there is no existing reference product, the concepts could only be evaluated against each other and the requirement list to cover all aspects. An evaluation of this product also included numerous subjective parameters, which complicated the procedure.

The workshop evaluation at KA together with the theoretical evaluation had the main impact on the concept selection. According to observations during the workshop discussions, it is likely that the employees evaluated the specific concept instead of taking into account small changes that could be made for improvements. This, in combination with the great impact each number in a top three grading have for such a small group of respondents, makes the results from the workshop not completely reliable. Furthermore has the chosen criteria and grading in the theoretical evaluation a highly significant impact on the result, which make the outcome very much depending on the project group´s opinions.

Lastly one can question to what extend the results from the evaluations would have differed if truck drivers would have been involved. The experiences gathered during the initial study adverts that such evaluations would not have resulted in much qualitative data in relation to claimed time. To involve drivers would rather be appropriate if the shifter with different knobs could be mounted and functioning in a truck.

8.2 FINAL RESULT

8.2.1 Generic perspective

A generic shifter is a wide concept that could have resulted in different solutions. It could be questioned whether a concept including several knobs is a sufficient solution and if one single product instead could fulfil the requirements just as well. As the initial research showed, there is a great variety in user demands linked to the differences in type of transportation. The project group therefore believe that a range of knobs are needed to fulfil all preferences in a satisficing way.

The solution could possibly have been made even more generic. Designing the knob so that it could be modified and customised by the OEM without cost driving tooling could be one way. Making the panel more modular so that buttons could be placed according to the specific OEM´s preferences, or making the panel adjustable in size could also be a solution. These ideas were however rejected, as there is an imminent risk that such product would lack in quality and possibilities of smooth integration.

8.2.2 User experience

As the result has not been evaluated with its intended materials mounted and in the right context, it is impossible to draw any definitive conclusion regarding the user experience during usage. It is also not reasonable to believe that the concept changes the truck driving experience dramatically as the shifter is only one of numerous components of a truck interior.

It is however likely that the concept enhances the shifting experience in relation to existing solutions. The mono stable movement will presumably give a sufficient feedback and an amount of sportiness appreciated by the users. The solid design of the knobs, with several steady gripping possibilities and modern aesthetics, will most likely contribute to a pleasant user experience.

8.2.3 Realizability

The final knob concept is designed to be highly realizable for KA. Both knobs and the panel use materials based on recommendations from the company and according to engineers at KA, the surfaces models made are good enough and suited for existing mechanics. Mechanical design of the inside of both knobs are however still required.

The development of the panel design was not nearly acquired with as much time as the design of the knobs. Because of that it was less prioritized it is rather conceptual and significantly more refinements are needed to make this functioning. This concerns the moving parts in particular, as the movement and durability has not been covered in this project. The design does however use existing solutions for all functionality, which indicates that the realizability can be considered high.

If the concept would be extended with a wider range of knobs, it would be beneficial to use the same components to a greater extend. That could for instance be applicable on the locking ring. A re-design of the knobs would then however be required.

8.2.4 Sustainability

The final concept has the three legs of sustainability in mind, social, ecological and economical. From a social perspective it is uncertain if the concept will have a measurable impact. The absence of vibrations in the shifter may however lead to a less morphological skeletal wear for the driver in a long-term perspective.

Regarding ecological sustainability, this concept is equivalent to existing shifters in most aspects. The PC/ABS polymer that is used can be melted and recycled. The main structure cannot be recycled in an efficient way as two different materials are melted together. It is however believable that it is the mechanical and electronic structure underneath the panel that will have the greatest ecological impact.

From an economical point of view the product will likely be sustainable as it conform to a modern and modular business model where KA can sell a ready-made product. This reduces the investments cost for the OEM, and respective company can focus on their area of competence.

CONCLUSION

The research showed that the integration of a gear shifter could be done in various ways and that truck drivers' opinions regarding these products differ significantly. It was though shown that this group of users had a positive attitude towards a mono stable solution and saw potential in improvements regarding comfort and ease of use. The usability tests indicated that several shift patterns are appropriate to use in this sort of shifter. It is though hard to determine what additional functions that could add value to the product due to the differences in embedded functionality between trucks.

The final result is a highly realizable shifter concept designed to fit the different stakeholders' requirements and preferences. It is designed to fit in different positions, and to suit all types of trucks and fields of operation. For the product to be commercialised, further evaluation of the concept in its right context as well as mechanical development is needed.

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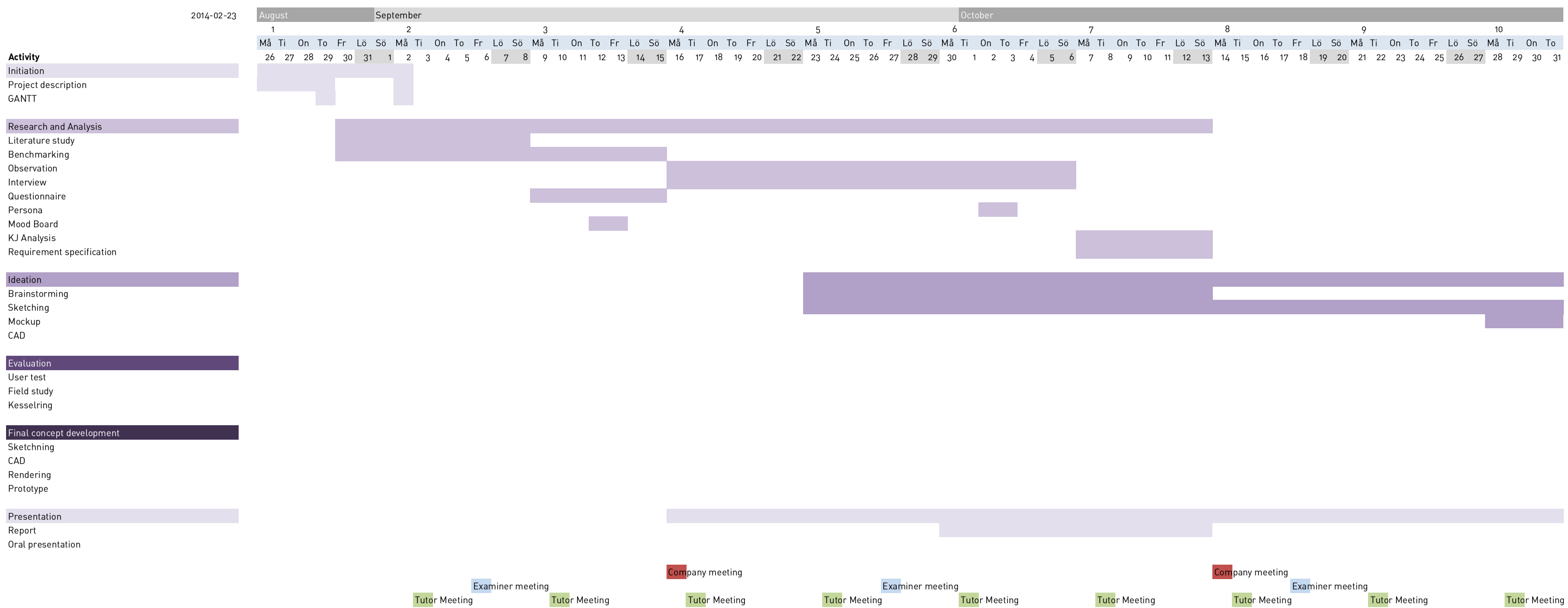
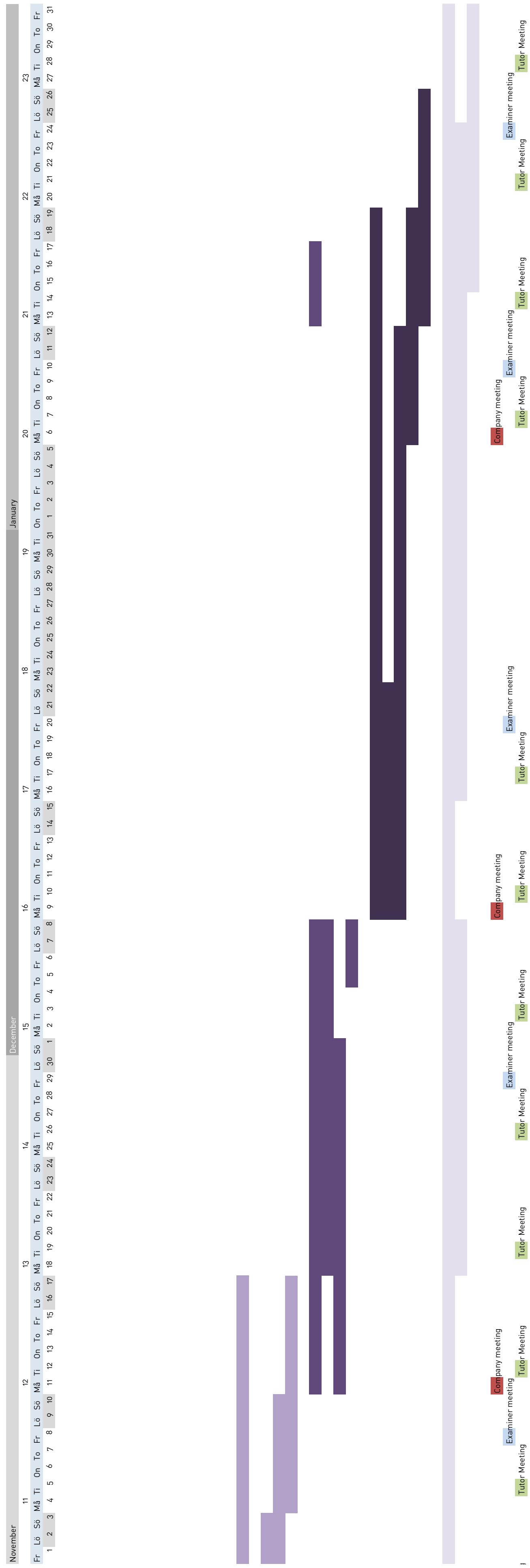
APPENDICES

APPENDIX I - GANTT CHART




November
December
January
11
12
13
14
15
16
17
18
19
20
21
22
23
Tutor Meeting
Examiner meeting
Company meeting

APPENDIX II - SHIFT SEQUENCE

The gear shift sequence used in the usability test. The sequence is designed to represent an ordinary driving route.

N
D
R
D
R
N
D
R
D
R
N
D
M1
M3
R
D
M2
M1
M2
R

ANVÄNDARTEST

MONOSTABIL VÄXELSPAK FÖR LASTBILSINDUSTRIN

ENKELSTEG VS. DUBBELSTEG

Upplevd tid - Hur snabbt kan jag genomföra önskad växling?

	Mycket snabbare	Lite snabbare	Likvärdigt	Lite snabbare	Mycket snabbare	
Enkelsteg	○	○	○	○	○	Dubbelsteg

Trygghet - Hur trygg du är i att den avsedda växeln kommer läggas i?

	Mycket tryggare	Lite tryggare	Likvärdigt	Lite tryggare	Mycket tryggare	
Enkelsteg	○	○	○	○	○	Dubbelsteg

Jag föredrar

Enkelsteg	○	○	○	○	○	Dubbelsteg

Därför att:

FÖR MANUELLT LÄGE: FÄLLNING VS. KNAPP

Upplevd tid - Hur snabbt kan jag genomföra önskad handling?

	Mycket snabbare	Lite snabbare	Likvärdigt	Lite snabbare	Mycket snabbare	
Fällning	○	○	○	○	○	Knapp

Trygghet - Hur trygg du är i att det manuella läget aktiveras/avaktiveras?

	Mycket tryggare	Lite tryggare	Likvärdigt	Lite tryggare	Mycket tryggare	
Fällning	○	○	○	○	○	Knapp

Inuitivitet

	Mycket mer intuitiv	Lite mer intuitiv	Likvärdigt	Lite mer intuitiv	Mycket mer intuitiv	
Fällning	○	○	○	○	○	Knapp

Jag föredrar

Fällning	○	○	○	○	○	Knapp

Därför att:

APPENDIX IV - USABILITY TEST DATA

Fel 1	Fel håll i A
Fel 2	Fel håll i M
Fel 3	Förbi N
Fel 4	Förbi M-växel
Fel 5	Överflödigt tryck
Fel 6	Felaktigt m-mode-val
Fel 7	Övrigt fel
Fel 8	För få tryck

FP1	E1	E2	EK1	EK2	D1	D2
N	1					
D						
R						
D	1					
R						
N						
D						
R						
D						
R						
N						
D	1	1				
M1						
M3						
R						
D						
M2						
M1						
M2						
R						
TID1	60	50	44	43	44	42
TID2	24	20	19	20	22	20
4	3	1				

FP2	D1	D2	E1	E2	EK1	EK2
N						
D	5					
R						
D						
R						
N						
D						
R	5					
D						
R						
N						
D						
M1						
M3						
R						
D						
M2		2				
M1						
M2						
R						
TID1	57	49	43	40	48	45
TID2	19	24	20	19	25	20
3	2	1				

FP3	EK1	EK2	E1	E2	D1	D2
N						
D		5				
R						
D						
R						
N	1		1			
D			1			
R						
D						
R				1		
N						
D	1					
M1						
M3			2			
R	7					
D						
M2		2				5
M1						
M2						
R						
TID1	57	46	48	42	40	34
TID2	27	22	22	19	18	15
10	3	2	3	1		1

FP4	D1	D2	EK1	EK2	E1	E2
N						
D						
R						
D						
R						
N						
D				1		
R						
D					1	
R						
N						
D						
M1						
M3	2		2			
R						1
D		5		1		
M2	2		2	2	7	
M1					2	
M2				2		
R						
TID1	52	51	52	61	56	48
TID2	27	27	24	34	27	23
12	2	1	2	4	3	

	FP1	FP2	FP3	FP4
(EvsD)Upplevd tid	1	1	2	1
(EvsD)Trygghet	-1	-1	-1	1
(EvsD)Jag föredrar	-1	1	2	1
(FvsK)Upplevd tid	1	-2	-2	1
(FvsK)Trygghet	0	-2	1	-1
(FvsK)Intuitivitet	-1	-2	-1	-1
(FvsK)Jag föredrar	1	-2	-2	-1

FP5	E1	E2	D1	D2	EK1	EK2
N						
D		1				
R						
D						
R						
N						
D						
R						
D						
R						
N	5					
D	1					
M1						
M3						
R						
D						
M2			2			
M1						
M2					2	
R						
TID1	50	42	46	38	46	39
TID2	22	19	22	22	22	17
4	2		1		1	
2						
1						
2						
1						
-1						
-1						
-1						

FP6	EK1	EK2	D1	D2	E1	E2
N						
D				1		
R						
D						
R						
N						
D		1				
R						
D						
R						
N						
D	1	5	1		1	
M1						
M3						
R						
D						
M2			2			
M1						
M2						
R						
TID1	46	46	47	44	43	37
TID2	21	19	20	21	18	18
7	1	2	2	1	1	
1						
-1						
-1						
-1						
0						
-1						
1						

FP7	E1	E2	EK1	EK2	D1	D2
N						
D	1	1		1		
R						
D						
R		1				
N						
D						
R					1	
D						
R				1	1	
N						
D	1	1	5			
M1					5	5
M3						
R			5			
D	1					
M2	5	2				
M1				5		
M2						
R						
TID1	69	47	47	43	49	43
TID2	36	20	23	21	23	18
14	1	4	2	3	3	1
1						
0						
1						
-2						
0						
-2						
-2						

FP8	D1	D2	E1	E2	EK1	EK2
N						
D				1		
R						
D						
R						
N						
D						
R						
D						
R						1
N	3					
D		5				
M1						
M3						
R						
D						
M2						
M1			2			
M2			2			
R						
TID1	45	42	45	42	47	39
TID2	22	21	25	19	24	17
6	1	1	2	1		1
-1						
0						
-2						
-2						
-2						
-1						
-2						

FP9	EK1	EK2	E1	E2	D1	D2
N						
D	1					
R						
D						
R						
N						
D	1	1				
R						
D						
R						
N						
D	1					
M1		4	5,6			
M3						
R	1					
D						
M2						
M1						
M2						
R						
TID1	47	43	39	37	44	34
TID2	22	19	17	19	22	16
7	4	2	1			
2						
-1						
1						
-2						
-2						
-2						
-2						

FP10	D1	D2	EK1	EK2	E1	E2
N						
D						
R						
D						
R						
N		3				
D						
R						
D						
R						
N						
D						
M1						
M3	2					2
R	7					
D						
M2						
M1						
M2						
R						
TID1	43	41	41	40	39	37
TID2	20	20	17	16	17	16
4	2	1				1
2						
0						
1						
-1						
-2						
-1						
-2						

FP11	E1	E2	D1	D2	EK1	EK2
N						
D				5		
R						
D						
R						
N				3		
D				5		
R						8, 1
D						
R						
N	1					
D	5					
M1						
M3			7			
R						
D			7			
M2				2		
M1		5				
M2	4					
R						
TID1	45	37	38	41	38	39
TID2	18	17	18	19	19	17
11	3	1	2	4		1
1						
0						
1						
-2						
-1						
-1						
-2						

FP12	EK1	EK2	D1	D2	E1	E2
N				5		
D						
R						
D						
R						
N						
D						
R						
D						
R						
N	1					
D	5					
M1						
M3	7					
R		1		1		
D						
M2	2	2	2			
M1	2					
M2						
R	1					
TID1	58	50	49	50	44	43
TID2	28	26	23	24	22	19
9	5	2	1	1		
1						
-2						
-2						
-1						
2						
-2						
0						

FP13	E1	E2	EK1	EK2	D1	D2
N						
D						
R						
D						
R						
N						
D						
R						
D						
R						5
N						
D						
M1						
M3	2					
R						
D						
M2	7,2	7,2	2			
M1						
M2						
R						
TID1	45	41	47	42	40	38
TID2	23	20	24	20	18	17
4	2	1	1			
2						
-1						
2						
-1						
-2						
-2						
-2						

FP14	D1	D2	E1	E2	EK1	EK2
N						
D	5					
R						
D						
R						
N						
D	1					
R						
D						
R						
N						
D	5					
M1						
M3						
R						
D		5				
M2	7					
M1						
M2						
R						
TID1	45	46	41	37	40	38
TID2	20	22	19	17	18	18
5	4	1				
1						
1						
2						
-1						
-2						
-2						
-2						

FP15	EK1	EK2	E1	E2	D1	D2
N						
D					5	5
R						
D						
R						
N			6			
D						
R						
D		5				
R						
N						
D						
M1						
M3						
R						
D		6				
M2	2					
M1						
M2						
R						7
TID1	42	35	38	35	34	32
TID2	20	18	16	15	15	14
6	1	2	1		1	1
2						
0						
1						
-2						
0						
1						
-1						

FP16	E1	E2	D1	D2	EK1	EK2
N						
D		5	5	1		
R				1		
D						
R						
N						
D						
R						
D				1		1
R		1				
N					1	
D						
M1						
M3	2					
R		1				
D						
M2						
M1						2
M2						
R						
TID1	53	44	47	51	52	51
TID2	30	20	22	20	27	25
10	1	3	1	3	1	1
1						
-1						
-1						
0						
-1						
-1						
-1						

FP17	EK1	EK2	D1	D2	E1	E2
N						
D	5					
R						
D						
R						
N						
D						
R						
D						
R						
N	1					
D	1	5				
M1	7					
M3						
R						
D						
M2						7
M1						
M2						
R	1					
TID1	57	43	42	41	36	36
TID2	28	21	19	20	17	17
7	5	1				1
1						
-1						
1						
-1						
-1						
-1						
-2						

FP18	D1	D2	EK1	EK2	E1	E2
N						
D	1			5		
R			5			
D						
R						
N						5
D			1			
R						
D						
R					1	
N						
D	1					
M1						
M3	2					
R						
D						
M2		7	2			
M1	2	2	2	2		
M2						
R						
TID1	61	45	53	43	43	41
TID2	30	21	29	21	15	18
14	4	2	4	2	1	1
1						
-2						
1						
0						
-2						
-1						
-2						

Median	Medel
1	1,2222
-1	-0,5
1	0,5556
-1	-0,944
-1	-0,889
-1	-1,222
-2	-1,333

CONCEPT EVALUATION

KONGSBERG AUTOMOTIVE, MULLSJÖ 2013-12-02

1 FLASH CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

2 BOX CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

3 POLYGON CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

4 THUMB CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

5 JOYSTICK CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

6 CHUBBY CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

7 CURVE CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

8 MINI CONCEPT

Appropriate positions	Opinions	Improvement proposal
☐ CENTRE CONSOLE ☐ BESIDE SEAT ☐ DASHBOARD		

TOP LIST

1.

2.

3.

APPENDIX VI - KA WORKSHOP RESULTS

	WS1		**WS2**		**WS3**		**WS4**		**WS5**	
	Opinions	Improvement prop.	Opinions	Improvement prop.	Opinions	Improvement prop.	Opinions	Improvement prop.	Opinions	Improvement prop.
1. FLASH	Bra känsla mot handen. Skön att vila handen på.	Inte delning mitt på pga skarv mot handen	Den svängda formen gör den skän att vila handen på			Större radier	Stabil att hålla i, lätt att tippa, funkar bra bredvid sätet		Kändes kantig i handen beside seat. Formen gav bra stöd för handen när den placeras längre fram. Gillar tanken på belysning, för lite sånt i lastbilar nu.	
2. BOX	"Hal". Handen glider av framåt. För bred		Behagligt sidogrepp. Smal i toppen gör toppgreppet lite "hårt". Rak, enkel, snygg. Funkar bra i DB. Fingergrepp är bra.	Gör formen i toppen bekvämare.	Ser inte ut som att den kan tippas		Bredvid sätet inte bra, lite för kantig känsla		Skön, rubust intryck. Bra även på dashboard	Gärna mjuk topyta beside seat (gäller alla knoppar)
3. POLYGON	Vassa kanter. Känns som att det finns en vridfunktion visuellt	Skippa display i knopp. Räta upp den alternativt öka plunge kraften - den växlar själv när man vilar handen	Känns riktigt bra i DB. Bekväm form ligger väl i handen. Formen gör att det känns som man kan växla oavsiktligt när man vilar handen.		Snygg		Kantig i tippen. Bra fram och bak. Bra i storlek		Skön att hålla i. Den framåtlutade formen gör att den är bra även beside seat.	
4. THUMB	Vass vid sidogrepp		Väldigt behaglig att växla med pek och långfinger. Ytan för tummen kändes lite för kort.				Intressant form bak/fram. Ingen form för tipp. Lite för liten		Kul koncept. Inte jätteskön i tippen. Annars bra och smidig i dashboard. Bra även i sittpos.	
5. JOYSTICK	Tråkig och vass		Känns omotiverat stor för DB. Enkel och bekväm form.	Kanske skulle sitta mer framåtlutad.	Lite trist		Känns bra i handen. Bra i tippen, mjuk. Lite väl hög		Lite lång och "i vägen" när man håller i ratten och den är i dashboard. Tydligt sidogrepp, inte lika tydligt sidogrepp beside seat och centre console. Förvånansvärt bra i de pos trots liten toppyta	
6. CHUBBY		Större radie uppe på. Kontaktstress när man vilar handen. Korvad tip.	Känns väldigt bra i CC och BS. Vinkeln kändes lite skum i DB. Skön form.	Möjligen kan toppytan vara något planare för att förbättra toppgrepp.	Mjuk. Skön både med sidegrip och topgrip.		Lite rund form fram/bak. Inte skönt med raka kanter när den tippar		Rund och skön (dashboard). Liten toppyta beside seat.	
7. CURVE	Vass lunje mot tumroten. Bra grepp		Bekväm i CC. Svårt att hitta ett bekvämt grepp. Kanske den skulle vara större?		Lite vass i vänsterkanten om man använder top grip.		Snygg form. Bekväm att hålla i, lagom i storlek. Skön att tippa. Snyggt med front-ytan. Lite vass kant		Väldigt skön i handen i dashboard. Vass kant beside seat. Lite vass även i centre console.	
8. MINI	Bra storlek för handen. Vass linje för tipp upp och ner.	För liten för displayfunktioner	Går att greppa bra från toppen och på sidan. De skapra kanterna gör den lite obekväm att vila handen på.	Kanske något rundare, känns lite för liten	Skön att växla med fingrar (bak) och handloven (fram). Mindre skön att tippa.		Skarp kant på dashboard. Skön at tippa. Bra storlek		Beroende på shifterns "tröghet"/manöverkraft används mer eller mindre del av handen. ev. för liten för stora karlar. Kantig framsida. Storleken känns inte lika viktig beside seat & i centre console. Vass framsida i de nedre lägena.	

	WS1	**WS2**	**WS3**	**WS4**	**WS5**	**SUM**
1. FLASH	2	3	1	1		**7**
2. BOX						
3. POLYGON				3	3	**6**
4. THUMB	1	1	2	2	2	**8**
5. JOYSTICK						
6. CHUBBY	3					**3**
7. CURVE			3		1	**4**
8. MINI		2				**2**

CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg Sweden, 2014

Department of Product and Production Development
Division of Design and Human Factors