



Industrial Design of Enzo the driver assistant

Master's thesis in Industrial Design Engineering

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Industrial Design of
Enzo the driver assistant
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Abstract

The Master Thesis is a degree project in Product Development where the focus has been on design and create a form expression linked to a company's core values. The project work has been done in collaboration with an industrial player to validate and verify the result. The developed product will be the first product the company industrialise and plan to set the form rules for coming products.

The development process started identifying the requirements from study visits, workshops, interviews, and research about technology, safety and ergonomics—summarised information in a requirement list to have a frame of reference when starting the development.

Analysing the company values and visual guidelines was to gain knowledge about the aesthetics criteria. The gathered information was translated into frameworks consisting of imageboard, mood board and product profile character. The frameworks were used as a guideline when generating ideas during the idea generation development. The generated ideas were expressed through sketches to study different forms and functions. Overall, complex ideas were created with an open and few constraints in mind and were used as a base for the product development process.

During the development, process concepts were created and evaluated against each other. Some of the concepts were eliminated or refined. CAD software, sketches, and physical prototypes helped visualise the concepts, and the evaluation was done through stakeholders. The development process resulted in a concept system consisting of the base mount,

unit, and combiner where the industrial design had form language based on company identity. The form language can be used for a future product portfolio, and when the company is finished with the hardware development, the product is ready to be industrialised.

The final design strengthens the company identity and enables fitment in different car models. The expression of the design fulfils the safety, functional and ergonomic requirements.

Keywords: industrial design, engineering concept, product development, form analysis

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I am grateful to everyone involved in this project. Without all stakeholders, this project would never be realisable. I have enjoyed this project from the first day, and I will bring the learnings and knowledge from this project to future challenges.

I want to thank the company Consenz founders, Reza and Anders, for giving me this project and sharing knowledge and inputs.

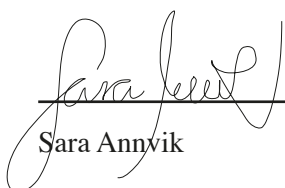
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1. Introduction

This chapter provides an introductory picture of the client, project background, technology information, purpose, aims, delimitations, and workflow.

1.1 Project Background

1.35 million people die in traffic every year, and 95% of those live in developing countries with low access to technology (World Health Organization, 2021). The car manufacturers only focus on producing new cars mainly in the upper segment, making it hard for the developing countries to afford the technology to prevent accidents. Moreover, people in industrialised countries die because of interactive applications as cellphones are used while driving (World Health Organization, 2021). Solving that, driver support as a connected Head-up display (HUD) suited for any car will be developed and presented during this thesis.

objects and decrease the reaction time while driving compared to traditional displays. The technology has been available and used in aeroplanes for over 60 years, and pilots daily use the concept in commercial aircraft (Popular Mechanics, 1955). In 1988 Oldsmobile Cutlass Supreme was the first car with a HUD but was not a success (Chis, 2010). Since the HUD became more technologically advanced, it had successes on the market and has been commercialised (Mutchler & Kinsella, 2020). During the time, the cost of a HUD decreased from \$ 100 000 to \$ 1000 in a modern car (Mutchler & Kinsella, 2020).

1.2 Head-Up Display (HUD)

A HUD is a display that implies the driver to keep their head up and fixes on the surroundings. HUDs utilise lenses or mirrors to create an image on a transparent surface forward a windscreen. It implies a feeling of a second layer in front of reality. HUD devices improve the ability to react to more



Figure 1 Consenz first prototype, (Söderström, 2021)

1.3 Organisation

This project involves other actors that have influenced the direction and results of the master thesis—the different actors in the project are presented below, see Figure 2.

1.3.1 Consenz

The company named Consenz is the initiator of this project and has been responsible for providing the project and valuable information linked to the development work. The company is responsible for the hardware and business development of the product.

The hardware was developed during another master thesis project before this project, see Figure 1. Much information is gathered from the development work and is used in this report.

1.3.2 Boid

The Design Studio Boid named stakeholders in the report have been involved during the development work for brainstorming together and process inspiration.

1.4 The company

The development work is for a company named Consenz, which have a mission to democratize road safety, and develop modern driver support tools that should not be a privilege only for those who can afford a new luxury car; they should be accessible to everyone. The initial product is a connected, fully voice-assisted HUD that makes it possible to access all functions needed and wanted from a cell phone while driving without ever taking it out from the pocket (Consenz, 2021).

In 2020 their initial goal was to develop a prototype and proof of concept of the hardware, see Figure 1. The HUD have a dash camera that scans the road ahead and provides valuable data for service innovation. The dedicated connectivity offers wi-fi to passengers and enables Over-the-air (OTA) updates, giving the driver access to the latest technology and services (Consenz, 2021). The HUD is a central part of the company’s customer and business offering and uses all their time to take this product to market.

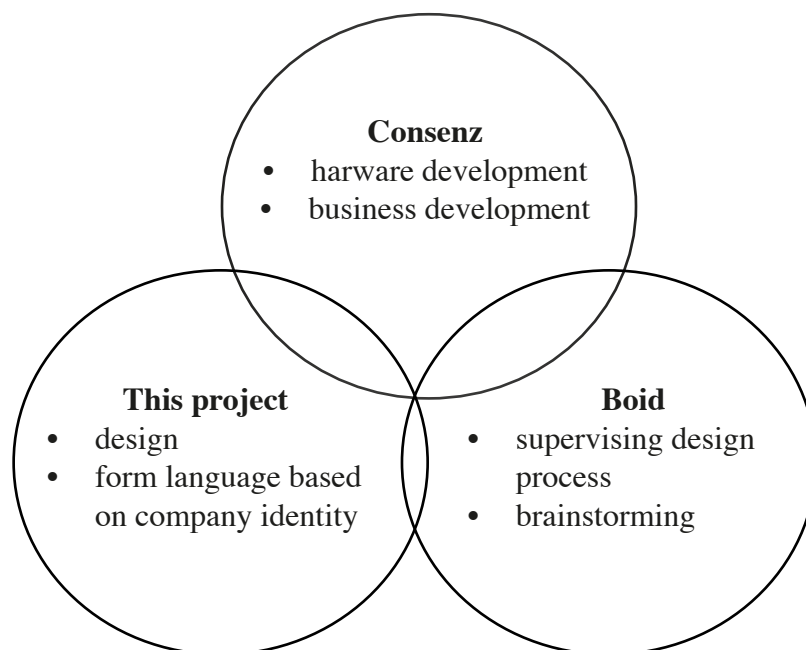


Figure 2 A overview of the project stakeholders, (Annvik S)

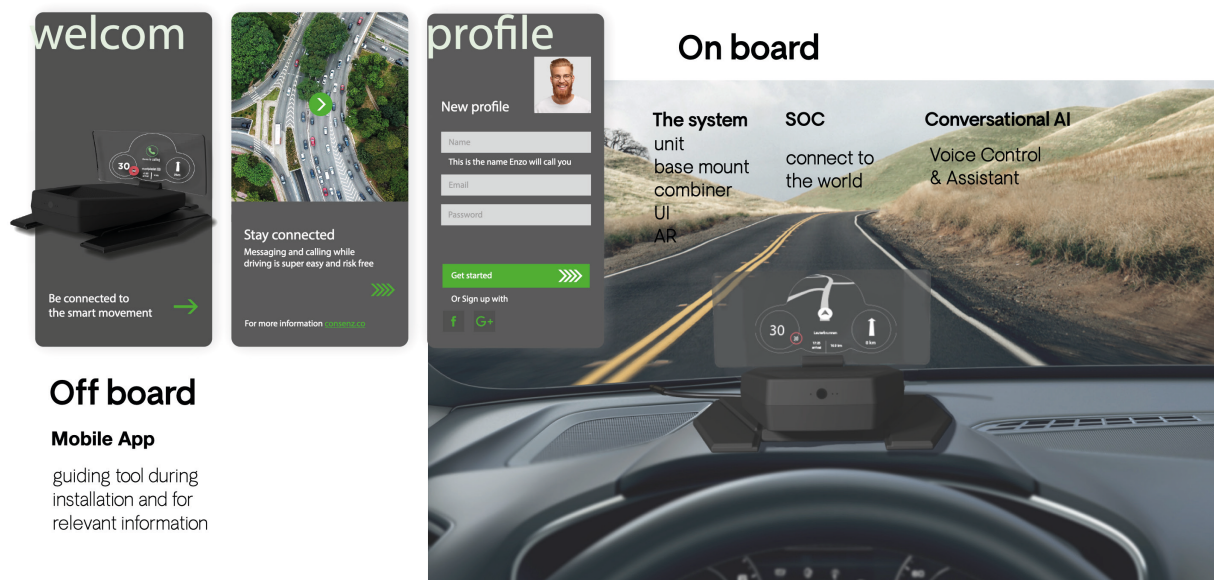


Figure 3 Architectural picture of Enzo, (Annvik S)

The company's target audience is to sell to the Swedish market initially. After the primary product function is established on the market, the company plans to sell to Europe and mainly focus on developing countries. In the thesis, all requirements and design decisions are taken from selling it to the Swedish market.

1.5 Enzo

The HUD concept is named Enzo and is divided into two modes, on-board (when driving) and offboard (not moving) (see Figure 2). While Enzo is on board, it consists of three base systems explained further in figure 3.

1. **The unit**; which encloses the hardware and projects information through artificial intelligence (AR) using a designed user interface (UI). The master thesis focus on this system.
2. **The SOC**; assuring Enzo connects to the world

3. **Artificial Intelligence (AI)**; an intelligent interactive voice assistant to guide the driver the whole journey.

When Enzo is off boarding, the **mobile app** is for guidance during installation and relevant information.

1.6 Purpose

The company has never launched a product beforehand and have no set form language or design guidelines. The purpose of this Master Thesis is to create a design for the prototype. This work includes creating a form language that strengthens the company's brand identity and fits into a given number of cars. Shape, material, and colour should be evaluated based on the company's brand values, the market, and the main target groups.

1.7 Aim

The project aims to explore different design solutions for a HUD system, starting with understanding the design space and delimitations of the design solutions. The project aims to result in:

A proof of concept will be an industrialized prototype that will take through final production preparation with a few minor changes as possible. The final concept will be the companies 20 first units on the market.

The project also aims to find answers to:

- *What are the key factors to designing a successful piece of a HUD?*
- *What constitutes a product with clear brand characteries?*
- *Are the product design user friendly and understandable?*
- *What design identity can the company use in their product portfolio?*
- *What knowledge of material and manufacturing processes is required to design the HUD well prepared for production?*

1.8 Delimitation

High-level effort needs to be put into designing the unit. The design needs to follow the limitations of the company's partners to produce and manufacture the product on time and between the set cost limits. Below there is a list of activities that will not be considered.

-The exact technical functionality will not be considered.

-While the user interface on display is crucial to the computer-human interface, this project will only use existing and placeholder interfaces. Similarly, the voice interaction flow will not be considered.

Tests will only be conducted on the company's technology at the start of the project. Further evaluations will be conducted through literature and state of the art research.

-The regulations regarding aftermarket and Original Equipment Manufacturer (OEM) will not be investigated.

2. Theory

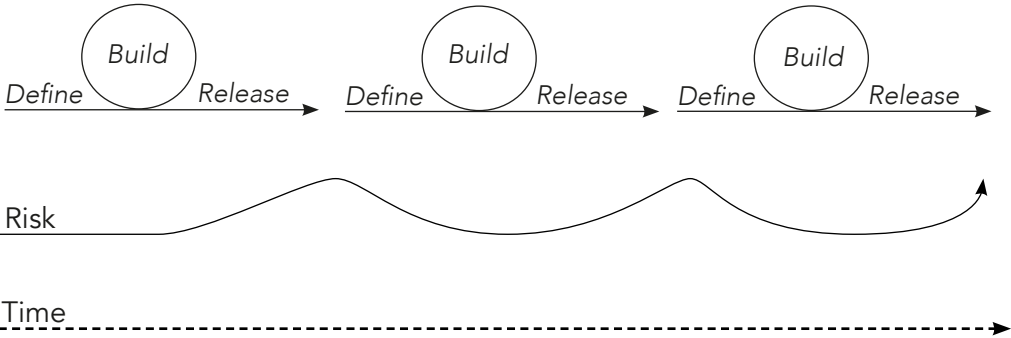
In order to make it easier for the reader and to satisfy the report, this chapter takes up the theory behind the working process. The framework, context, and influencing factors for the development work are characterized to facilitate the understanding of the report.

2.1 Working progress

The Product Development Process considers all the needed activities to take the product from concept to market. The process includes activities that define the market need, conceptualising, development, and building a proof of concept.

There are different approaches for Product Development, and two common frameworks are the waterfall and agile approaches (Ulrich, Eppinger & Yang 2019). The waterfall approach is a linear project management approach that works with a sequential project plan where each phase involves the next as a waterfall, see Figure 4. The waterfall approach is an old

Agile Approach



Waterfall Approach

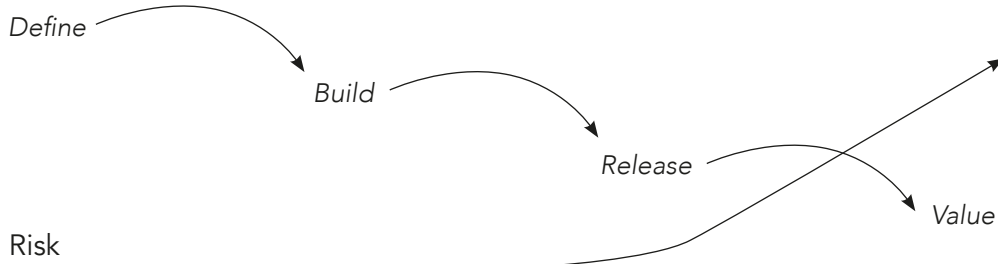


Figure 4 Agile approach vs waterfall approach over time, (Annvik S)

structured methodology that works very good. The agile approach is shifting the balance from planning to learning, and the approach differs from the waterfall approach (Ulrich, Eppinger & Yang 2019), see Figure 4.

The idea of “agile” thinking or innovation has spread worldwide fast, and today adapts beyond its context of Product Development. Agile is an approach close to “lean” development and works when developing something that never has existed before and needs to move quickly (Ulrich, Eppinger & Yang 2019). The idea is to develop a minimum viable product, in so-called sprints, to show customers and get a reaction. Depending on the feedback, the developing team received quick information with a small investment. The team can iterate the sprint with the new feedback to create an even better product (Ulrich, Eppinger & Yang 2019).

2.2 Design Thinking

Design thinking is a framework to help designers choose the proper process, such as observing and experimenting and seeing what is technically feasible and what the user wants, see Figure 5. It makes the development team understand that the design needs to participate early to help create a gap between the design, development, and other departments (Maqe, 2021). Design thinking is a Human centre app-

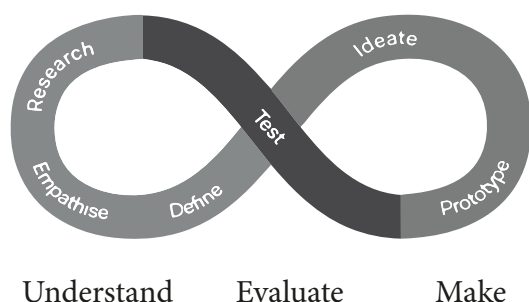


Figure 5
Design Thinking Process, (Annvik S)

roach. Today human-centred design (HCD) emphasizes putting activity and including the users in the design process. The International Organization for Standardization (ISO) has, through its requirements and recommendation for human-centred design, provided six principles for Human-Centered design (ISO, 2019):

1. The design bases upon an explicit understanding of users, tasks and environments.
2. Users are involved throughout design and development.
3. The design is driven and refined by user-centred evaluation.
4. The process is iterative;
5. The design addresses the whole user experience.
6. The design team includes multidisciplinary skills and perspectives

2.2.1 Agile Design Sprints

Agile Design Sprints is a fast, agile approach to product design to test new ideas, see Figure 6. The outcome of the design sprint is validated with prototypes, testing by real users and clear insights on where to go, see Figure 6.

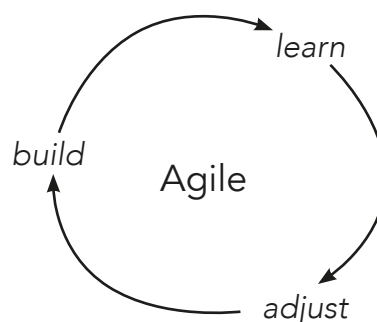


Figure 6
Agile approach, (Annvik S)

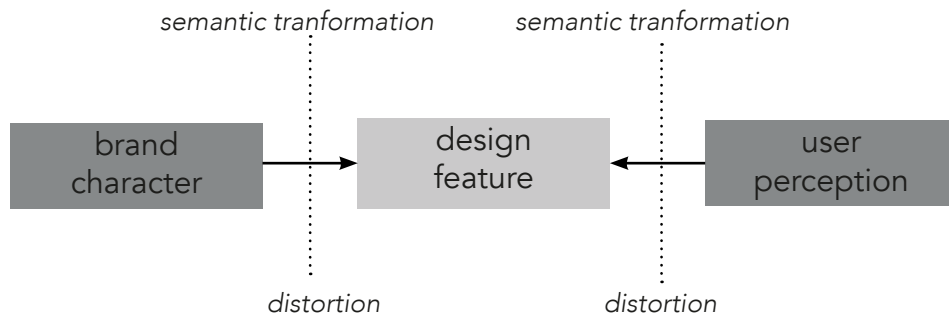


Figure 7 Semantic transformation, (Annvik S)

2.3 Semantic Aspects

To communicate feeling and expression theory of semantic aspects was used to determine the Product Identity, chapter 6.

Character and design features are central for design semantics, see Figure 7. There are several approaches to product analysis that intend designers to understand the meaning embodied in products. Brand recognition is one particular area of application of designs semiotics. Brand-specific meanings evoke through design features in products, and specific characteristics link to brands. For instance, Volvo characteristically by safety, Scandinavian and dynamic, whereas Nokia aims to be personal, friendly and human (Karjalainen, 2009).

“The trick is to transform the character into the physical domain by designing deliberate semantic references to products.”

-Karjalainen, 2009

While designing, a common mistake is only to use brand characteristics (the left side in Figure 7). It can result in weak user perception and make no sense. Transforming the user perception of the product is an essential aspect to cover the whole semantic scale, see Figure 7 (Karjalainen, 2007).

2.3.1 Transformation

Formal elements relate to special meaning, depending on how the form is organized into a whole and arranged. All forms have meaning, and all meanings can describe with words (Wikström, Dagman, & Karlsson 2011).

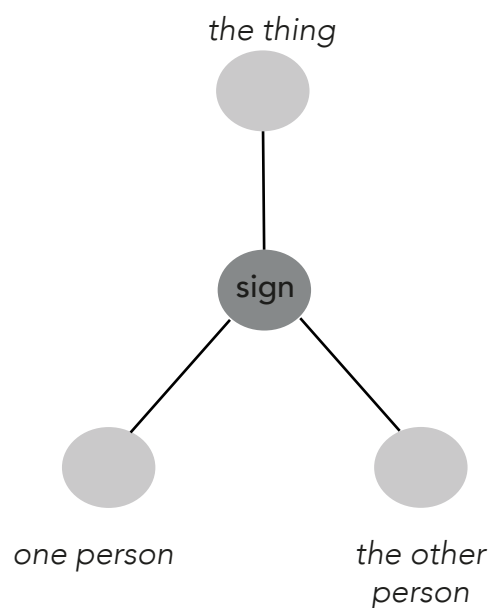


Figure 8 Semantic principle, (Annvik S)

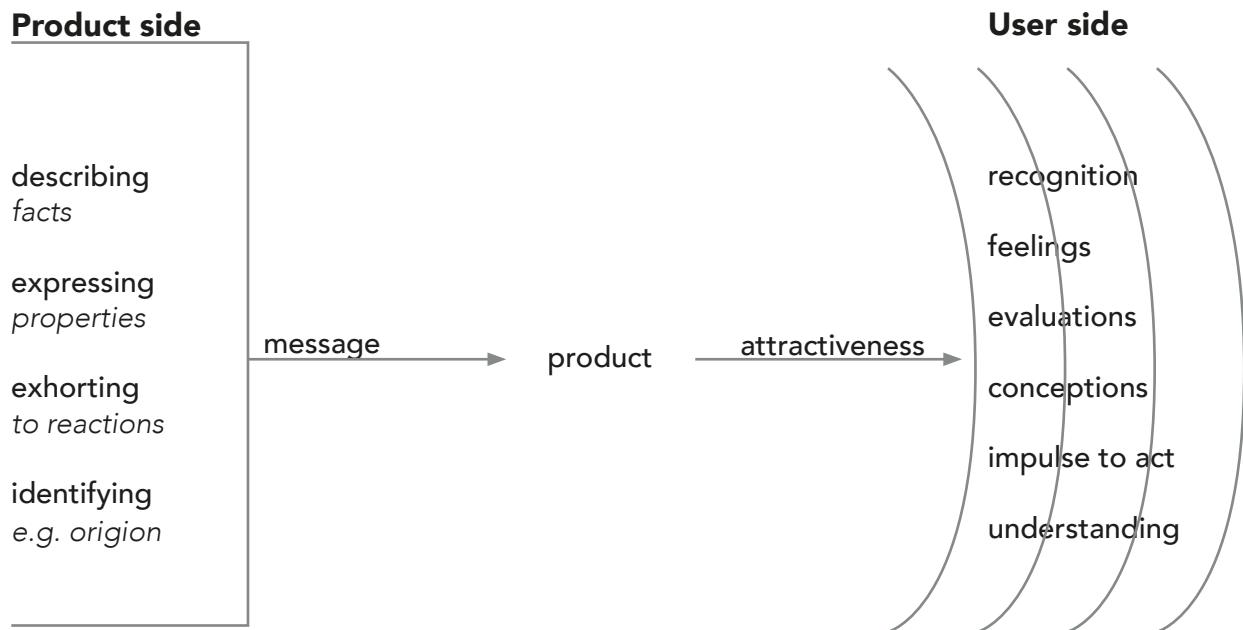


Figure 9 Semantic functions, (Annvik S)

2.3.2 Semantic principles

The confusions of feeling, thoughts, notions and associations make up the counties of attractiveness. What one person feels for a product does not mean the other person feels the same.

What people feel is not directly implemented or the same for everyone. It is a matter of understanding and usage of the product and understanding what it needs to communicate to the market and the user (Monö,1997). In Figure 8, the lines symbolise the semantic functions concerning the sender resulting in expressions and signs.

2.3.3 Semantic Functions

People feel a relationship between preferences and social and cultural life, or what MONÖ (1997) calls the Network of forces. A description of an object does not automatically result in a specific appeal. Why is it essential to convert the world into the list of requirements into lines, surfaces and colours of a product? With the help of four semantic functions presented below. The semantic functions theory helped to identify the requirements for the product

into design guidelines. Figure 9 illustrate the function transformation from the product side into feelings on the user side.

Describing

The product needs to express its purpose and meaning (Monö,1997). In the case of a HUD, the form of the product should be intuitive to orientate and operate for installation and not to cover the field of view. Assuring this, research within product usage and requirements needs to expose.

Expressing

The product properties should express through the form design. Is it a cheap or expensive HUD? Is it safe? Monö exemplifies different car models. All cars consist of four wheels and chassis, although they all express different things. Some car models express speed and performance, some safety or intelligence (Monö,1997).

Exhorting

The product should send signals to the user. These signals can connect to safety, such as do not put the fingers here, or the signals can connect to functions, for example, turn up the volume here.

Identifying

The product should identify itself as belonging to a product group or brand by location, nature or category. The belonging feeling can be achieved by using form language, logotypes, straightforward design, and so on (Monö,1997).

2.4 Visual Aspects

Design plays an essential role in creating and building brands (Wheeler, 2013). Design embodies emotion, context and feels, and brand identity also appeals to the sense; consumers can see it, feel it, watch it and hear it since the company does not have and product portfolio to analyse. Research within their brand identity needs to be done, and the theory is presented below.

2.4.1 Visual Brand Identity

A product with visual brand recognition has a decisive competitive factor within various recognition factors. A strong brand communicates the correct core value to its users and recognises the product to the belonging brand (Wheeler, 2013). There are many products associated with high quality, although for their recognition able design, they use design features consistently in their lineup, differentiating it from others.

”Brand identity fuels recognition amplifies differentiation and makes big ideas and meaning accessible. Brand identity takes disparate elements and unifies them into a whole system.”

-Alina Wheeler, 2013

Core Values

Consciously or unconsciously, all products mediate a message, which shall preferably be the value to the users. The values are representations of what the user experience when it is in contact with the product. There is no barrier to communicating the message in a perfect world, and the message can not be misleading or misunderstood. However, it is not that easy to communicate the right message. In the real world, Wheeler (2013) explain that companies need to work hard with their core values based on their product design to avoid misleading or noise appearing in the message.

2.4.2 Tagline

A presentation of company tagline is to understand what they want to deliver and stand for. The tagline captures the company’s brand essence, personality, and positioning to distinguish it from its competitors (Wheeler, 2013).

A tagline is initially used for advertising, although it is essential to clarify the company statement and the sense the company encapsulates their commitment for future development (Wheeler, 2013).

2.4.3 Brand Essence

With constantly new coming products and a highly competitive market, is it more important than ever to communicate the brand of the product (Wheeler, 2013). Companies constantly communicate their brand to stay competitive and strategically communicate with customers, which is called brand essence.

For example:

Volvo – Safety

Apple – Think Different

Nike – Authentic Athletic Performance

Walt Disney World – Magical

2.4.4 Visual Design Cues

When designing a product, there is a space full of different design solutions of form, shapes, colours, textures and logotypes, and all these combinations need to communicate the correct value and meaning. If the design choice communicates features that correspond to brand core values, it is called visual design cues (Karjalainen, 2007).

There is a division of visual design cues, explicit and implicit. The division differs regarding specific towards the exclusive design features. The explicit cues are connected to physical features and repeating form features. The implicit design cues are not directly readable but is perceived as a sum of the full expression of the product (Karjalainen, 2007).

2.4.5 Visual Brand Recognition

Brand identity involves every feeling associated with a product, the created images in the mind, sound, smell, etc. The visual components involve consistent product image and also marketing tools. It resonates more effectively, reflecting and belonging to the brand than other brands that are not working efficiently. Creating brand recognition is an activity that needs to be consistent with both spoken and written messages.

The clothing lifestyle brand J.Lindeberg is working hard with its visual brand identity. Johan Lindeberg represents a life people want to live and creating a community out of that. They express themselves as Swedish, board-less, sporty, fashion and feministic. People buy their products because they feel belonging to the community, which is successful visual brand recognition. It is achieved by realizing logotypes and, most importantly, product design that guides in recognizing collections in form, colour and how they market themselves.

2.5 Haptic Product Experience

Evaluating if the form has correct expression, the haptic product experience is studied. The theory is used during the whole product development process, especially during evaluation. Haptic is the active sense of touch and associates everything sensory receptors can recognize in the skin as muscles, tendons and joints. Interacting with products such as lifting, pressing, touching something or a surface, the persons obtain haptic impressions which send out signals to the brain. The haptic sensed properties of the product, like stiffness, weight, etc., convey an overall impression (Wikström 2011).

The results of the haptic experience were that shape is the experience of the actual physical form. The material is also essential as a product gestalt, and the shape and material together represent the physical aspect that works on a concrete sign in the semiotics. Metaphors can be regarded as icons and can be used to give product-specific expression. The expressions and metaphors are objects in the Peirce sign model (Wikström 2011).

2.6 Material properties

Below is an explanation of the aspects that must consider when choosing materials, both semantic and technical.

2.6.1 Semantic aspects

Different materials express different characteristics of a viewer, and they evoke different feelings and experiences. There are no transparent devices to meet the personal demands that aesthetics and emotional experience place on a product.

In choosing material, it is essential to keep the user's perception and interaction with material related to the product in mind to meet the user's

design requirements. Why are people attracted or not by certain materials? What drives the material's experience and reactions? How can we choose materials that the user will love and avoid being disliked? Questions such as these can guide a user-centred choice of material, i.e. an attempt to maintain the user's desire and anticipated experience (Karana, Pedgley & Rognoli, 2013).

Aesthetic experience can be how the material feels or looks, the understanding of the meaning that can be how the user judges that the material is after previous experiences and emotional experiences that are how the user is affected by the material (Pedgley, Rognoli & Karana, 2016). There are three individual components of the material experience. All three components should be taken into account when choosing materials related to the expression sought.

2.6.2 Material age in different ways

Some material wear can be perceived as positive for the product's expression from the user's perspective, while others change it to negative.

Choosing a material for a product should thus also consider how long the product's life cycle is expected to be and what environment it will operate in, and the change in the material's expression must then be assessed based on whether it is a positive change or negative for the viewer.

2.6.3 Technical

Material selection is complex as it must match a range of design requirements that are functional and usable as material properties and the material character.

2.7 Design for the environment

Today's new products should be designed for

the environment (DFE) and minimise the product impact. During the design process, there are four principles for DFE (Ullman, 1992) where three of them will be relevant in this project and are explained and reviewed below.

1. Be Aware of the Environmental Effects of the Materials Used in Products
2. Design the Product with High Separability
3. Design Components That Can Be Reused to Be Recycled

3. Method

The following chapter describes the overall process and how the methods were used during the project.

3.1 Introduction

The design thinking process presented in section 2.2 was used as an inspiration to choose the suitable method for the development work. The chosen method follows the same flow and activities as can be seen in figure 5, and the overall process can be seen in Figure 10. The Research and Identifying work concludes finding product information, understanding the company's identity, and then translating all that information into

design guidelines. Further to the execution and evaluation phase, including idea generation and concept development work, was the agile approach applied to fast generate and evaluate ideas. Several tools were chosen from the textbook: Product design and development by Ulrich, Eppinger & Yang (2019), and some of the tools were used as inspiration to the used method. In the end, all this ended up in a final concept solution presented in *chapter 9*.

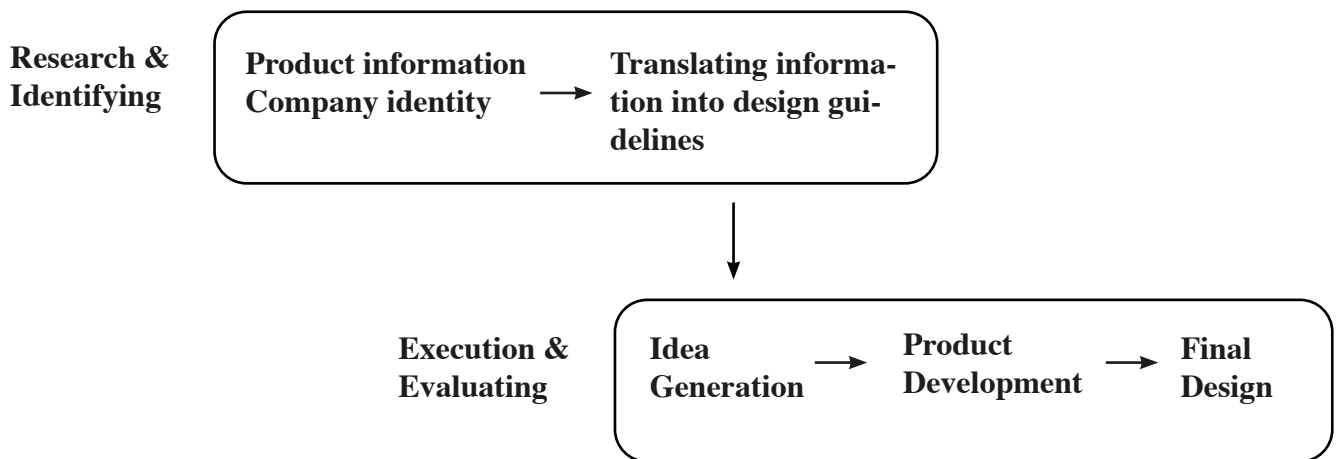


Figure 10 Method of product development process, (Annvik S)

3.2 Overall process

In Figure 10, a flow chart of the overall development process is visualized. For understanding the problem and identifying the requirements, research withing technology, regulations, ergonomics, and so on were gathered into a list of specifications. Research within the market and the stakeholder's competitors was done to guarantee not making the same solution—further, findings of the company's brand value and identity to create a visual and personal understanding.

A product profile was developed based on the established information and requirements by transforming the researched information into design guidelines. The design guidelines were put into different frameworks as an imageboard, mood board and a product profile character.

With defined design guidelines and extensive information, the work now progressed into the creative direction involving idea inspiration. The idea generation included an elaborate brainstorming session that was a free activity where few constraints were in mind, and the design guideline frameworks from previous chapters were in mind. The idea generation ended with an open and creative prototype session.

While coming into the concept development step, the agile, iterative approach was used to fast generate ideas and come forward with the development, see Figure 6. Many iterations were done before the final concept was set. The process ends with presenting the final concept and presenting final form decisions, material, colour, texture, and manufacturing choices.

3.3 Research methods

This section describes the data collection methods used during the project to identify the needs, what requirements are placed on the product, and find relevant information and

evaluation (Ulrich, Eppinger & Yang 2019).

3.3.1 Interviews & Consultations

An interview can be an effective way to examine the needs and requirements of a target group. Interviews are a question-based method that involves the interviewee telling about their own experience and opinion about the problem area in question. This goal is to achieve a deeper understanding of the user's views and needs (Wikberg Nilsson, Ericsson & Törlind, 2015). An interview template is built up like a funnel to achieve a good interview, with more general questions at the beginning and more specific towards the end. How structured an interview is can vary greatly. In semi- and unstructured interviews, there is more room for probing, i.e., the interviewer can ask improvised questions based on the answers given by the interviewee. In this way, one can get deep into the understanding of the user and its needs. How interviews was used in the project can be read in *Concept Development, chapter 8*.

In order to get feedback from users and people with knowledge, interviews and consultations were held in different ways to develop and refine the system. Short interviews, more profound interviews, observations, and several consultations helped evaluate and progress in the project.

3.3.2 Literature review

Relevant sources of information for the project are investigated, such as books, articles, material databases and websites. The literature review utilizes most in the *Theory, chapter 2*.

3.3.3 Workshop

A workshop is a creative meeting around a focused theme where people from the target group, experts or utterly unrelated to the area gather to explore a problem or problem area (Wikberg Nilsson, Ericsson & Törlind, 2015). Through a workshop, the purpose is to utilise

the group's potential and creativity to investigate how a problem can be solved and thus find potential complete or partial solutions to the given theme (Wikberg Nilsson, Ericsson & Törlind, 2015). Workshops were held in *Concept Development, chapter 8*.

3.3.4 User function process

The user function process is used in *Identifying Requirements, chapter 4*. The user function process is a method to describe the user flow of the product, which means design thinking needs to consider the aspects regarding the flow.

3.4 Identifying method

Having people involved in the project with the same picture of the work's purpose requires good communication between the company and the contractor. Many methods offer an opportunity to create a structured foundation to stand on and ensure that everyone works in the same direction (Ulrich, Eppinger & Yang, 2019). To maintain communication following methods have been used in the project.

3.4.1 Mood board

The mood board was a helping tool during the *Idea Generation, Concept Development, and evaluation of the Final Concept, chapter 7- 9*. A mood board is an inspiration board collected with a collage of images to assist creativity, analysis, evaluation and is used to gain inspiration at the beginning of the design process. The mood board was used to visualise a coming product's perception and set a goal for the entire product design process.

Three mood boards were done due to the tendencies of two different forms of language based on the persona or brand image and a mood board for material inspiration.

3.4.2 Imageboard

To understand how the company and the product want to be previewed, image boards are

used in the *Consenz and Product Identity chapters 7 & 8*.

An imageboard is a collage of pictures to help decide the product's consistent emotional feeling and expectations. An imageboard also assists creativity, analysis, evaluation and is used to gain inspiration at the beginning of the design process.

3.4.3 Persona

Personas have been valuable in this project and are used in several *chapters 6- 9* when creating the design framework, evaluating the concepts and describing the final design. The personas are used during evaluation and communication during the development process.

Using persona enables development for different users and their needs. Personas also avoid designing general design solutions that nobody wants or designing the product for themselves. The personas can help the developer find latent needs or describe what the product develops at (Ulrich, Eppinger & Yang 2019).

3.4.4 Product profile character

The product design was characterised as a product profile to communicate the design guidelines and expressed feelings. After translating the company's values and visual features, defining the mood board, imageboard, and personas, the product profile was summarised into a product profile character. The product profile character was used for communicating and evaluating activities in the report.

3.4.5 Specification of requirements

The needs and requirements that have emerged from the data collection compile in a list. It is not a static list, but there may be additional or de-prioritised requirements during the work (Ulrich, Eppinger & Yang, 2019). The method is used in *Identifying Requirements, chapter 4*.

3.5 Idea generation method

The following methods have been used to generate ideas and facilitate developing ideas for solutions during the project. The purpose of the methods is not to create logical and well-defined concepts but rather to build up a large amount of creative and innovative ideas. To create innovation requires a large number of ideas to take off; the more, the better (Ulrich, Eppinger & Yang, 2019).

3.5.1 Brainstorming

Brainstorming was a used method on many levels and at different stages during the development process. It is a simple method of finding new ideas and directions of thought. Brainstorming generates many ideas from the list of requirements and lets people think open and freely discuss creative ideas and solutions together (Wikberg Nilsson, Ericson, Törlind, 2015)(Ulrich, Eppinger & Yang, 2019). More about the brainstorming session can be found in *Idea Generation chapter 7*.

3.5.2 Sketching

The purpose of making drawings has changed over time, for the project drawings has been making to push the start of the design process, for initial ideation, brainstorming, and preparing for final design and features. Since time is an issue, sketching was used to visually compare renderings and Computer-Aided Design (CAD) and was used during the whole *Concept Development, chapter 8*.

3.6 Concept visualisation method

During the project, sketches and prototypes have been an essential part of communicating and validating possible solutions. Below is a description of all the methods used for visualization during the project.

3.6.1 Computer-Aided Design

CAD has, among other things, been used as a tool for visualising geometries that are difficult to sketch by hand. It has also been used to produce drawing materials for manufacturing and communicating with company partners. CAD has been used in *Concept Development and Final Concept, chapter 8 & 9* for visualization.

3.6.2 Physical models

Sketches and suggestions for problem solutions have been visualised using prototypes with a different richness of detail depending on what is to be conveyed or tested. The prototypes have been intended to validate and provide an opportunity to evaluate functions, sub-solutions, and complete solutions (Ulrich, Eppinger & Yang, 2019). Different ways of building prototypes have been used.

Paper and Cutting board prototypes have been used in *Concept Development* for testing functionality and size.

Styrofoam has been used during the Idea Generation to visualise form and size fast. 3D printed prototypes have been used in *Idea Generation, Concept Development and Final Concept, chapter 7- 9* for a more detailed evaluation of concepts.

4. Identifying Requirements

This chapter analyzes technology, ergonomic, safety aspects and competitors to identify the product requirements and what needs to be considered during the development.

4.1 Introduction

The findings are gathered from workshops, study visits, literature and interviews. The presented information in this chapter is the basis for the knowledge base before starting the product development process. At the end of the chapter, all findings will be gathered in a requirement list to guarantee that these crucial aspects will not be missed later in the process.

4.1.1 The purpose of the product

The company wants a product that can be sold to most drivers. They plan to publicize the product in the year 2021 with a target price of €499. They also want the device to be standalone, voice-controlled, provide a good image, and connect to the car through onboard diagnostic (OBD-port, connection to communicate with the car's control unit).

4.1.2 User function process

When designing the product, it is essential to understand the user process during installation. Also, to pinpoint essential requirements regarding easy use and to fulfil its function,

see Figure 11. The design needs to enable assembly in all different car dashboards, easily connect cables, and give freedom to adjust.

4.2 Technology

Setting the design, essential knowledge about the technology needs to be established. Information regarding the HUD, projection, technology and components are described below.

4.2.1 HUD Technology

The company's prototype is composed of two main components, a thin-film-transistor (TFT) and a combiner, see Figure 13. The TFT screen is a variant of a liquid-crystal display (LCD), creating the image and guiding the combiner's focus light (Södergren, 2021). The combiner combines the generated image with the outside view.

The TFT screen is controlled by electronics, which are controlled by a computer, microcontroller, or combination. In Figure 14, the parts are visualised. Usually, the combiner is made of transparent material on which the light from the optics is reflected. The reflec-

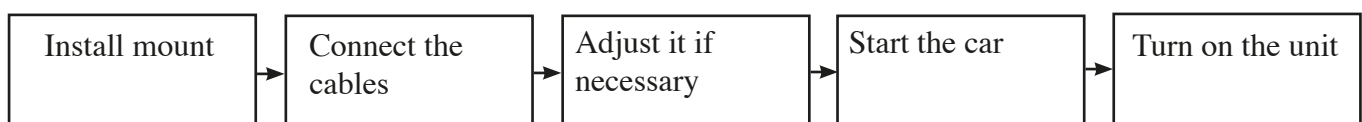


Figure 11 User function process, (Annvik S)

ted light combined with the outside light continues through the material. The combiner acts as a part of the optics by altering the reflected light, see Figure 14. The combiner often has a spherical surface and therefore acting as a lens (Södergren, 2021)

4.2.2 Components

All the product components for the prototype are listed below, and are divided into outer and inner elements. The inner elements need to be mounted inside the HUD, and the outer ones need to be mounted outside. Knowledge about the outer elements is to know what details the product needs to have space for. The inner elements are to guarantee that things fit inside the product.

Outer Elements

Power button
 Status LED
 Microphone mute switch

USB contact
 Headphone jack 3.5 mm
 SIM/SD CARD opening

Ambient light sensor
 Camera - 140 FOV
 Lense to camera
 Microphone array
 Speaker

Combiner
 TFT Screen
 (information about size, see Figure 12)

Inner Elements

SOC (system on chip)
 PCB (kretskort)
 Battery
 GPS antenn (small rectangular)
 LTE antenn (small long)

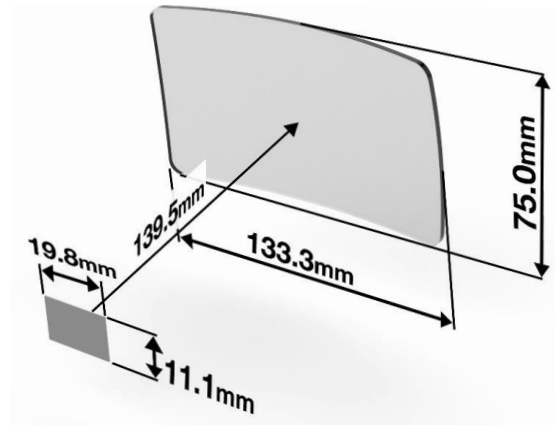


Figure 12
 Combiner and Screen size and distance, (Söderström, 2021)



Figure 13
 HUD Components, (Söderström, 2021)

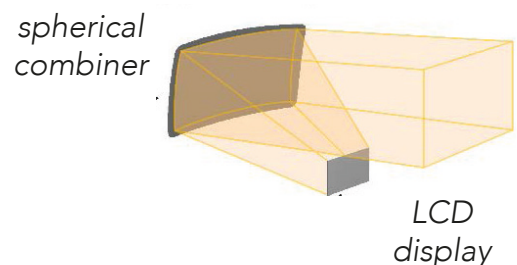


Figure 14
 HUD Projection Technique, (Söderström, 2021)

4.3 Regulations

There are few regulations regarding technical devices or similar for placement in the car. Stated regulations are that phones and other communication equipment can not affect a negative traffic situation. Own added equipment can not have anything that can fly around in the event of an accident (the responsibility of the vehicle owner, not the driver responsibility) (Swedish regulation, 2017).

In the Swedish regulations, the following is noted (2017: 1284)

"When driving on the road with a motor vehicle, the driver may engage in activities such as the use of mobile phones and other communication equipment only if it does not adversely affect the driving of the vehicle. The driver must not use this equipment in such a way that he or she holds it in his or her hand. "

-Regulation (2017: 1284)

In the article, Söderström's report (2021) pinpoints that devices on the dashboard can not take up much of the field view. In Söderström's report, the following is noted:

"Obligations to provide vehicle OBD information and vehicle repair and maintenance information 1. Manufacturers shall provide to independent operators unrestricted, standardised and non-discriminatory access to vehicle OBD information, diagnostic and other equipment, tools including the complete references, and available downloads, of the applicable software and vehicle repair and maintenance

information. Information shall be presented in an easily accessible manner in the form of machine-readable and electronically processable datasets. Independent operators shall have access to the remote diagnosis services used by manufacturers and authorised dealers and repairers. Manufacturers shall provide a standardised, secure and remote facility to enable independent repairers to complete operations that involve access to the vehicle security system. "

- Söderström, 2021

4.4 Ergonomics

The HUD need to have the correct position and fit all users, so a theory concerning physical and cognitive ergonomics can be studied.

4.4.1 Seating ergonomics

The HUD needs to make sure the driver can both see the road and instrument panel and, in the same way, not be in the way of the driver. The driver height affects what they see, and the view can block by the screen (front of the unit) or the steering wheel. Figure 15 shows three different views, where the first shows an example of the driver is positioned too low, the second shows the correct view, and the last is positioned too high. For this should not become a problem, the combiner needs to have the possibilities to be angled (Södergren, 2021), see Figure 15.

4.4.2 Mental Models

Mental models are helpful to study when designing products that require user interaction.

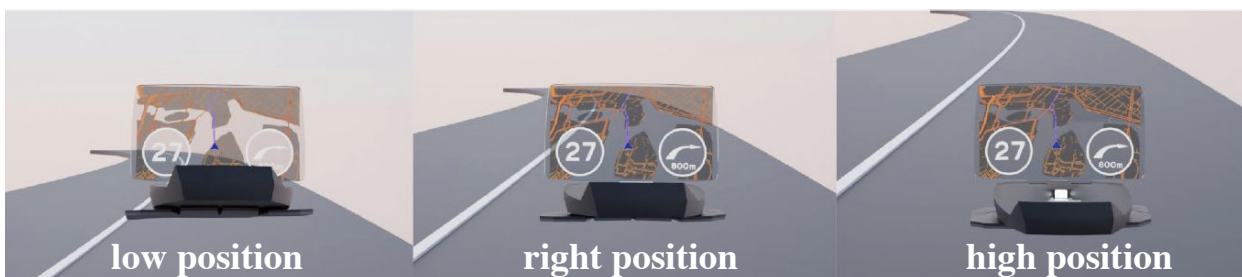


Figure 15 Differences in perspective for females and males, (Söderström, 2021)

The mental model is based on how the user thinks, talks, and the system works. Observations and interviews can be held to investigate how the task performs. (Gentner, D. Stevens, A L. 1983). The knowledge of how the task performs and interact can be helpful when designing the product to make it intuitive. Mental models help to design the on and off, mute and push-buttons. When pushing the buttons, it needs to feel secure, and the unit can not move. The buttons need to be accessible and ergonomic. If usable buttons are placed on the unit, the system must also be at arm's length.

4.5 Materials

Based on the semantic aspects of the HUDs choice of material, the observer's desire for colour, shape and expression must be met. Since the interior of a car is to a very high degree from a particular aspect considered, the HUD's expression is directly decisive for whether it fulfils its intended effect, that is, its aesthetic expression. The choice of material for a HUD should therefore not counteract but rather reinforce the board's desired expression.

Below is a description of the aspects that must be considered when choosing materials, both semantic and technical.

4.5.1 Semantic

The material expression needs to meet the temporal material expression of the dashboards. The colour should not stand out to steal the attention of the driver. Push buttons need to be visible during dark evenings and nights. Since the user will montage the system by themselves, the material should resist grease stains and other marks during use.

4.5.2 Technical

Today's HUD is often made of a thermoplastic material that can be formed using heat and have low density. This material can be re-

cycled but deteriorates over time. Casting or injection moulding is the most common thermoplastic manufacturing method.

The surface can not be too reflective since light is projected from the TFT screen and can harm the driver in any way. At the risk of an accident, the weight of the system contributes to the impact. The lighter product, the better, which is why the material weight must contribute to its lightness. The material can not be too brittle; in the worst case of an accident, the material can not generate glass shards.

Friction and abrasion will frequently happen, which can create heat and, in turn, damage the material and create dots. The material is also exposed to much sunlight, and colour changes can appear.

4.6 Car models

Since the cars sold today are usually already equipped with a HUD or similar technology, the company users probably own an older car model that is not equipped with a HUD display or similar. Data from 2018 most sold cars in Sweden were registered (Södergren, 2021). During 2018 the most sold brands models were Volvo and Volkswagen, Volvo consists mainly of the corporate sector ownership, and Volkswagen consists primarily of public sector ownership, see Table 1.

A presentation of the four most sold models illustrates the differences between the form and space between window and dashboard.

Rank	Number	Market %	Model
1	95020	5.33	VOLVO S/V60
2	82020	4.6	VOLVO XC60
3	80752	4.53	VW GOLF
4	78249	4.39	VOLVO S/V90N
5	62216	3.49	VW PASSAT
6	44255	2.48	VW TIGUAN
7	32592	1.83	KIA CEED
Total	475104	26.65%	

Table 1 Most sold cars 2018

Volvo S90/V90

Nappa material on the dashboard and have space between the dashboard and windscreen, see Figure 16.



Figure 16 Interior Volvo S90/V90 (Volvo 90, n.d.)

Volkswagen Golf

The dashboard is curved in the front and has a high inclination after the front, making it less space between the dashboard and windscreen, see Figure 17



Figure 17 Interior Volkswagen Golf (Volkswagen G, n.d.)

Volvo S60/V60

The dashboard is made of Nappa material and the V60 model have a different form than V90 model, V60 is flatter and have more space between the dashboard and windscreen, see Figure 18.



Figure 18 Interior Volvo S60/V60 (Volvo 60, n.d.)

Volkswagen Passat

Same problem as Passat golf, less space between dashboard and windscreen but have a flatter form compared to the golf, see Figure 19.



Figure 19 Volkswagen Passat (Volkswagen P, n.d.)

4.7 State of Art

This section aims at describing the leading competitors and their main design on the market.

4.7.1 Dominant Design

Several car models already offer HUD in a different range of prices, features and technical solutions. There is also some automotive HUDs on the market with different technical solutions and price ranges. In 2016, the HUD's aftermarket production stopped because cheap dominant versions of previous devices replaced the new technical solutions (Söderström, 2021), for example, Wins Novelty Co, see Figure 20. Also, some brands that have made the same journey as the company plan to do are NAVDY and HUDWAY instead of doing copies of the product.



Figure 20 Sheap versions of HUD's (Perry. J., 2019)

4.7.2 NAVDY

Figure 22 shows NAVDYS’s HUD with dynamic mapping, smartphone integration and car diagnostic information. The solution is projected in front of the driver, making the driver have their eyes up and cell phone away (Mulcahy, 2019).

The solution is similar to the stakeholder product idea, and their design is smooth and clean. NAVY’S base is similar to a GoPro base where the unit connects to the base that grips the device’s mount, see Figure 22.



4.7.3 HUDWAY

Figure 21 shows the product of HUDWAY, which is designed to operate with a smartphone. The design has a phone mount and a belonging glass and facilitates seeing the road and directions in front of the driver. HUDWAY’s solution is different from stakeholders’ products, where it needs a cellphone and belonging app (Hudway, 2021).

The whole installation is one product package where the user needs to install and put their phone on the product to make it work. The design feels functional and straightforward, see Figure 21.



Figure 21 HUDWAY product solution (HUDWAY LLC, 2013)



30 Figure 22 NAVDY’s product solution (Mulchay. P, 2019)

4.8 Insights

As introduced, this chapter intends to present important discoveries and draw theoretical conclusions. As an essential part of design thinking and the available information, it has created a basis for future processes to lean back on. A summary of the conclusions presents below.

While going through the information, a decision to divide the product into two modules would facilitate accomplishing all given requirements, see Figure 23. The product system is divided into a base mount and a unit holding the combiner. All these specifications are both narrowing and defining the design space. Since the system is divided into modules, a set-based and a pinpoint base approach will guide the product development process. Below all information is gathered in a specification list, see Table 2.

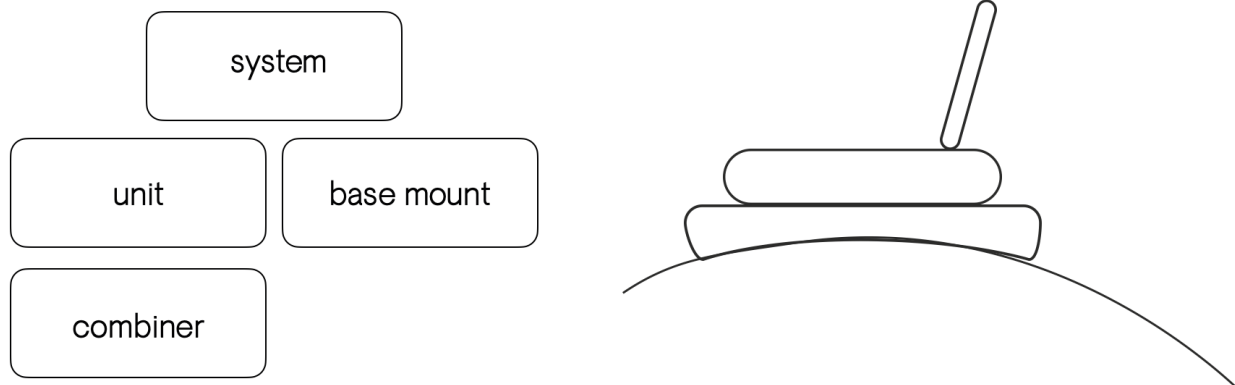


Figure 23 System divided into modules, (Annvik S)

Criteria	Justification	Evaluation method	Value
Safety	The part of the device or mount in the way of the driver's view of the road should be	Test & Product Design	Max 45 (mm) high
	The base mount should be strongly affixed to the vehicle and the device must be able to be removed.	Product Design & Crash Test	
	The design of the HUD needs to fit different dashboards and also prevent vibrations.	Test & Product Design	
Dimensions	The hardware design needs to fit inside the unit.	Place the hardware inside the design	Min volume (see attached file in
	The minimum distance between TFT screen and combiner.	Product Design	139.5 (mm)
Material	The materials should not shatter and produce splitters.	Material Data	Min 200 (J/m ²)
	The material can not be reflective and disturb the driver	Material Data & Test	
	The material must withstand high temperatures	Material Data	Operating temperature range (-15° -to 60°) & Storage temperature range (-40° to 85°)
Environment	The HUD is placed where it easily creates dust	Product Design & Material Data	
	The device and mount should minimize the risk of resonant vibrations.	Product Design	
	The device should allow for adjustment for most drivers and cars.	Test & Product Design	
Design Constraints	The outer defined elements need to be considered when designing the unit.	Product Design	See attached file in Appendix G
	Nothing can be in the way of the projected area (between TFT screen and combiner)	Product Design	See attached file in Appendix G
	Buttons need to be at arm's length.	Product Design	
	The buttons can not light up and irritate the driver	Product Design	

Table 2 List of specifications

5. Consenz

This chapter aims to capture the company’s message and background to continue building the product design within the same message.

5.1 Introduction

Before start designing, it is valuable to gather information about the company. The information is gathered from interviews, study visits, and workshops.

5.2 Brand story

The company idea started with one of the founders, originally from a country with a high road accident rate, and he has always admired Swedish road safety thinking and attitude. The biggest inspiration for their idea is Vision Zero (Sweden’s commitment that no one should get killed or seriously injured in traffic). The aim is to make a global impact by exporting this vision to where it is most needed.

5.3 Tagline

The company aims to dramatically reduce the number of lives lost in traffic by using technology and connectivity to empower car drivers worldwide.

5.4 Core Values

- Driven by our mission (confidence why / what we are doing)
- Empathetic/ Supportive
- Honesty
- People-oriented/ Human-centric
- Curiosity

5.5 Key brand values

- Support
- Safety
- Belonging
- Human-centric
- Education

5.6 Brand Message

The big idea is to create an aligned totem around a strategy, behaviour, action and communication. These worded statements are used to become a culture that helps consumers make choices (Wheeler, 2013). The statements share a message that affects the product design in thinking, and the company’s idea is described below.

5.6.1 Message Support

- we need to make sure “users” feel cared for every step of the way, that they can rely on us
- we have their backs covered through the whole journey behind the wheel
- we show that we can be trusted

5.6.2 Message Safety

- technology supportive
- we keep the driver concentrated on the road / safe driving manner
- we ask /remind drivers to think that wrong actions lead to bad repercussions (that can affect their beloved ones).

Safety is an important need, so we should try and include a prominent call-to-action that's easily visible throughout our site to give users a way to support our cause or participate in efforts to give back. That way, they can feel like they are doing good in the world just by interacting with our brand online.

5.6.3 Message Belonging

- We ask for being a part of our community to build the global impact
- Gamification, feeling of doing an essential thing in a playful/easy way

5.6.4 Message Human-centric

- Concentrate on that we empowering driver and leave the last/final decision for them
- We share that driver has a choice to keep themselves and their beloved ones safe
- Emphasize that we are people, not just a company (fails, success, corporate life)
- We highlight that the Voice assistant helps to be always in touch / to be in charge, even while they drive

5.6.5 Message Education

- To educate/ inform about danger and safety on the road
- Explanation why it is necessary to drive sustainable
- To advise how to drive in an environmentally friendly manner and why it is important

5.7 Enzo's personality

Enzo the driver assistant are:

- Very reliable
- Knows everything about traffic and safety
- Understands that driving should be fun
- A bit competitive
- A nice guy!
- A man on a mission (to make safe and comfortable driving accessible to everyone)

Figure 24 The Conenz team, (Annvik S)



5.8 Brand Self Image

Successful products often imagine what others (users) can not see and the tendencies to deliver it. This is the company's vision and how they want to be seen by others, see Figure 25.

-I am multifunctional

-I am competent and professional in what I am doing, and I like to educate and guide people. I am happy to be helpful I have the ambition to be a part of global problem solving and start the movement/ to motivate people in action I believe every person can change the world a better place but together, we reach it much faster

-I love people, I care about them.

-I am responsible, you can trust and rely on me.

-I like to be in control, to keep things in order, have discipline and stick to a routine that feels comfortable and safe I like and choose comfort. Will never agree to limit the comfort of my everyday life.

-I like to follow the rules and feel annoying when someone is not serious/ break them I like to know more about the world of new technology. I am a city guy, drive a lot and I very like to travel by car."

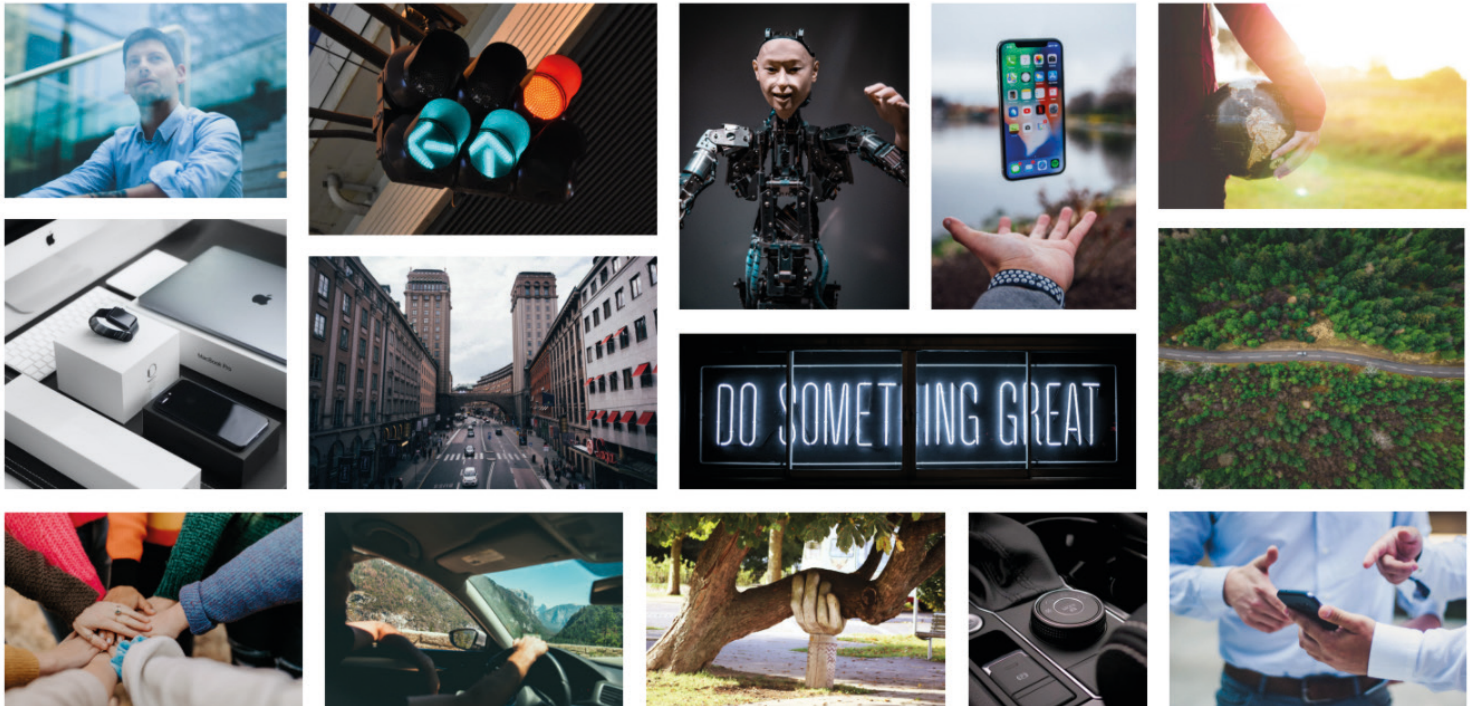


Figure 25 Conenz brand self image, (Consenz, 2021)

5.9 Signature

A signature is structured with a logotype, brandmark, and tagline, see Figure 26 (Wheeler, 2013). The company signature is both text and symbolic driven. The font and the form meet each other, and the brandmark is based on letters from the signature.

The brandmark embodies the business goals in the way of expressing the feeling of high technology level. The straight lines create a hard and masculine feeling, and the brandmarks edges on the left side communicate a soft and caring feeling.

Since the brandmark is based and designed from the logotype, the signature expresses a similar feeling.

5.9.1 The sequence of cognition

What is essential is that the brain memorises shape first. Visual images can be remembered and recognised directly, while text must be decoded into meaning (Wheeler, 2013).

Shape

When seeing the signature, the shapes will be memorised first, and while reading the logotype, it is necessary to understand the shapes to understand later what the text means.

The shapes of the brandmark are symmetric, and the shapes of the letterforms are both soft and hard, see Figure 27.

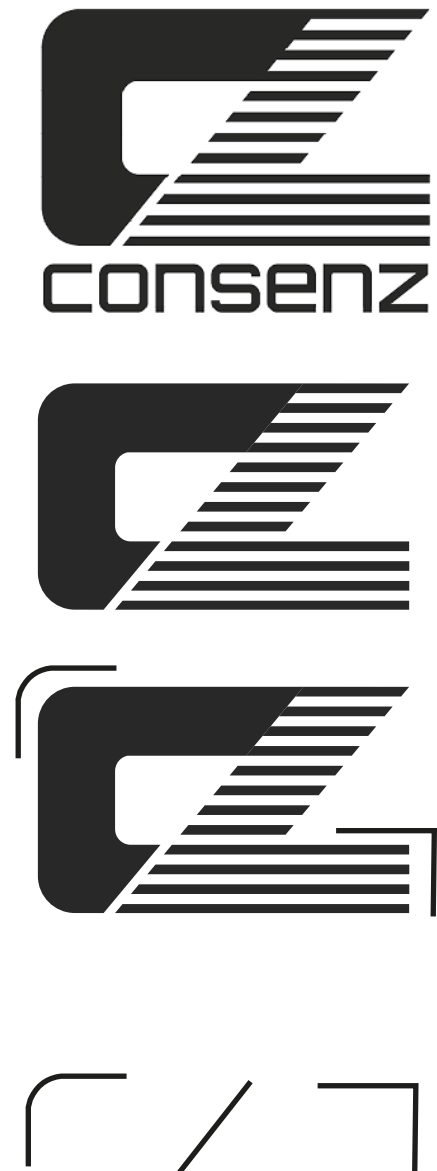


Figure 27
Brandmarks and forms, (Consenz, 2021)

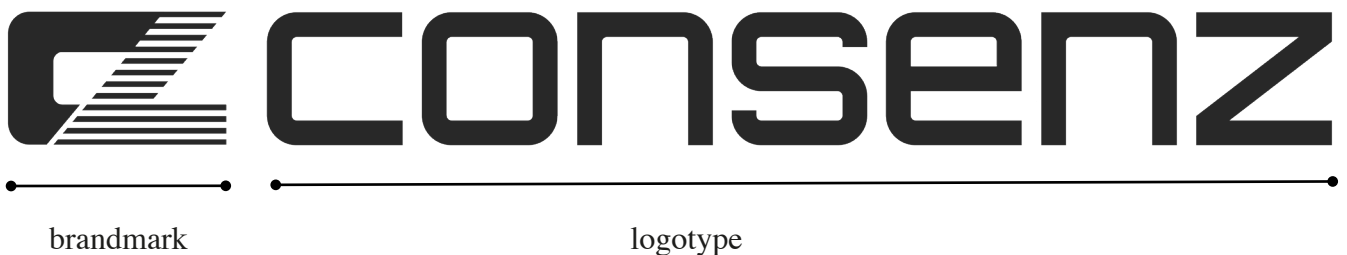


Figure 26
Signature (horizontal / landscape), (Consenz, 2021)

Colour

In Figure 28, the company’s colour palette is presented and each expression of every colour. The colour explanation matches the core values and what they stand for.

When building brands today, the brand must make a difference—the company bases their values on the triple bottom line, people, planet, and profit. The colour palette facilitates communication of this message out to the customers.

A colour palette that meets company values and vision is essential because throughout repeated exposure, big companies today have dropped the logotype from their corporate signatures and only using the colours to become a leading signature in their advertising (Wheeler, 2013).

Form

Language is more challenging to process than understanding shapes and colours. Furthermore, that is why it is essential to communicate the right colour and shapes. The product design shapes contribute to the users feeling and understanding of where it belongs.

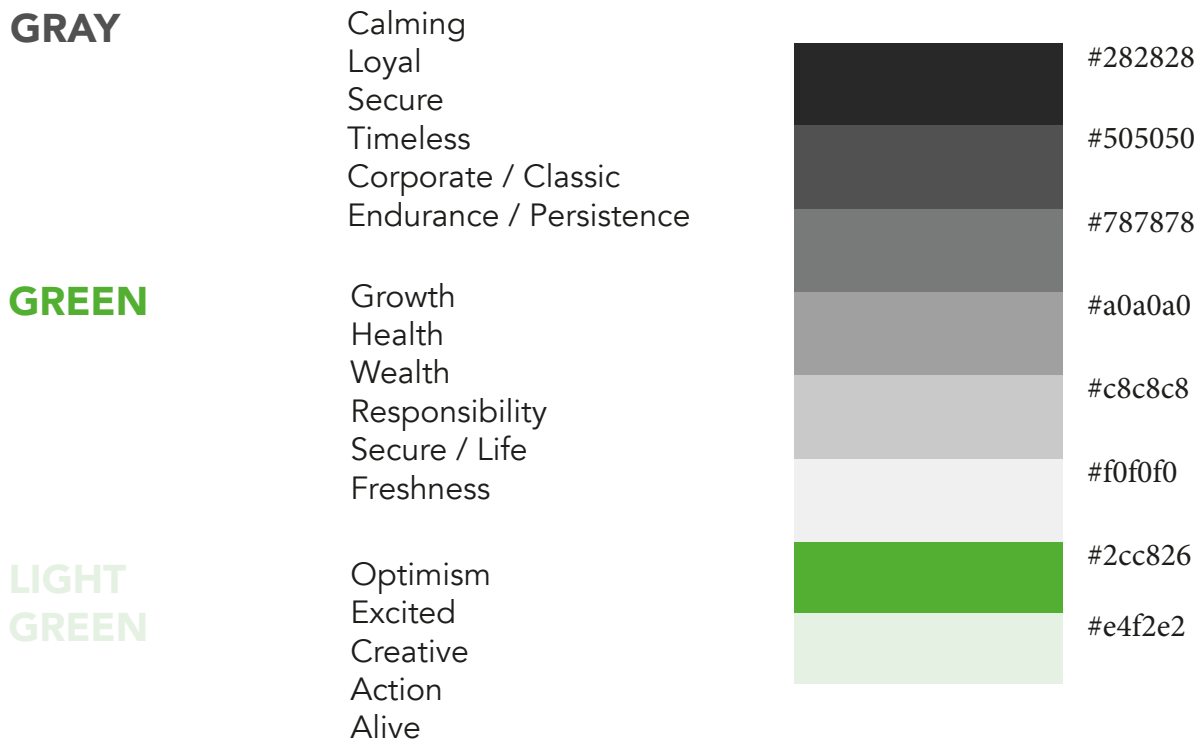


Figure 28 Color palette and explanation, (Annvik S)

6. Product Identity

In this chapter, a presentation of semantic references, mood board, imageboard, and personas for the product will be found.

6.2 Introduction

The coming chapter will transform the researched information from *Identifying Requirements chapter 4* and *Consenz chapter 5* into design guidelines and product specifications and presents below.

6.2 Translation

This section will review the transformation between the company's values and characteristics into a product identity and design features. The transformation will be done by analysing the given information in *Consenz, chapter 5*, with references from the *Theory, chapter 2*.

6.2 Translating Core Values

In *section 5.4* the company's core values were identified. Below is an analysis of each value's definition, what they mean and communicate.

Safety

To communicate a safe feeling the design needs to be robust and stable (Wikström, Dagman, and Karlsson 2011). Another essential aspect Wikström, Dagman, and Karlsson (2011) mention is that the product's choice and sound affect safety.

Support and Human-Centric

To create a supportive and human centric feeling, the product needs to be user friendly and easily communicate its functions. By

guaranteeing the product, the form fulfils the functional and ergonomic aspects facilitates a supportive and human-centric feeling (Wikström, Dagman, and Karlsson 2011).

Belonging

It is not quick fix to create a belonging feeling. The belonging feeling is an intersection of inclusion (thoughts, ideas and perspective of all individuals), equity (consistently recognizing) and diversity (multiple identities representation) (Wikström, Dagman, and Karlsson 2011). The moment the observator feel comfortable, and match the individuals goals and dreams creates a belonging feeling.

Several aspects of the design affect an affiliation with the product, system, accessories and app, and installation has a significant impact.

Repetitive and recognisable forms and an easy app installation, where support, follow friends statistic and routes provide can increase the belonging feeling.

6.1.2 Translating characteristics

Applying the knowledge from chapters 4 & 5, *Identifying Requirements and Consenz*, into a profile of product characterise helped get a clearer view of the product design character. The profile is marked and scaled with the characteristics, and the following will each character be explained shortly. The product profile character has bolded words for the aiming

design feeling features, and the scale is used to evaluate the concepts, see Figure 29.

Robust/Fragile

Robust design refers to the fundamental design and secures the product functionally working. This message needs to be expressed in design features.

Rough/Smooth, Cold/Warm and Hard/Soft

The company sign and message is a convention between soft and hard shapes, and its convention affects the feeling of cold/warm and rough/smooth. A smooth design usually also communicates a warm and soft feeling, and a rough design often communicates a colder and harder feeling.

Stable/ Unstable and Secure/Insecure

All added equipment in the car needs to communicate a secure and stable design feeling.

Below are definitions of experience in a study concerning shape:

Heavy/Light and Big/Small

It is essential that the system is not in the driver’s way and that the design is as minimal as possible.

Balanced/Unbalanced

Balanced feeling uses repetitive lines and harmonic forms, and this feeling can indicate supportive and belonging expression.

Simple/Complicated

To make the design feel simple, it needs to be user-friendly and easily understandable. Wikström (2019) describes that simplicity creates harmony, contrast and dynamism.

Identity/Non-identity

By identifying and using the company values and mission building up a reputation that expresses a similar product identity.

Graspable/Ungraspable

The shape and size must be graspable and the user must understand how to handle the product.

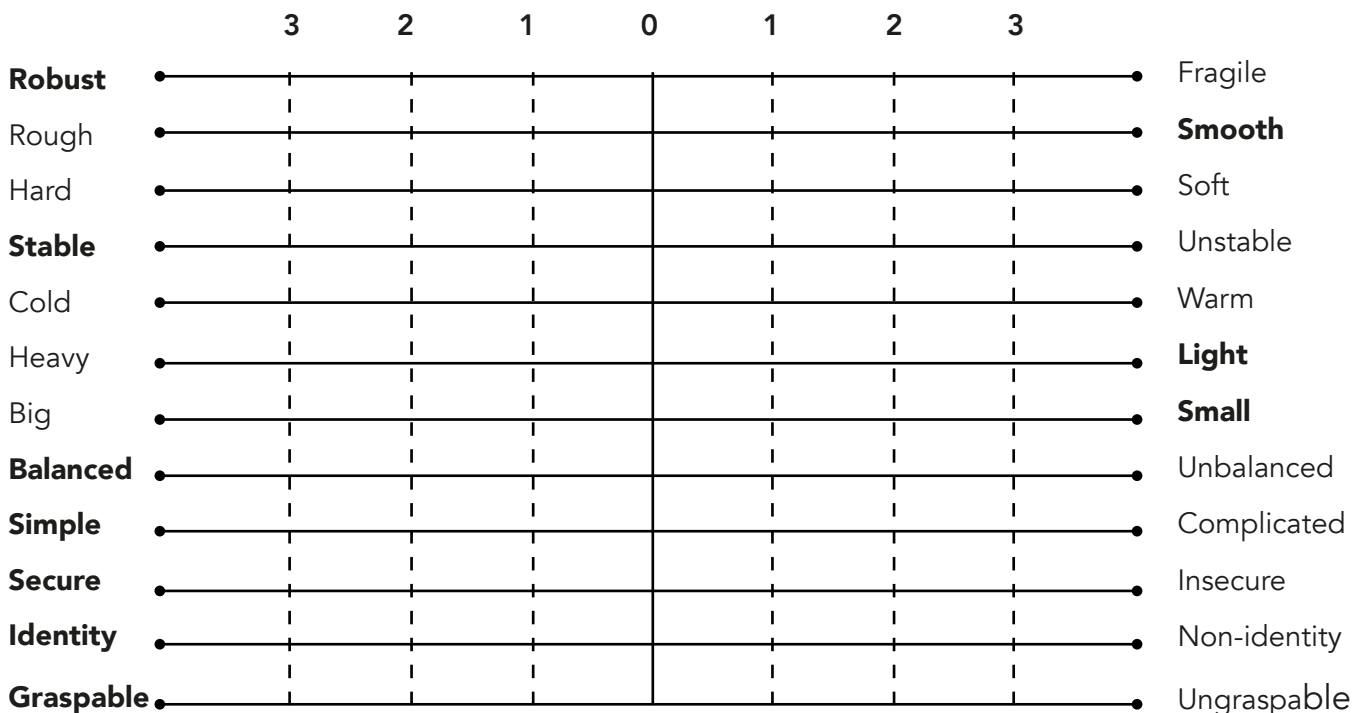


Figure 29 Defined product profile characteristic, (Annvik S)

6.2 Personas

Based on user research presented in the Söderströms report (2021) and in *chapters 4 & 5, Identifying Requirements and Consenz*, a user profile and personas will be presented and analysed below.

The product mission is to create a need for the product and a feel of the community. The people who already have a new car shall also need to buy the product or join the community. Succeeding with this delegates an understanding of peoples lifestyles.

6.2.1 Eva

Figure 30 identify the first segment of users and are one of the first adopters of the product. Table 3 presents a summary of three weighted criteria for an overview of what the Evas segment prioritises.

Eva	design	technology	user friendly
wheight	4	4	3

Table 3
A summery of Evas´ s wheighted criterias



Eva Enthusiast

Eva is a 29 year old Dev-ops engineer. She likes to read tech magazines & news about tech. She has a new found car hobby and tries to incorporate her tech interest in the new hobby. Usually discusses and shows smart tech solutions at forums online, also to friends & family. Doesn't necessarily see a sole owned car as the "go to" transportation and sees value in co-ownership, car pools and public transportation.

Summary

Age 29
Location Gothenburg
Occupation Dev-ops Engineer
Income Middle
Married, 1 kid

Car interest/familiarity



Early adopter



Tech interest/familiarity



Values

Innovative tech solutions
Connectivity and integration
Highly customizable mobile tech
Being positively surprised by depth of tech capabilities

Goals

Having seamless tech setup in car
Getting recognition for hobby interests
Being able to enjoy a car as a hobby apart from transportation

Frustrations

Being restricted by technical "dead-ends"
Overly slow reaction & computing time in tech products

Figure 30 Persona of first segment of users, (Annvik S)

6.2.2 Brian

Figure 31 identifies the second segment of users and are a part of the segment who will be critical to the product initially and, after a while, understand the advantages. In Table 4, a presentation of the weighted criteria of the Brians segment shows.

Brian	design	technology	user friendly
wheight	2	4	5

Table 4
A summary of Brian’s wheighted criterias



Brian Business

Brian is a 51 year old man working as a business owner. He starts his day from home, but usually goes towards work-related destinations during work. Usually feels like he’s unable to continue being productive and planning while driving, and that driving inhibits his ability to work effectively. He wants his home office and car to be connected.

Summary

Age 51
 Location Skövde
 Occupation Business Owner
 Income Middle
 Married, 1 kid

Car interest/familiarity



Early adopter



Tech interest/familiarity



Values

Quickly going from A to B
 Being connected
 Getting notification and news on the go
 Effective tools that are connect-
 ed to his office computer/phone

Goals

Being productive while driving
 Not missing out on info
 Always finding best route
 Be able to everything, even
 while driving

Frustrations

Feeling stressed because he’s
 stuck in traffic
 Not being there at projected
 time
 Missing out on stuff because
 you were driving

Figure 31 Persona of first segment of users, (Annvik S)

6.2.3 Sam

Figure 32 identify the persona representing the significant segment of users. At the beginning of the product release, the third segment will be a bit sceptical. After a while, they will understand the benefits of the product.

The segments drive out from the same value but have different characters and conditions. Therefore, it is essential to communicate with users and use their preferences for validation.

In Table 5, a presentation of the weighted criteria of Evas segment shows.

Sam	design	technology	user friendly
wheight	4	2	5

Table 5
A summery of Sam´s wheighted criterias



Sam Safety

Sam is a 33 year old parent, constantly on the move. Drives from-to work, drives kid from-to activities and drives from-to grocery store etc. Her constant driving and juggling different tasks in her head, along with increased stress levels feels like it could impact her driving.

It has opened her eyes to the increased safety risk of her and her family. She wants to increase the safety for her kids by more planned driving.

Summary

Age 33
Location Stockholm
Occupation Office worker
Income Middle low

Car interest/familiarity



Early adopter



Tech interest/familiarity



Values

Safety equipment that's easy to use
Ability to get car, traffic and weather info
Tools that help organize
Statistics to improve driving

Goals

Perfectly planned driving and planned day
Ultimate safety for family
Effective driving
Everyday luxury & convenience

Frustrations

Badly organized might put people at risk
Getting too much info and no help to manage it
Stress when running out of time
Uncertainty of road safety

Figure 32 Persona of second segment of users, (Annvik S)

6.2.4 Pin-point persona needs

Three personas were created to understand the product users. The personas are used for gathering knowledge of which different contexts the product will be used in. Figure 33, has three circles representing the first, second and third segments of users. The inner circle represents Eva, who is the first buyer and user. In the middle circle, Brian represents a more significant segment that, after time, will found out the advantage of the product. The last circle represents the considerable segment of users who are more sceptical in the beginning but love the benefits of the product.

The large base of users has different identities and images, and their personalities and need are essential to understand before designing the product. The people who advantage the most are people who want new technology and feel confident relying on it. Also, people

like to delegate and looking for ways to make life easier. People who thrive on being a part of the modern movement feel self-contribution to something bigger/global. At last, those who are always want to be in touch/connected and are afraid to miss things.

A summerise of the gathered information presents in Figure 34. The Figure is used to understand what the users are looking for and prioritise when buying the product. Figure 34 gather what aspects can be used as selling points and helps the developer know what to focus on during the development.

It is essential to link the community and product identity. Building up a community based on information from the users creates a secure community and information that is valuable for the product identity.

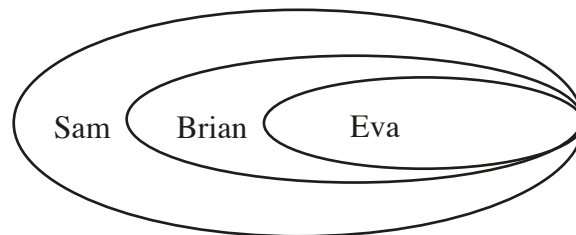


Figure 33 User segments, (selfmade)

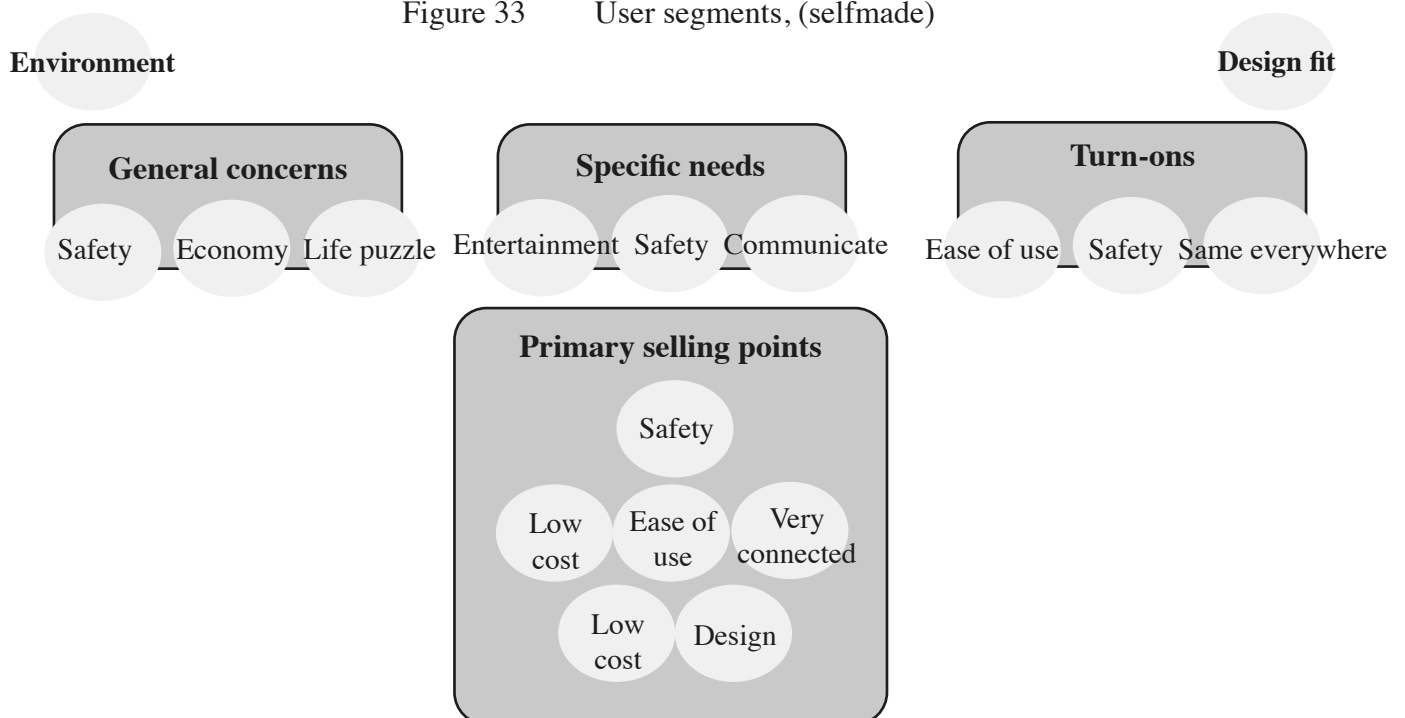


Figure 34 Analyzed users, (Annvik S)

6.3 Mood board

Guaranteeing that the product's development has the right product feeling were two mood boards made—the mood boards based on the two different feelings, edgy and soft. The mood boards were a tool to assure the company's communication of character and feel were right.

As there are soft and edgy elements in the brand mark, the edgy feeling matches the brand identity more, and the soft feeling matches the brand characteristics of caring and belonging more. The mood boards are modern, clean, professional and upbeat and inspired by *Consenz, chapter 5*.

6.3.1 Soft

The soft mood board in Figure 35 express a more inviting and familiar feeling. The caring and secure aspects of the brand highlight the soft feeling—the elements identify the stakeholder's framework of meaning and logic.

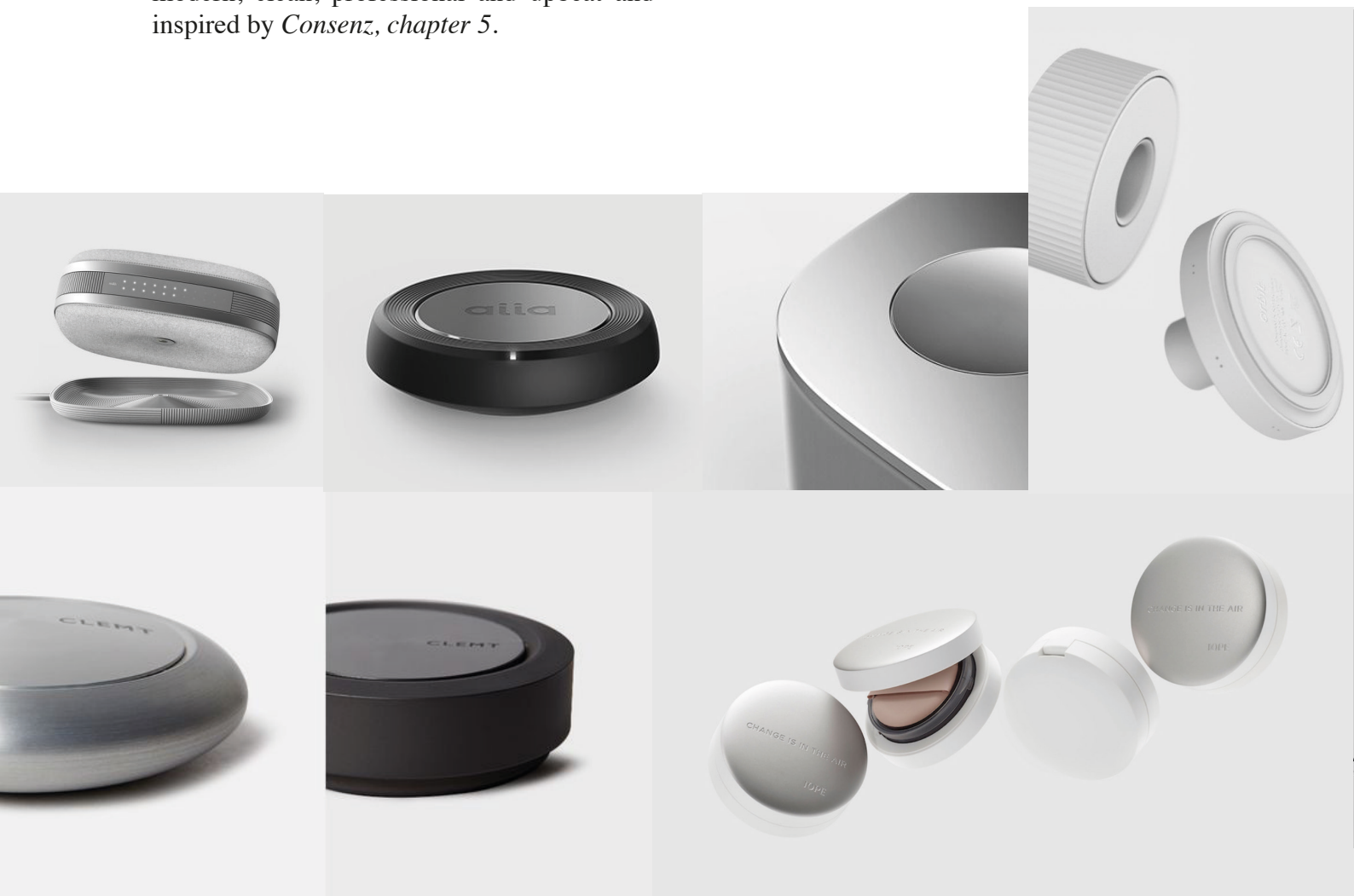


Figure 35 Moodboard, soft feeling (Soft, n.d.)

6.3.2 Edgy

The more edgy mood board is more straightforward and clean with a consistently strong feeling. The mood board also expresses a safe and Scandinavian feeling and engages better with the stakeholders' brand identity, see Figure 36.

6.3.3 The result

When presenting both mood boards, the edgy mood board was appreciated by the stakeholders.



Figure 36 Moodboard, edgy feeling (Edgy, n.d.)

6.4 Imageboard

After researching and analyzing the company, personas and brand identity and so on, an imageboard of how the product wants to be perceived were done, see Figure 37. The imageboard feeling expresses trendy, protective, innovative, empathetic and confident. A solution everyone can count on no matter what.



Figure 37 Image board (Unsplash, n.d.)

6.5 Material mood board

The material is a central aspect of the semantic principles. The imageboard only contains black plastic materials as the product needs to meet its environment (dashboard). Several examples in the imageboard use the material contrasts and its dividing line, where delicate surfaces meet rough surfaces, see Figure 38. Examples of different material textures also create an effect feeling. It is interesting to see how different materials and textures create a playful, sporty or stylish feeling.

6.6 Insights

Since the company is a start-up with no other products on the market and no product portfolio to analyze, it has been necessary to gather their brand idea, values and goals. They aim to sell the product worldwide to people who care about its community. The company want to communicate a straightforward safety and sustainability message.

The frameworks given in this chapter is the ground of the esthetical design aspects in the coming Development Process.



Figure 38 Image board of material (Material, n.d.)

7. Idea Generation

This chapter outline the applications and the outcome of the idea generation. The idea generation is a process to start create ideas; in the next chapter, these ideas become more defined and analyzed.

7.1 Introduction

The idea generation is a quantitative approach which later narrows down to a more qualitative approach. The idea of using this method is to guarantee the whole designs space and important idea direction is all covered. Different activities were used in this stage to grantee structural thinking and, at the same time, allow open reasoning. The process was evolved as followed:

Brainstorming -> Sketching -> Prototyping
-> Sketching

7.2 Brainstorming

The idea generation aimed to make sure that as many form directions as possible were examined. Several brainstorming sessions based on the whole system, unit, base mount, and combiner were investigated to ensure this.

With no previous knowledge more than specifications about the hardware, ideas were put into sketches as a first step to visualize the ideas. The requirements stated in Table 2 limited the design space and made conclusions that the form was not as free as the idea was from the beginning.

The requirements that needed to be considered was:

- Nothing can be in front of the combiner
- Hardware needs to fit
- The unit can not be too broad as it needs to fit in different dashboards
- Not too high, so it is in the way for the driver

Figure 39 & 40 shows some of the sketches that were done after the brainstorming.

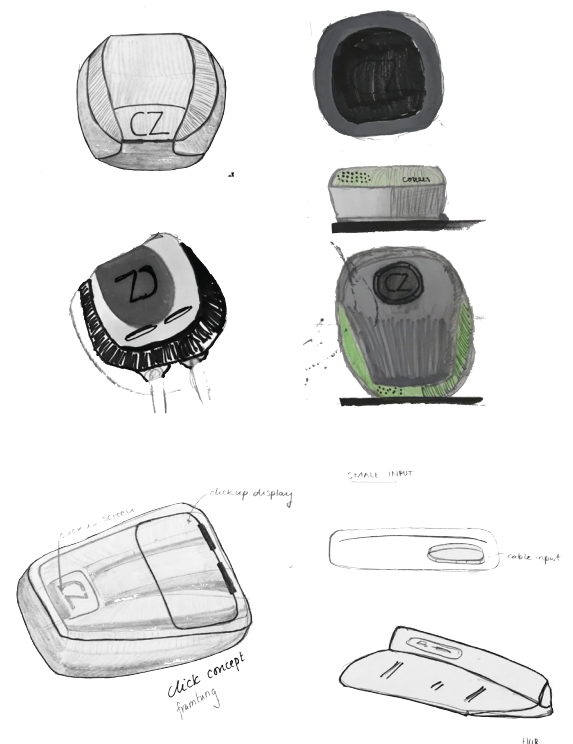


Figure 39 Sketches of possible solutions, (Annvik S)

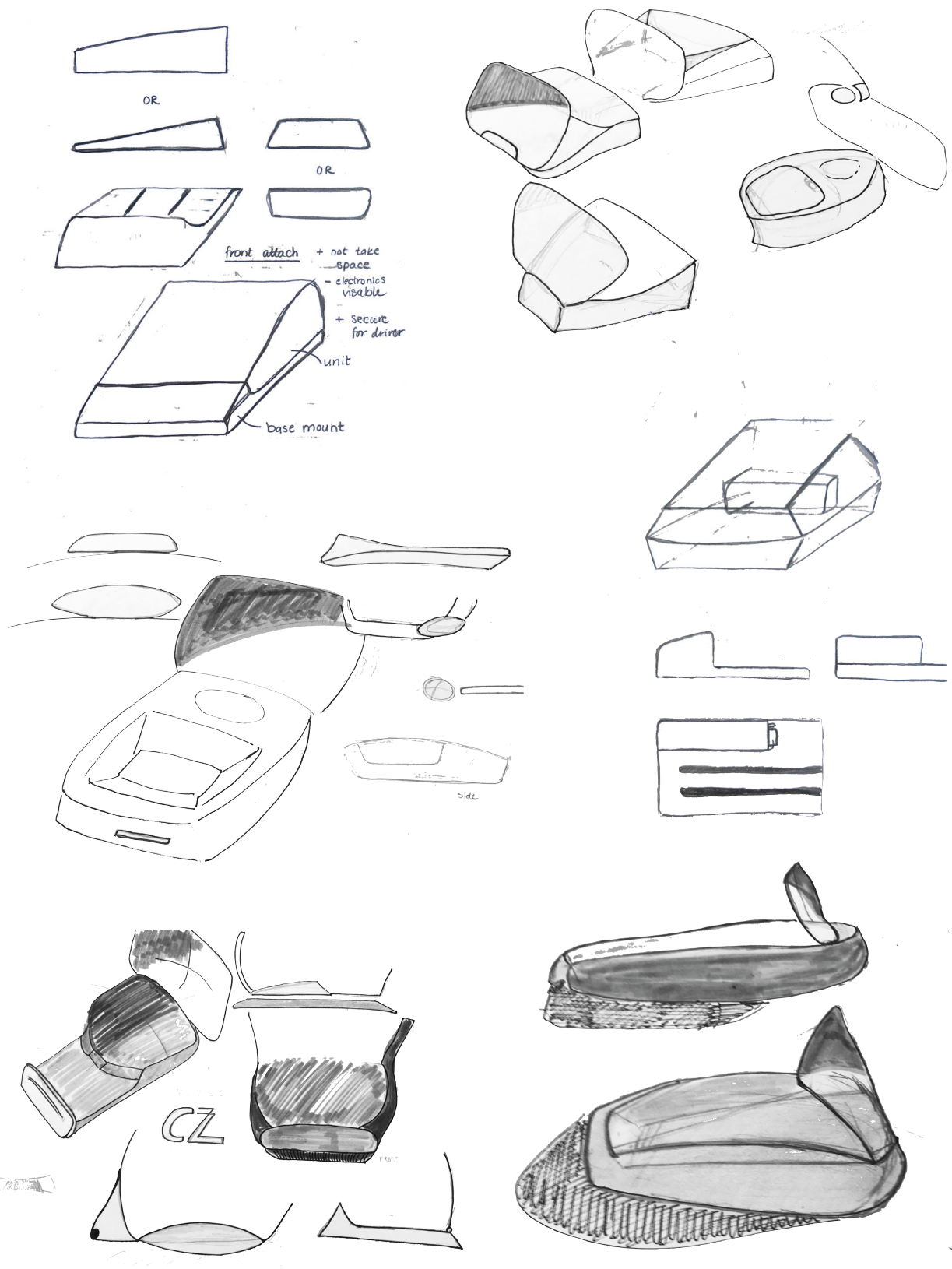


Figure 40 Sketches of system, unit, base mount and combiner solutions, (Annvik S)

7.3 Form ideation

Different forms in different views were drawn to get an impression of the possible forms see Figure 41- 44. The forms were evaluated and some were ruled out because they did not match the imageboard, mood board, product profile character or requirements.

Some of the forms were 3D modulated and placed in the right environment to further evaluate the forms in their actual use, see Figure 41.

When analysing different forms from a side view in Figure 41, results were taken that the first row expressed a coherent feeling from the soft mood board. The forms in the third row are coherent to the edgy mood board, and the last row in Figure 41 expressed a feeling of playfulness and did not match the mood board, imageboard or semantic profile product character.

Figure 43 shows designed proposals of the shapes from Figure 36 that fit the identity and feeling sought after. Figure 44 shows some examples of top views with possible forms, and in Figure 40, some different docking positions are sketched. Results were taken that the best design solution was that the base and unit should be mounted in the dashboard's front to guarantee it keeps its correct position.

The sketches in Figure 42 were hard to evaluate; more than the angled forms felt more light, and the other forms felt robust. For further refinement and feeling, prototypes were done in styrofoam to better understand the form feeling, see Figure 46.

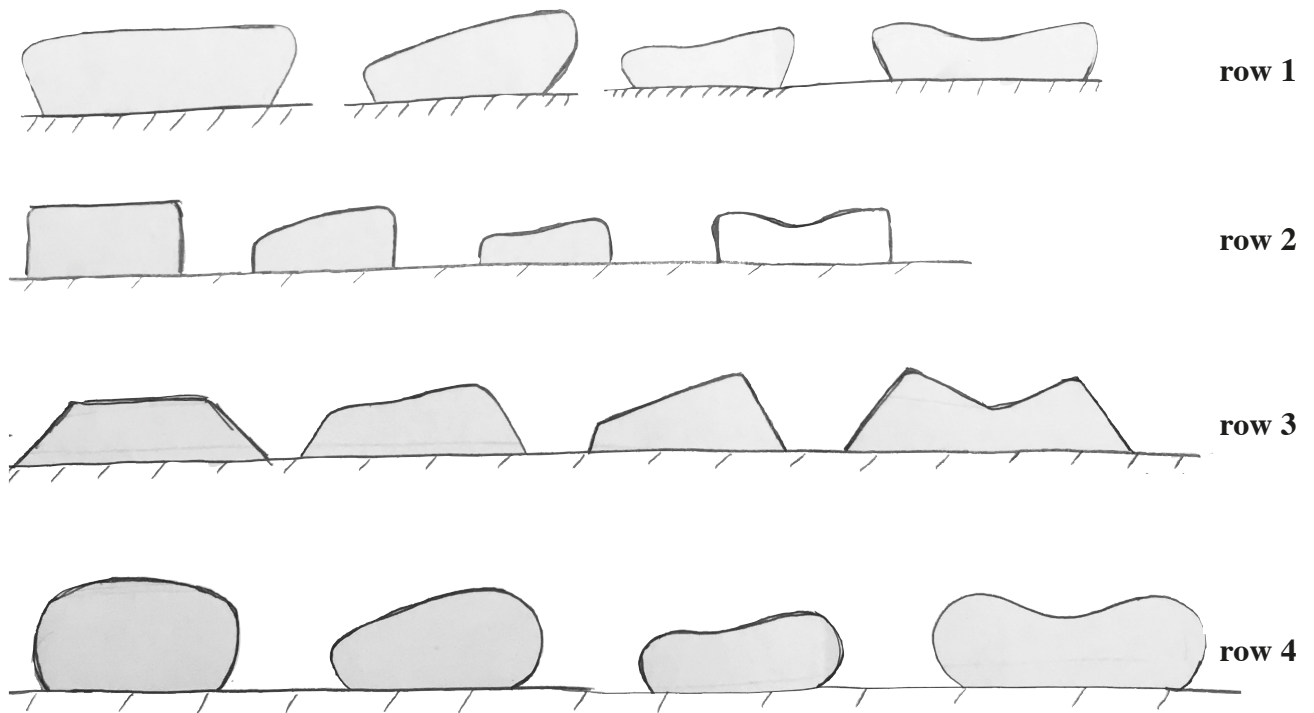


Figure 41 Sketches of forms from side view, (Annvik S)

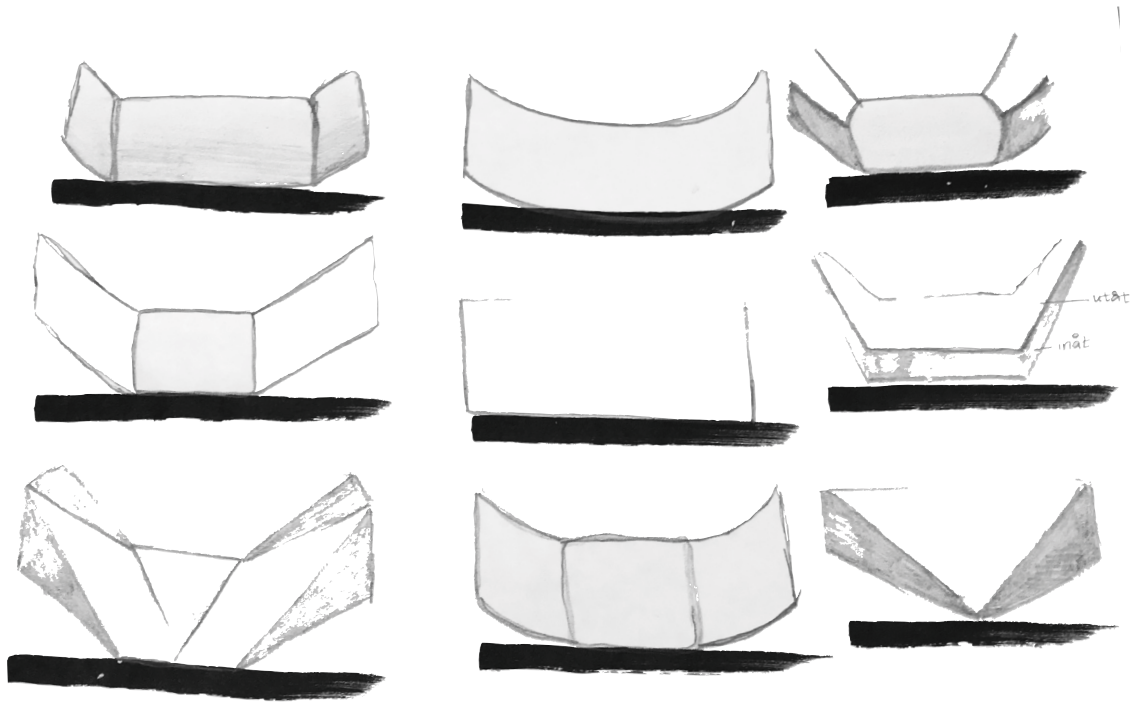


Figure 42 Sketches of forms from front view, (Annvik S)

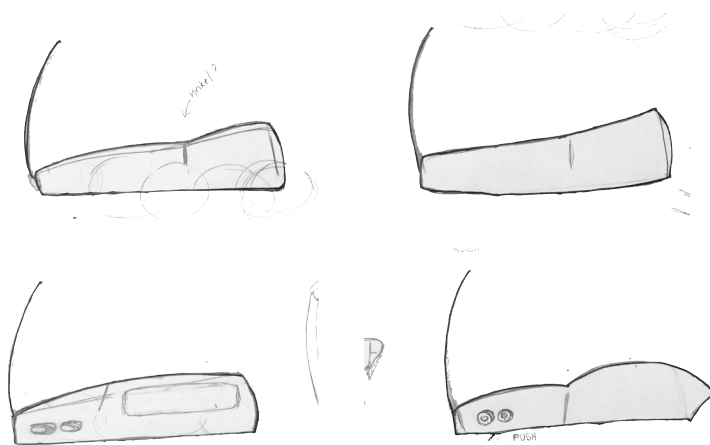


Figure 43 Sketches of forms from side view, solutions to have free way between screen and combiner, (Annvik S)

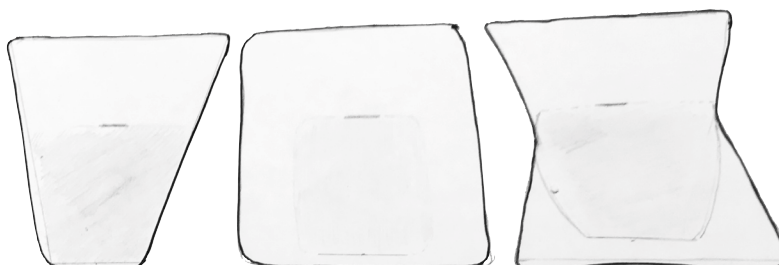


Figure 44 Sketches of forms from top view, (Annvik S)

7.4 Prototypes

For further development, an important step was to generate the most likely forms into actual prototypes with the help of 3D printing and styrofoam. By building mockups, the forms could be evaluated directly. At the same time, they were building these models, insights that the size was too big to fit in some car models.

When modulating prototypes in styrofoam, several prototypes felt too broad, and others felt too thin and not secure—a size between was needed to test. The second generation of prototypes was 3D printed with the new sizes, although the size was still too big when the prototype was tested on top of the dashboard, see Figure 48.

The size and form were refined even more and was later tested in real cars and 3D models. The 3D models in Figure 47 did not have that good result as expected because it was hard to get a sense of the feeling since the car was also 3D modulated with no correct materials or views, although it gave a sense of the size was better.

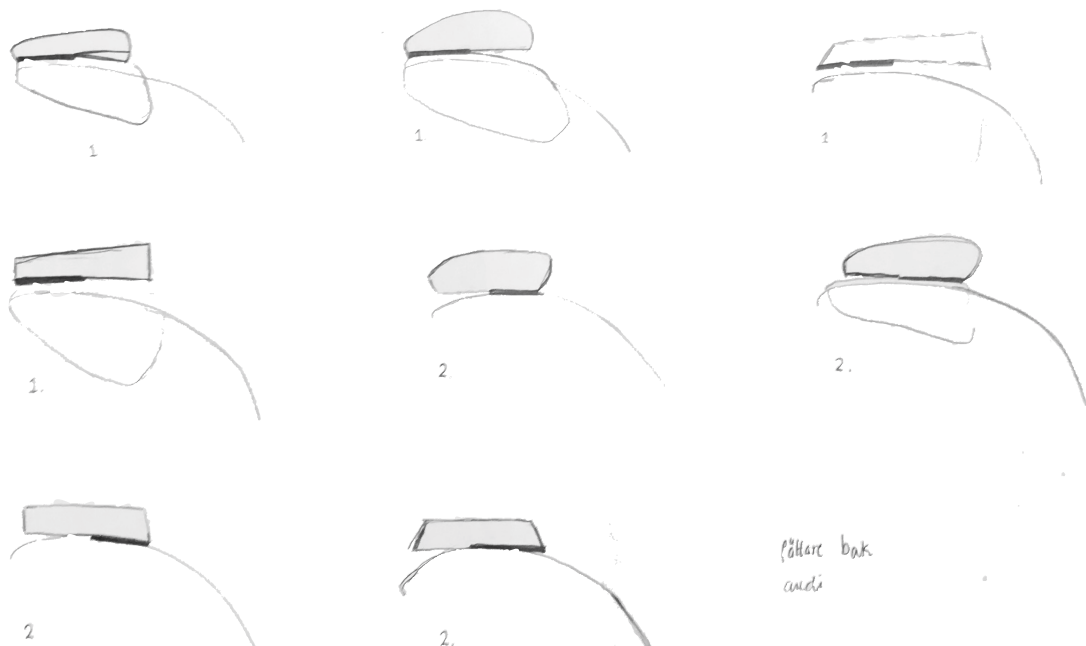


Figure 45 Sketches of forms attached on the dashboard, (Annvik S)



Figure 46 Prototypes made of Styrofoam, (Annvik S)

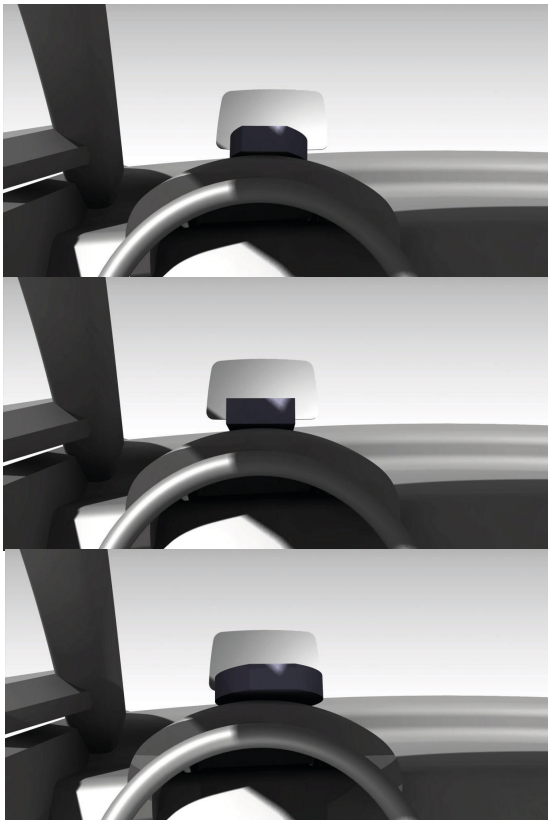


Figure 47 3D models inside the car, (Annvik S)



Figure 48 Prototypes tested in the car, (Annvik S)

8. Concept Development

This chapter describes the implementation and results for the concept development of the system. The concept journey is described, and all resulting ideas are presented.

8.1 Introduction

The purpose of this chapter has been to develop a concept system that includes a unit and a base mount that match and is usable in all different cars. The unit and base mount are divided into two concept development phases and conclude in a system development phase to guarantee the modules express the same feeling and is designed as a whole. The chapter ends with a system concept refinement where features and details are discussed.

8.2 Unit

This section describes the implementation and results for the concept development of the unit. The purpose of the development has been to develop a concept for how the unit is constructed and formed in interaction with other components. More detailed development of the other components for the final system can be found after this section.

8.3 Implementation

Several form generations have been iterated to ensure a well-worked form and match the company's identity. Each form generation is validated with a prototype and evaluation session. In the following chapter, three generations present information on how the different concepts were developed.

8.4 Form Development 1

Five different forms with inspiration from the idea generation were generated and

evaluated with the company and product profile character. Each concept is described below:

Modern

A concept with a marked waist, where each block from the waist is bevelled. The form gives a soft feeling, where the waist breaks it off, see Figure 49.

Thin

In a narrower and oblong form, the most extensive surface in front of the driver is bevelled. The form gives a soft and edgy expression, see Figure 50.

3layer

The form contains three visible layers that create a rounded form in the most extensive surface in front of the driver. The form express both soft and edgy feeling. The shape is also perceived as broader than the others, although it has the same width as the Modern and Whale concept, see Figure 51.

Whale

The form is simple and expresses a soft and robust feeling, see Figure 52.

Leftsharp

This form is non-symmetric, followed by a hard and a soft side. This form differs from the rest of the concept, which is flatter than the other concepts. This form expresses a

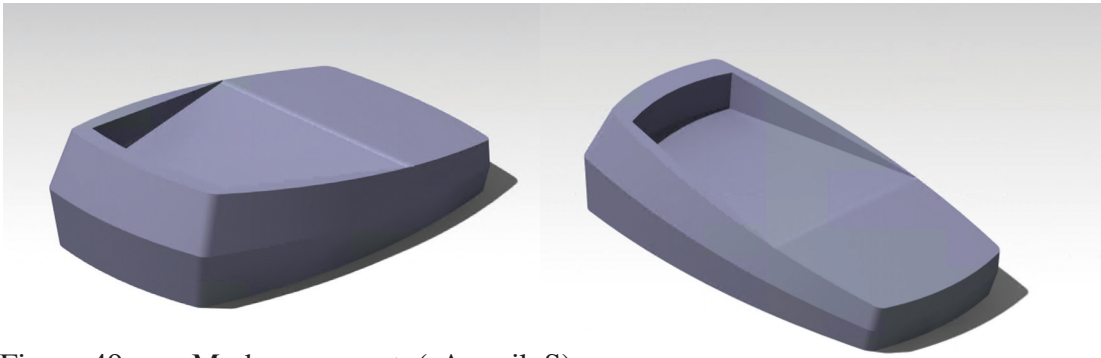


Figure 49 Modern concept, (sAnnvik S)

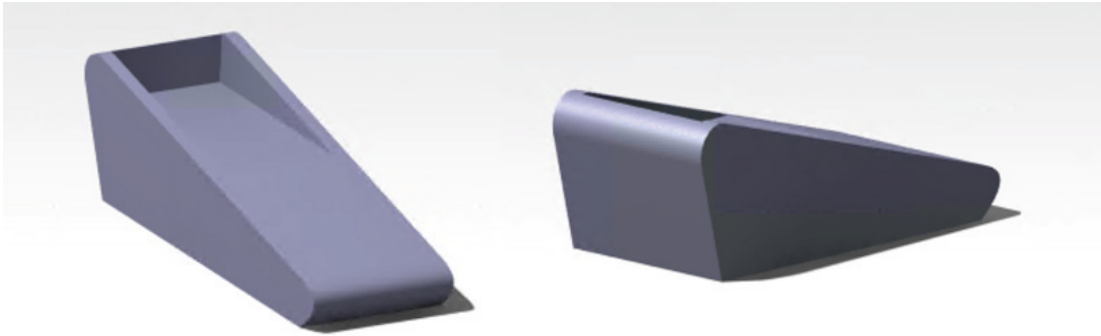


Figure 50 Thin concept, (Annvik S)

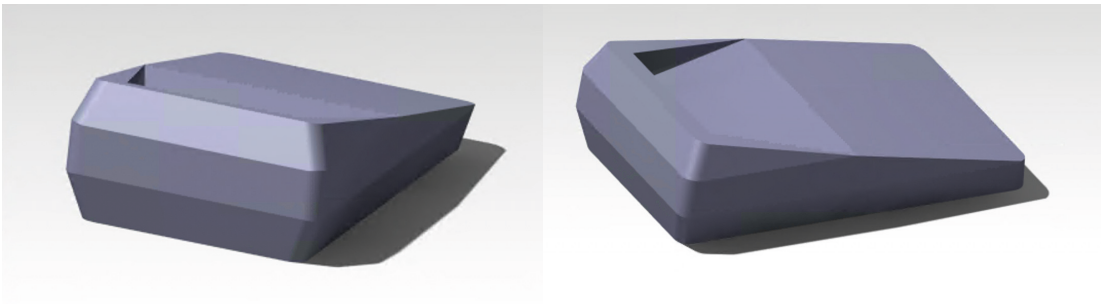


Figure 51 3layer concept, (Annvik S)

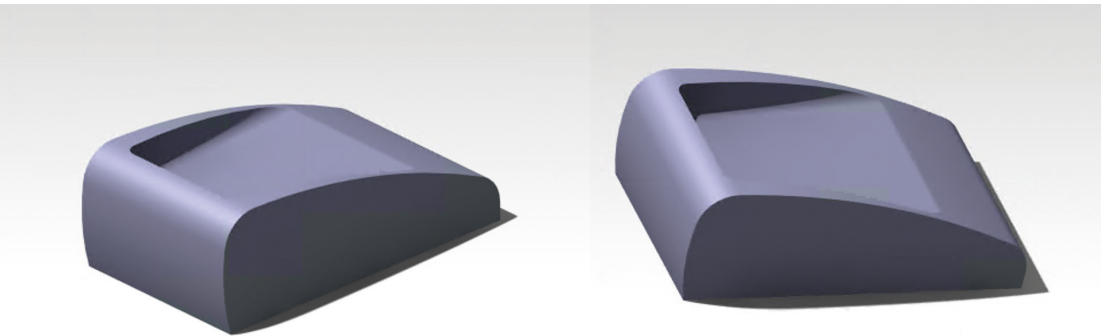


Figure 52 Whale concept, (Annvik S)

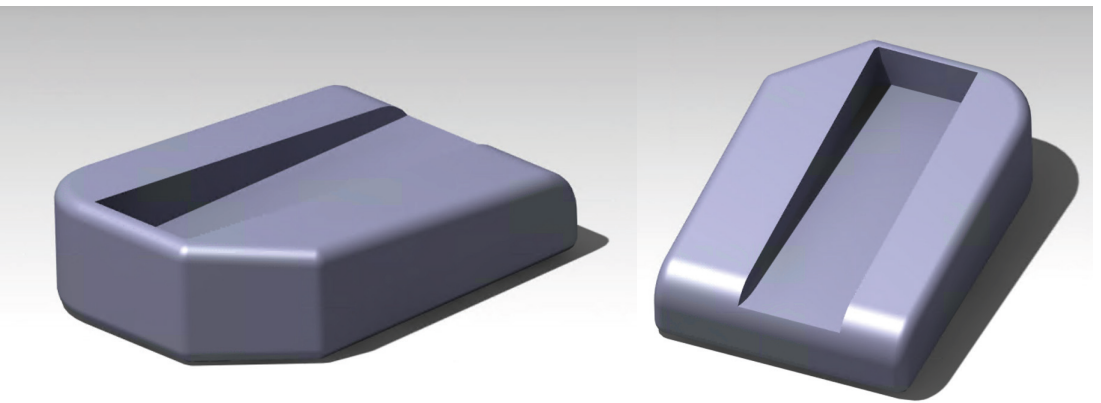


Figure 53 Leftsharp concept, (Annvik S)

more angular feeling with some soft touches, see Figure 53.

8.4.1 Evaluation

To evaluate the concepts objectively and find each concept's weaknesses, the product profile character *Appendix A* was used to compare against each other. The concepts that matched the profile continued to be developed, and those that did not match were eliminated.

The concept that met the profile character best was Modern, closely followed by Leftsharp. Thin and 3layers concept matched most of the aspects, some aspects were not extreme in any way, and some did not match at all. The concept that met the product profile worse was Whale.

8.4.2 Concept Results

A small summarise of the concept results will be followed.

Whale

The primary factor causing no further development was because it turned out to be heavy and big. Although other aspects of the profile matched well, these factors were too important not to consider, see Figure 54.

3layer

The concept met almost all factors. Unfortunately, the form was rated cold, heavy and oversized, nevertheless not that extreme as the Whale concept, see Figure 55.

Modern

The Modern concept met all prioritised factors of the profile, see Figure 56.

Thin

Thin met the given factors well, although the evaluation resulted in aspects as low identity, hard and cold, see Figure 57.

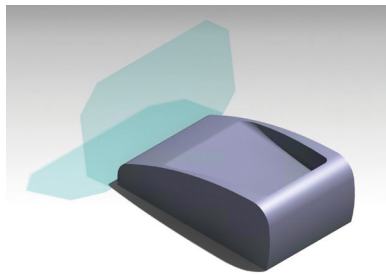


Figure 54
Whale concept, (Annvik S)

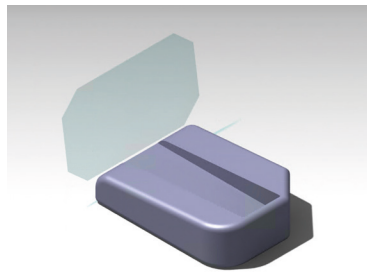


Figure 55
Leftsharp concept, (Annvik S)

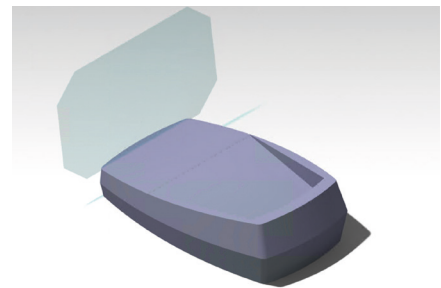


Figure 56
Modern concept, (Annvik S)

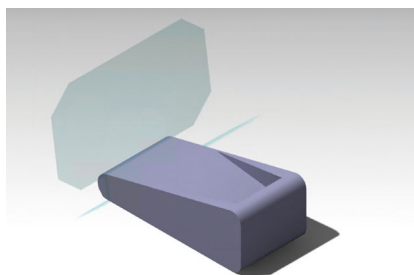


Figure 57
Thin concept, (Annvik S)

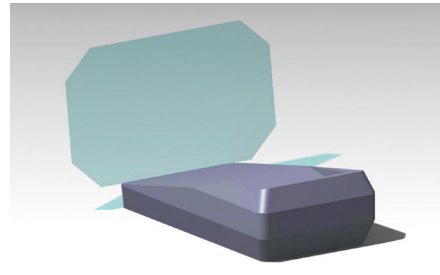


Figure 58
3layer concept, (Annvik S)

Leftsharp

Leftsharp met a number of aspects, and at some aspects, the concept rated low but still met the profile, see Figure 58.

8.5 Form Development 2

In the second generation of development, three concepts are presented, see Figure 59. Two of the concept are refined, and the third concept is a mix of the Thin and 3layer concept with a new name, the Lego concept.

8.5.1 Evaluation

These concepts are illustrated with 3D models and later evaluated with evaluations from the first and second segments of users. The four users needed to declare each concept with three worlds during a limited time. The time was limited to catch the first feeling of each concept.

Another concept evaluation on each concept was done with the company to gather their views of the form design. Their first intuition was equivalent to the small interviews with the users and validated the feeling of each concept.

8.5.2 Concept Result

The concept that received the best feedback from both the users and the company was the Modern concept. The conclusions were that the concept had a modern, inviting and easy form. The Lego concept form was also appreciated though concerns that the shape would not match all dashboards because of the angled feeling. The Leftsharp form was perceived as big, clumsy and old and did not receive any good feeling.

For more information about the design and its details, see *Appendix B, C & D*.

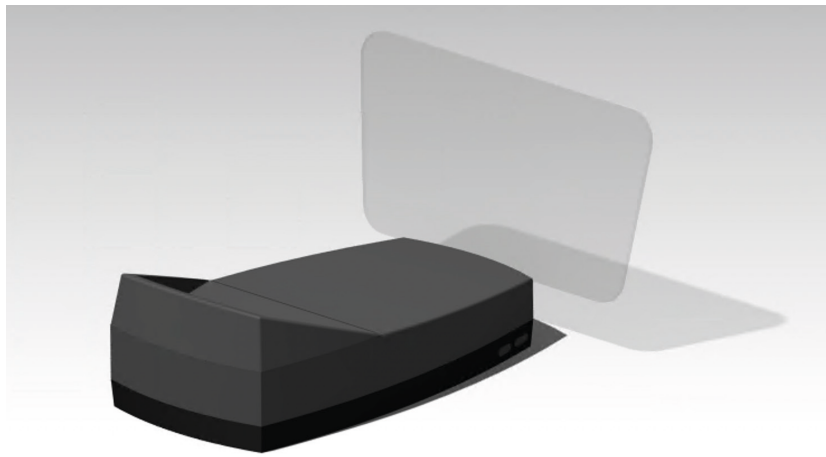


Figure 59
Three different concepts are visualized with 3D models in a perspective view, (Annvik S)

	Modern	Leftsharp	Lego
user 1	clean, modern, symmetric	big, clumsy, robust	sporty, good looking, exclusive
user 2	simple, easy, small	soft, big, clumsy	simple, easy, small
user 3	clean, modern, inviting	clumsy, old, big	anged, simple, easy
user 4	good looking, futuristic, modern	boxing, simple, big volume	easy, minimalistic, good looking

Table 6 Concepts feedback

8.6 Form Development 3

The second form development resulted in a decision, the Modern concept. In this section, generations of refining the Modern concept will be done. In the pictures below, there are 3D models where the base form are modified in different ways. The edges have different hems, seams and edges.

When modifications of grooving the sides and making one block higher than the other created an expression of identity at the same time retaining the expression of the basic form.

Figure 60 shows modifications of the form, working with two and three layers, shafted and angled sides. Figure 61 shows the results of the refined form of the Modern concept.

8.6.1 Prototype

The concept was 3D printed to receive a better realistic feeling, see Figure 62. The 3D model will be used during interviews to evaluate the concept more extensively in the coming section. Also, during the workshop, together with stakeholders. Feedback and results about the concept will be evaluated in the coming section, *System Concept 8.12*.

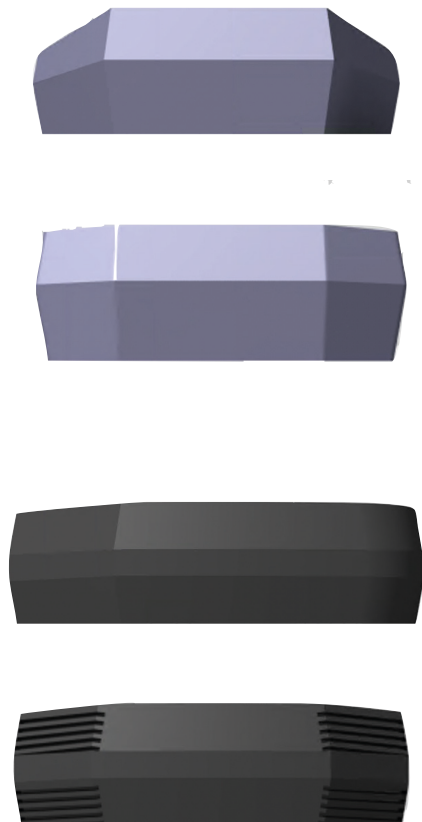


Figure 60 Refinements of Modern concept, (Annvik S)

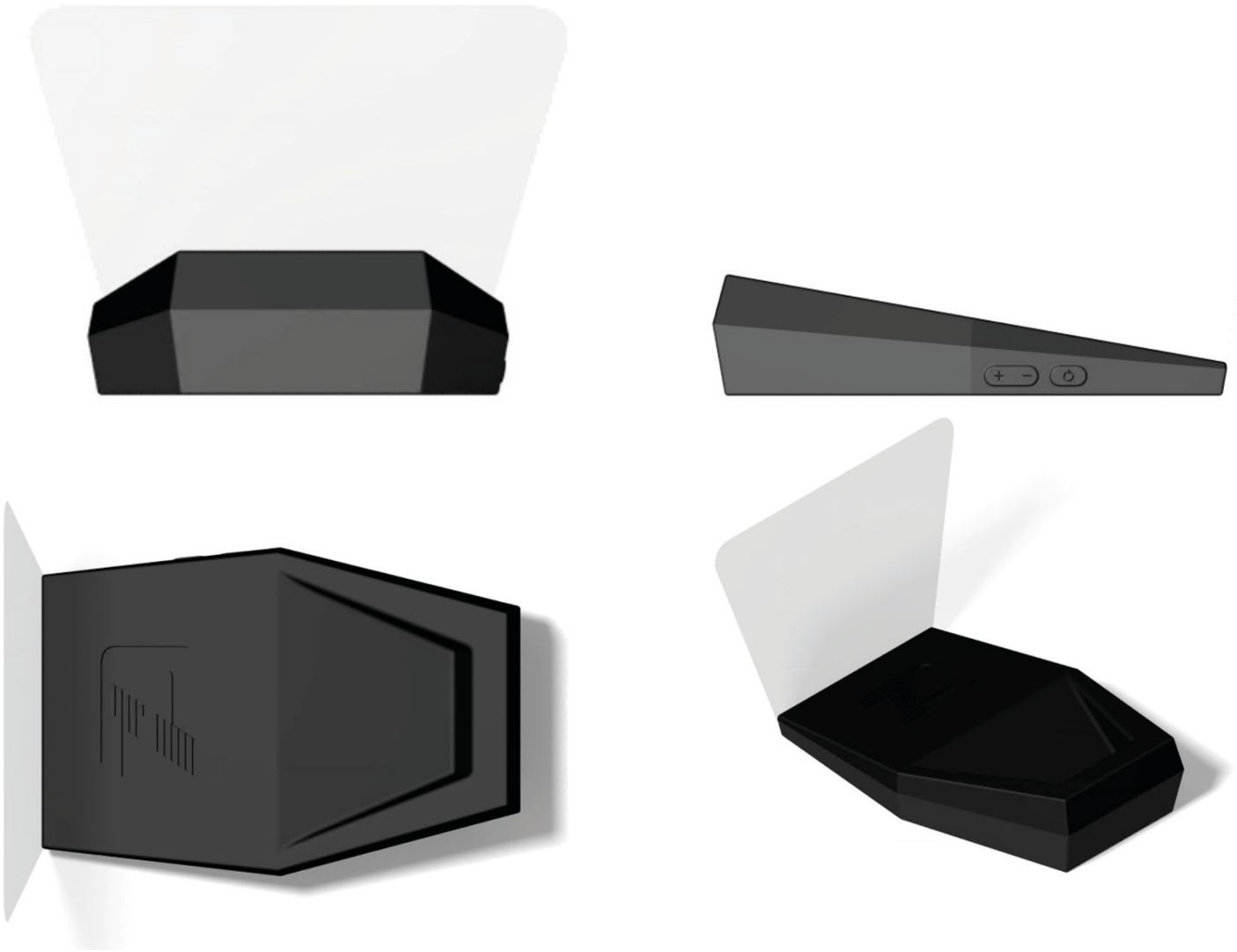


Figure 61 Final refinements of Modern concept,
(Annvik S)



Figure 62 Prototype of Modern concept,
(Annvik S)

8.7 Base Mount

This section describes the implementation and results for the concept development of the base mount. The purpose of the development has been to develop a base mount concept in interaction with other components. In the following section, the unit concept and the base mount concept are placed together as a system concept.

8.8 Implementation

The stakeholder is a newly started company that is in a pressured situation to get the product on the market. In talks with the company partners, they recommended using a standardized base as a basis and making a few modifications accordingly (see Figures 63 & 64). The development work of the base mount is therefore not as detailed as the development of the unit since the unit has a larger design space than the base mount at this instance.

In the following section, a presentation of the basis base mount will be held, and after that, form generations of refinements will be presented.

8.9 Ground Base Mount

The construction of the base mount is practical, with a magnetic base that effortlessly connects the unit with the base and transmits power to the device. The three sides of the unit are malleable and ensure that the base encloses most dashboards with its flexible construction and material, see Figure 63 & 64.



Figure 64 Ground base mount in car, (Annvik S)

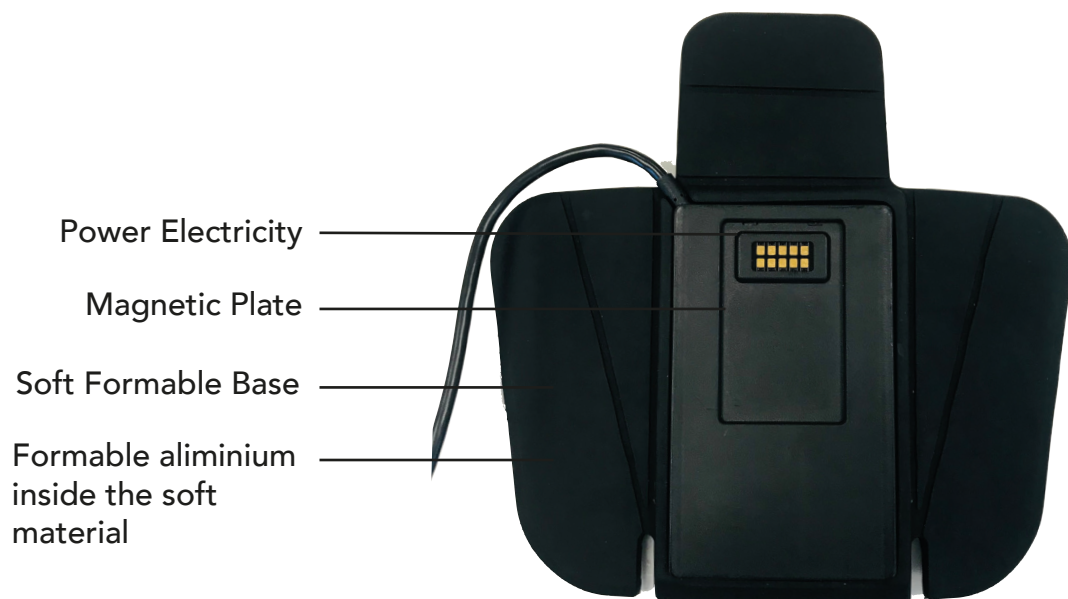


Figure 63 ground base mount part list, (Annvik S)

8.10 Base Development 1

With an arranged base plate, the focus was on designing the ends of the base to match the unit and become even more functional and stable. Five concepts were generated and illustrated with sketches. Since the primary purpose of the base mount is to create stability for the device, the five concepts were evaluated with paper prototypes.

8.10.1 Paper Prototypes

The paper prototypes were tested in three cars to observe the construction of the base was adapted to the shape. Below are the results from each concept presented. The prototypes can be seen in Appendix E.

Half

The Half concept provided stability, and the pattern adapted to the different dashboards well, see Figure 65.

Space

The prototype did not adapt to the dashboards because they lacked fold lines on the sides. The concept also lacked with the backside, which the backside provided more stability than expected, see Figure 66.

Slim

The slim concept was easy to handle, although it could have better shaping possibilities, see Figure 67.

Star

The Star concept adapted to the dashboards well, and it was easy to shape and handle, see Figure 68.

Frog

The Frog concept adapted to the dashboard, although it did not create as much stability as wanted, see Figure 69.

Figure 65
Half concept,
(Annvik S)

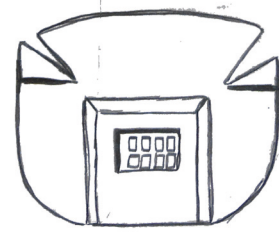


Figure 66
Space
concept,
(Annvik S)

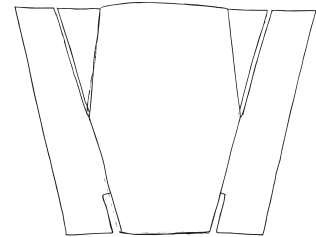


Figure 67
Slim concept,
(Annvik S)

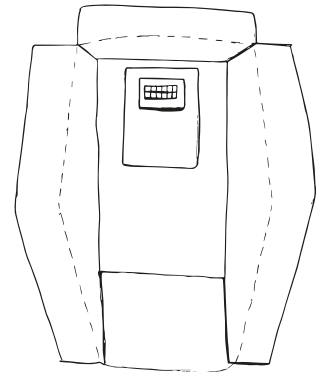


Figure 68
Star concept,
(Annvik S)

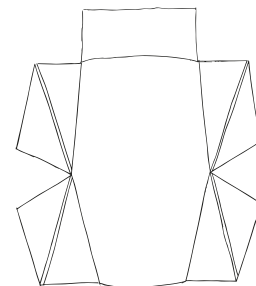
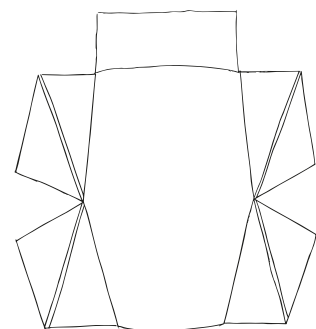


Figure 69
Frog concept,
(Annvik S)



8.11 Base Development 2

From the paper prototypes evaluation, three concepts were determined to be developed further. Refinements as small changes with the pattern and fold lines were made on the Half concept. The new concept Function is a compound of the Star and Slim concept. The form from the Slim concept combined with the Star concept makes a new concept more functional and easy to shape and handle, see Figure 70.

As mentioned before, the primary aspect of the base mount is functionality. As much as the author knows right now, both concepts fulfil the primary requirements of functionality and adaptability. It is also essential that the base mount and unit express the same form language.

A brainstorming session with the two concepts and the prototypes were held to validate ideas. The Half concept was eliminated due to the forms and feelings did not match the unit design. The Half concept has more round forms and expresses a more soft feeling than the unit dose. The Functional concept forms matched the unit better, see Figure 71.

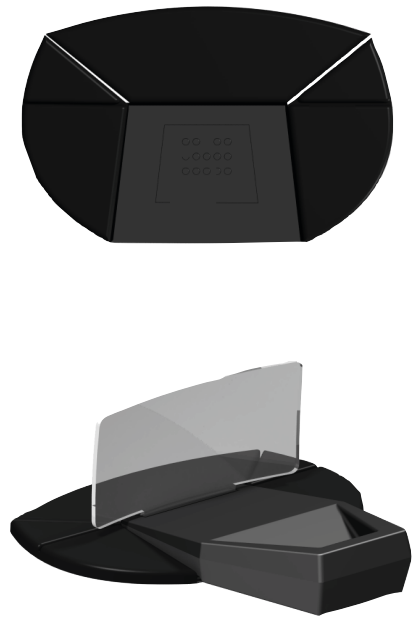


Figure 70
Base mount concept Half, illustrated with 3D models of the base mount and the whole system included base mount and the unit, (Annvik S)

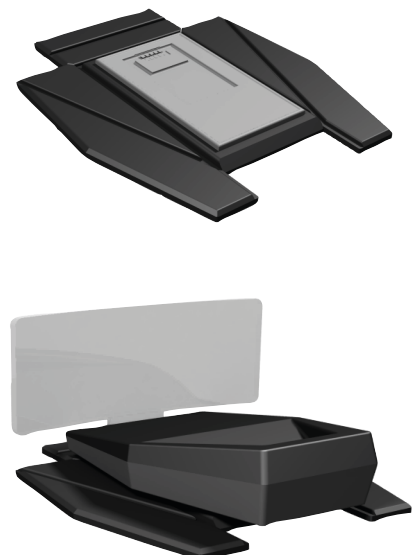


Figure 71
Base mount concept Function, illustrated with 3D models of the base mount and the whole system included base mount and the unit, (Annvik S)

8.12 System Concept

This section describes the whole concept system's implementation and results: unit, base mount, and combiner, see Figure 72. The company are in a pressured position and lacks money, and to save money and time, the combiner design needed to be standardised. This section focuses on the development of the whole system and how all parts interact with their components. Small details concerning the user-friendliness and stronger identity of the system can be found in this section.

8.13 Implementation

The parts in the system was 3D printed for visualisation, and the system was then tested in ten car models to see if the system had the right size and fitment, see Figure 73. A workshop with stakeholders and two extensive interviews with users were held. The interviews had two topics: the system's feeling and how to attach push buttons in a user-friendly way.

All feedback was summarised, and refinements on the system continued and will be explained below.

8.13.1 Workshop

A workshop with ten stakeholders verified that the unit's design was masculine and angled with a specific form of character. The summarise was that some edges were needed to smooth down because of the hard expression.

An interesting discussion during the workshop was regarding the products personas and the design. As explained in *Product Identity chapter 5* the personas prioritise different things. The different prioritising in the segments gave concerns regarding the design. To satisfy the whole user segment, perhaps two different designs or a not as extreme model needs to be developed.

Further discussions during the workshop focused on developing the whole system; body (base mount) and head (unit) need to match their expression as a whole body.

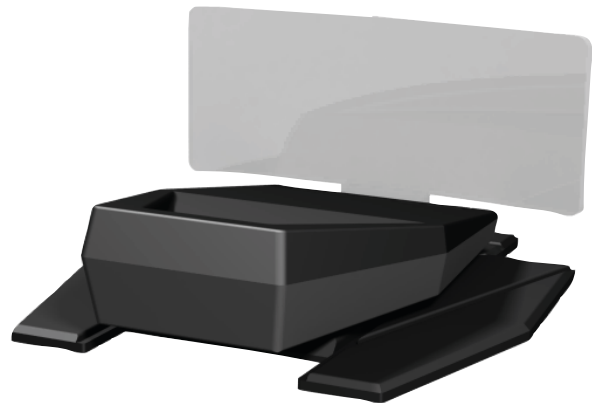


Figure 72
System Concept; base mount, unit and combiner, illustrated with a 3D model, (Annvik S)

Brand identity

A topic during the workshop was a discussion about strengthening the feeling of brand identity, where the stakeholder declared that they felt a strong brand identity and no more elements that strengthening the brand identity does not need to be added.

8.13.2 Interviews

Two in-depth interviews were held, which involved questions about the first feeling of the design, how the system was mounted in the car and the positions of elements and details.

Interview 1

A user from segment two who owns an electric car and loves new technology thought the system design was masculine. The system design had hard edges and a straight form language, which stands out from the dashboard and interior forms inside a car.

The user summarised that the most user-friendly push buttons need to be on the top of the unit to prevent the unit from moving. The speaker can be positioned on the top of the sides of the unit to create the best acoustic.

Interview 2

A user from segment three has four teenage children, lives a stressful life, needs a practical lifestyle, and cares a lot about her car; she explained that she liked the design.

The angular elements created an excellent identity feeling, although she thought the front of the unit felt high compared to the unit's back.

She explained her view to express the brand identity of the unit:

"If I buy something to put in my car, I want it to be invisible and discrete as much as possible. As it already stands out with its form language, there is no need to brand the unit. As for now, I own an exclusive car model, and if

I buy something for my car, I want the product to have the same brand or no brand at all."

She prefers to have push buttons on the side, visible for the driver and within reach—same material to make it as visible as possible.

Figure 73

System Concept; base mount, and unit mounted on a Volkswagen dashboard, (Annvik S)



8.14 Details of Concept System

After analysing the concept system, discussions regarding the details were made and can be found in this subsection.

8.14.1 Pushbuttons & Speaker

After discussions with users, the stakeholders and tests in cars, results were taken to place speaker and push buttons on the top of the unit, see placement in Figure 75.

The buttons will have the same colour as the unit, so the user mainly will interact with its buttons through touch. Then the buttons must be raised or lowered so that users can feel the button. Size, placement, and colours of the touchpoints higher a good product feeling. (Wheeler, 2013)

8.14.2 Camera & Microphones

Sketches and models in 3D helped decide where to place the camera and microphones, see Figures 74 & 76. It is essential that the camera and microphones are in the front of the

user and that the handlebar is not in the way. In Figure 74, options to place cameras and microphones on the upper layer of the upper part of the unit. After tests, it showed it was okay to place the camera in the middle of the unit's height, see Figure 76.

8.14.3 Material choice

To create more character ideas to have two different materials or surface roughness. After interviews, discussions, and references to the product profile character *Section 6.2*, the system wants as visible as possible, decisions to have the same material of the unit and the base mount was decided.

8.15 Insights

To summarise the development work, the concept has a character and express the feeling of the company. However, the concept design is too angled and masculine and needs to be refined to match the first and second user segments. The development work is to compromise between identity and visibility.

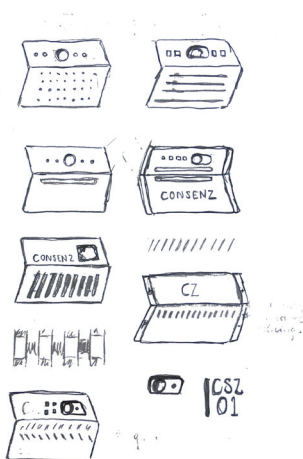


Figure 74
Sketches of different position of camera, microphones and speaker in front of the unit, (Annvik S)

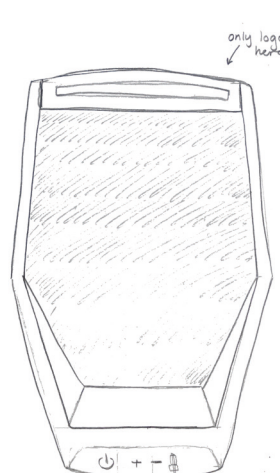


Figure 75
A sketch of how to position push buttons and speaker, (Annvik S)

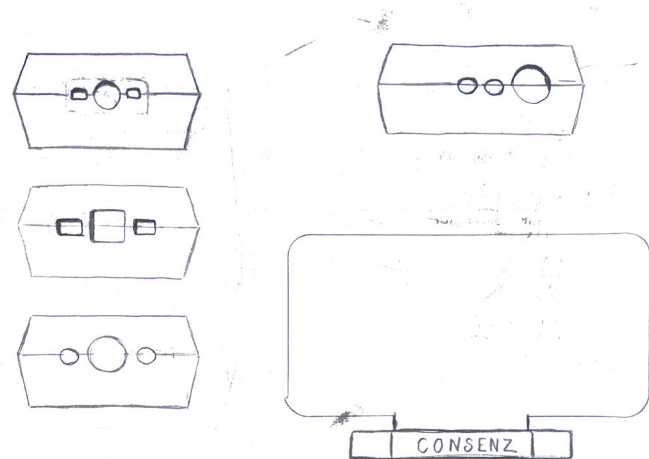


Figure 76
Sketches on different solutions to place camera and microphones on the unit, (Annvik S)

9. Final Concept

This chapter outlines and summarises the HUD as a system and as individual parts in terms of visual expression, features, ergonomics, materials and manufacturing. Overall sustainability and user analysis are described at the end of this chapter.

9.1 Introduction

The designed HUD system named Enzo (Figure 77 & 78) is a head-up display intended for people with high technology and car interest. Also, for those who have a stressful life and feels good when they are effective. The common goal with Enzo is to increase the security out in the traffic and improve sustainability. Enzos modules consist of a base mount connected with a unit and a combiner. Enzo has a masculine form of appearance combined with a visible smooth design that melts in with different dashboards, see Figures 77 & 78. The design process has been user functional and esthetical driven and is the company's prototype.

9.2 The system and its expression

The desired form identity is explained through frameworks as a mood board, imageboards and product profile character. The product profile character is used below to explain the final design.

Enzo is designed to be understandable, melt in with the car interior but still have its own identity. It has been essential to be functional, ergonomic and fits into a lot of different dashboards.

The final unit design has a divided top and bottom and create a feeling of stability and robustness. With the units smooth and rounded lines and edges, the surface merges perfectly

with the soft and smooth feel of the dashboard. The straighter and hard lines of the design are inspired by the edgy mood board and also increase the company identity.

The curved front form decreases the feeling of light and small, and the silhouette of the device gets a much neater impression from the front. The curved shape makes it more user friendly and grab-able when the front is not that broad.

As mentioned, the unit consists of two blocks, top and bottom, that use repetitive lines and forms and contrast each other and creates a balanced impression. The design is simple with repetitive lines and soft edges, and certain elements have more straight lines that initiate a more identical shape.

The details as the camera, pushbuttons and speaker, increases the company identity with clean and straight elements and will be discussed later in this chapter.

9.3 Corporate Identity

Since the company does not have a product portfolio to study when creating the form language, the design has been created through requirements and company identity. The values that have been in focus are: supportive, safe, belonging, human-centric and educational.

Supportive is represented by its focused user design. The base mount needs to be installed first, and with a magnetic bottom connects with the unit and supply the unit with power,

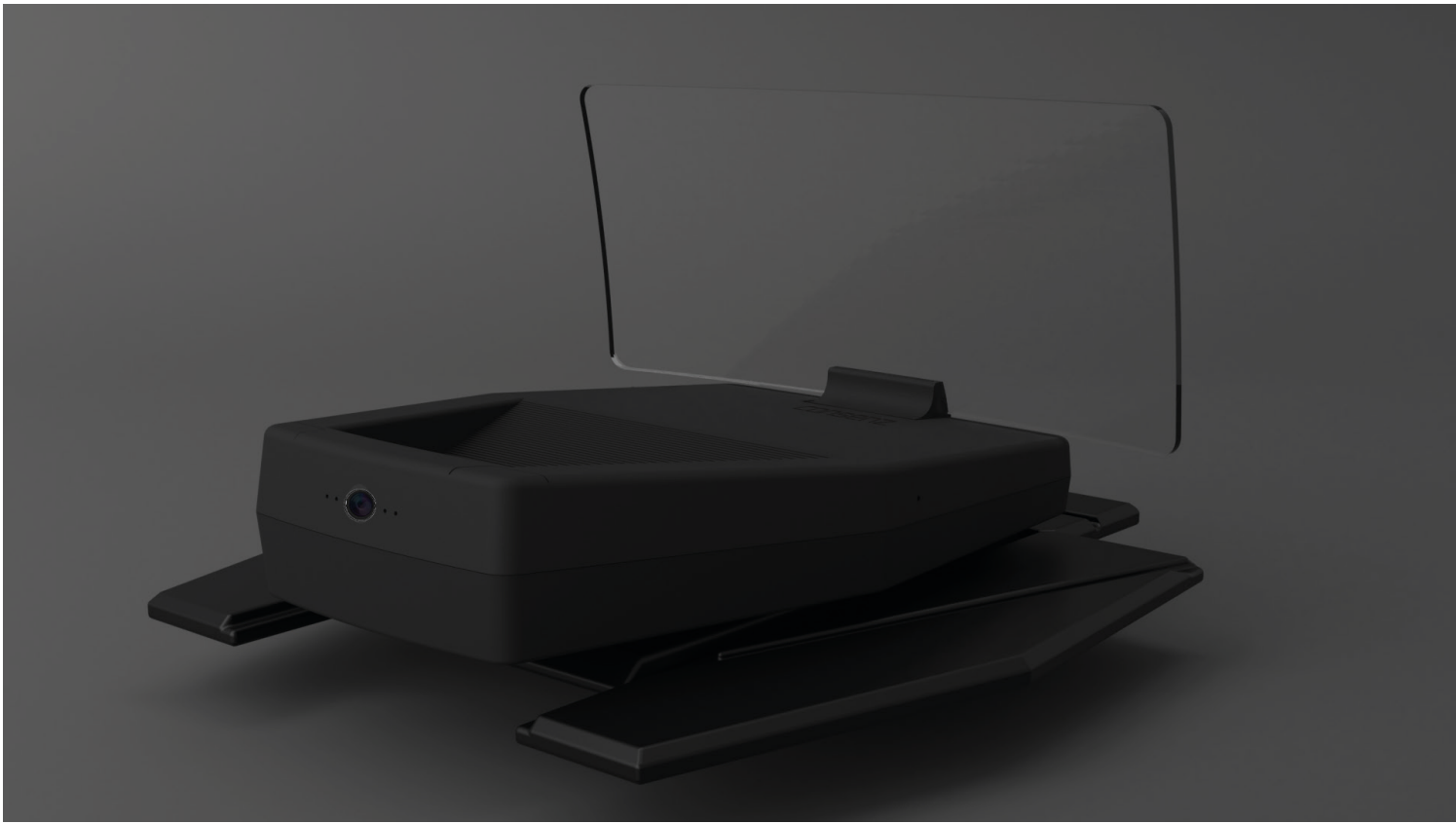


Figure 77 Side view of Enzo, (Annvik S)

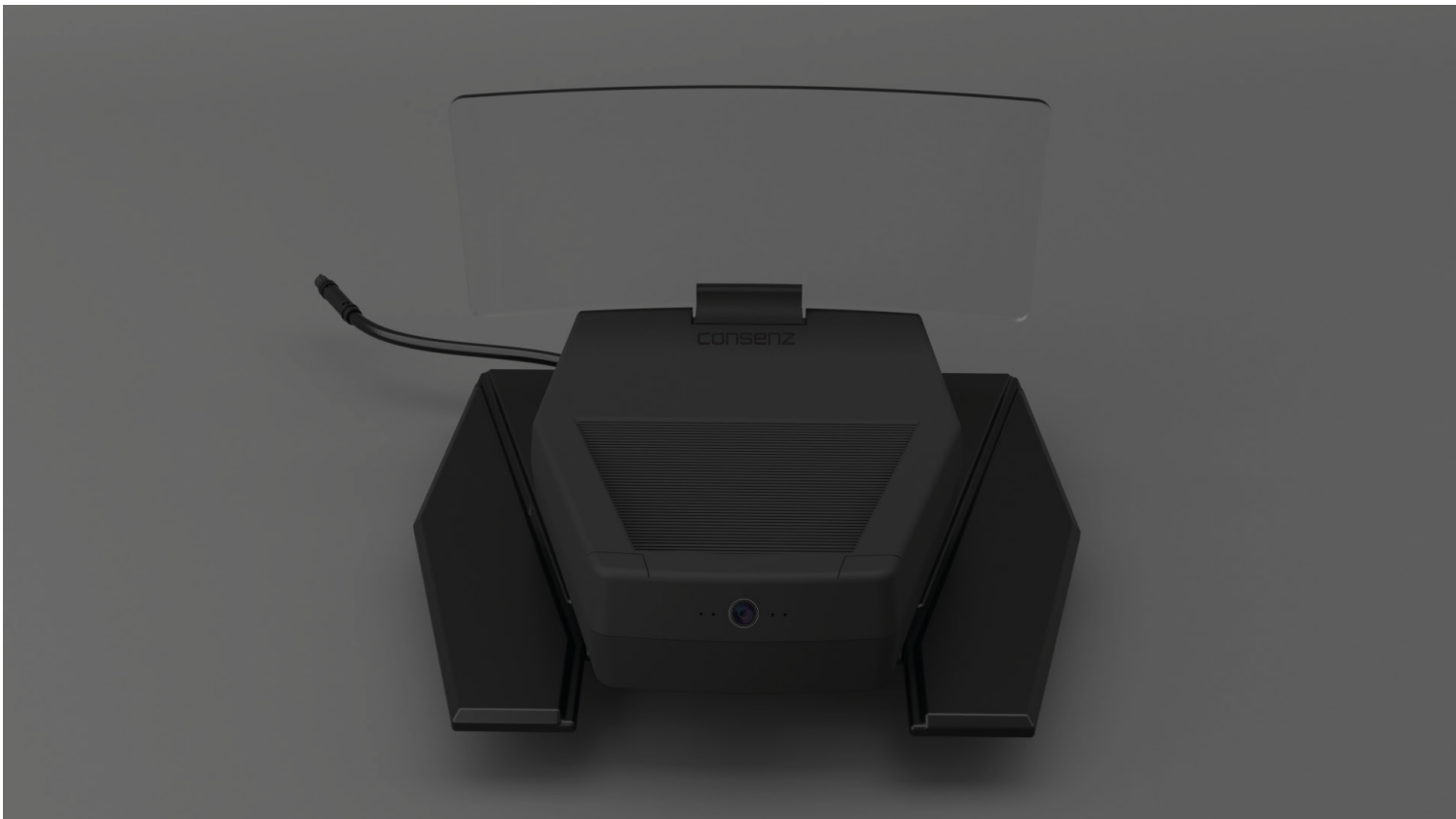


Figure 78 Top/front view of Enzo, (Annvik S)

see Figure 80. The combiner can be angled to suit different drivers and preferences. The unit only have two buttons, on and off and mute function, for remaining features, the device requires interactions orally, see Figure 78.

Safe is represented by the 'lips' of the base mount; the 'lips' secure the position of the system and guarantee it stays where it should see Figure 80. The system does not require integration with the device more than orally or if the driver wants it to be turned on or off. The bottoms are positioned on the top to secure the system does not move when interacting with the unit see Figure 80.

Belonging is represented in the form by its clear repetitive lines of different angles and shapes. There are some traditional round and smooth shapes where straight lines break the expression of ordinary and make its own. The size of the unit is not much larger than today's mobile phones and makes it easy to handle.

Human-centric and educational represents more of the app design and visual guidelines that shows on the combiner glass. The focus is to be user-focused and communicate a clear message to the user see Figure 79. During the system's installation, the app will guide the driver to facilitate the installation.

9.4 Product Profile Character

When evaluating Enzo out from the product profile character, the evaluation showed that the design met the feeling and expression as desired, see *Appendix F*. The only criteria that did not match the profile were that the user perceived the design rough and not smooth.

9.5 Brand recognition

Creating a recognition brand feeling has been a constantly working progress. Brand elements in the design can improve recognition and a desirefeeling. The texture of the speaker and



Figure 79 Front view of Enzo with user interface, (Annvik S)

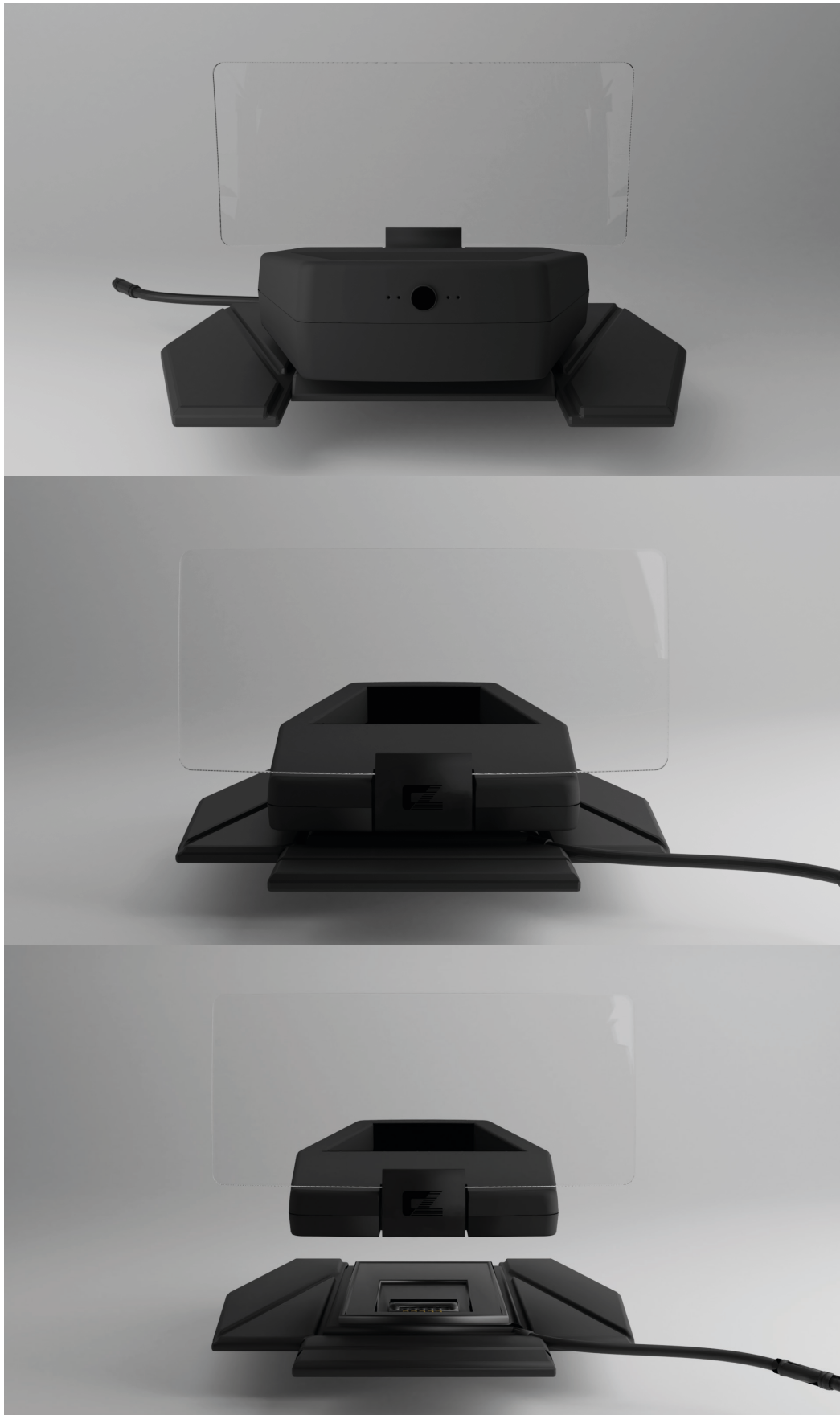


Figure 80 Different views of Enzo,(Annvik S)

the angled waist are elements that can be used in future product portfolios see Figure 77.

9.6 Material and manufacturing selection

The requirements placed on the material presented in *chapter 4*, these aspects have been taken into account. Each system material will be described below, divided into the base mount, unit and combiner. The chosen material and manufacturing process are validated with company partners that will industrialise Enzo. More about colour and texture are mentioned in the coming section below *Colour and texture section 9.7*.

9.6.1 Unit

The unit top detail is made of Polycarbonate (PCABS), which is very durable. The thickness of the unit is 1-3mm, and magnetic plates sized 8mm in diameter and 6mm thick are attached on the unit's ground, and the complete profile will be moulded, see Figure 81.

Injection moulding basics the process is described with three parts: an extruder, mould and clamp unit. The process begins with spraying the material in a mould that maintains a certain pressure to reduce shrinkage. Some material is gradually fed out all the time at the same time as the mass begins to solidify. After the mould has cooled, the mould is removed with the help of spikes.

What is essential to keep in mind during injection moulding is that the product that is formed must be able to be taken out of the mould, which means that the mould form cannot go out and then in, without it gradually growing outwards or keeping the same shape, see Figure 81. This is why the unit is divided in the middle to enable manufacturing. To create a single detail, additive manufacturing is the only manufacturing method to use, which

would have been a more expensive production method if the unit needed to be sold in several copies.

9.6.2 Base mount

The soft material on the base mount is made of Polyethylene (PTE), and the base mount consists of a metallic base where the PTE has been moulded around the metal plate and been refined through cutting the final details.

9.6.3 Combiner

The combiner is made of polycarbonate with an antireflective coating layer. The coating layer is vacuum treated in an oven that melts the film on the polycarbonate. The surface finish is fine, and the material is transparent. The combiner is moulded and refined through machine milling.

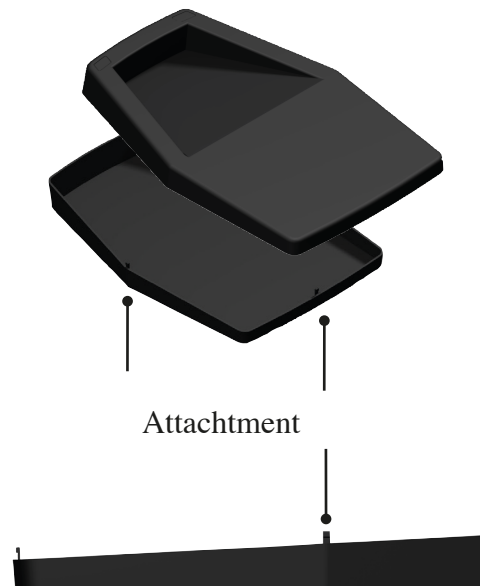


Figure 81 Manufacturing detail, (Annvik S)

9.6.4 TFT Screen

The TFT screen is a standard component that will be mounted on the unit. When it was tested on the prototype, the evaluation showed a wide thermal variety. Discussion changing the TFT Screen into LCOS Screen can make improving results.

9.7 Colours and textures

The whole system is coloured in black to be as visible as possible and match the dashboard. The colour provides an aesthetic, clean and professional feeling. It also increases the solid and stable feeling compared to lighter colours.

The base mount and unit are made of different materials, although communication with Mold-Tech that manufacturing textures believe there is a solution to create the same texture and surface finish. Having the same texture and surface finish have been preferable, but depending on the price tag and time limit, this is a decision in the company's hands.

Different textures and surfaces were analysed, and the chosen texture is from Mold-Tech Engraving Group named MT-11510 (0.0007 deep & 18 μ deep).

The logotype on the unit consists of the same material and colour but has a different texture that is not that visible but still stands out. The chosen texture is from Mold-Tech Engraving Group named MT-11001 (0.0001 deep & 3 μ deep) and has a more refined surface and an expression of glossiness. This texture choice gives the HUD a more characteristic appearance with elegant, recognisable elements, see Figure 82 & 83.

9.8 Customer branding

The logotype is placed on the top of the unit, and the brandmark is placed on the back of the unit, see Figure 82 & 83. The brands will have the same material and colour but with different textures and surface finish. The brand then becomes discrete and elegant, and distinct from its competitors and product copies.

9.9 Functionality

Identifying the requirements from *Chapter 4*, legal and ergonomics aspects needs to be fulfilled, below are different functions that are verified described.



Figure 82 Branding detail, (Annvik S)



Figure 83 Branding detail, (Annvik S)

9.9.1 Legal aspects

The main reasons for having a separate base and unit are to guarantee the safety aspects with added equipment in the car.

In case of an accident, the base mount and its connection between the unit will stay still and not cause an accident that can injure the driver. All edges are smooth down not to cause any injure, and the unit places on its position easily that guarantee the unit stays in its position. The base mount design makes it fit many different dashboards and can be mounted in the right way.

9.9.2 Ergonomic aspects

The ergonomic aspects noted in chapter 4 have been taken into account so that all different drivers can feel comfortable while driving. The combiner, therefore, mounts on a hinge that enables the combiner to be angled, see Figure 84. Also mentioned is that the surrounding can be hot and have been considering when choosing the material.

9.9.3 During Driving

While driving, there is no light or other attachments that can irritate the driver or drag attention to its more than the combiner display, see Figure 85. There is no need for interfering with the unit while driving, and it will be controlled by voice. The dark material and texture guarantee the light does not mirror or light up to drag wrong attention.

9.9.4 Driver interface

Since the company's combiner interface is not set in stone, these aspects were not considered when developing the design.



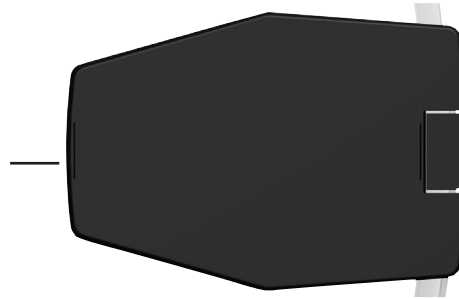
Figure 84
Unit angled combiner possibilities,
(Annvik S)

9.10 Accessories and functions

To understand Enzos overall functions an explanation will follow in the next side.

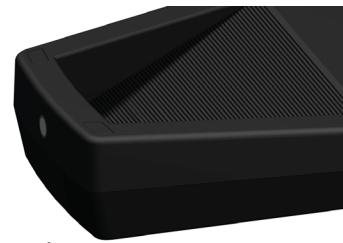
Fan

Air holes in the front and back create a natural airflow throughout the unit, so the system does not get too hot. It is the display unit that generates the most heat.



Attachment

The base mount consists of a metal base connected to the unit that has several magnetic pellets in size 8x6 mm embedded in the bottom.



Microphones

two microphones further back on the unit are mounted for the far-field.

Speaker

with knurled horizontal lines indicating the function of speaker systems

Pushbuttons

Two buttons are shaped after the edges of the unit, and the size enables the fingertip feel up the button. The buttons are lowered so the users can feel the button without not seeing it.

Light sensor

the light sensor is placed towards the user to register the ambient light to regulate the display light according to the environment.

Placement of technology

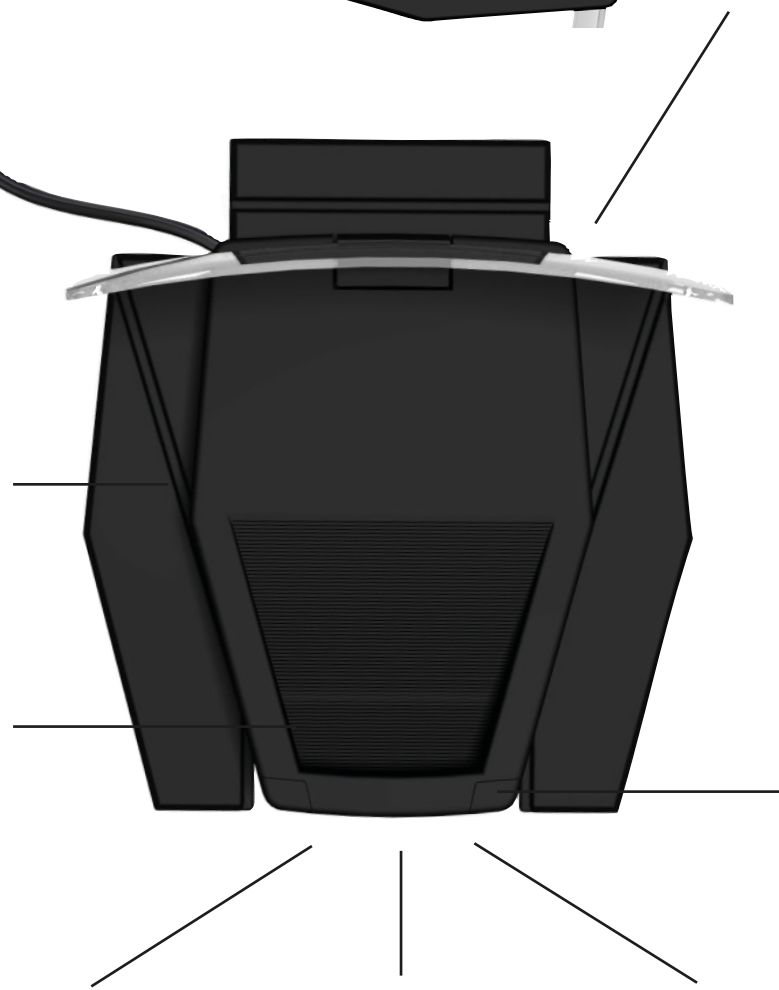
Positioned microswitch that contains light sensors that enable the use of the buttons.

Microphones

Five microphones are placed in total where three of them are near field microphones and the other two are placed at the rear are far field microphones. This placement is for removing background noise, an algorithm that perceives voice recognition.

Double-sided tape

Under the base, there is a film of double-sided adhesive tape that attaches the base to the dashboard.



9.11 Sustainable aspects

Three of four DFE goals will be used to evaluate and examine the sustainable aspects with the final concept.

1. Be Aware of the Environmental Effects of the Materials Used in Products

The unit Global Warming Potential was calculated, and with the exact unknown composition of the device, the device is assumed to have basically the same impact as a mobile phone (Söderström, 2021). As the device is larger than a smartphone and has more plastic details and the base and the glass, the global warming potential from manufacturing is a small increased number compared to mobile. Assumptions of the electricity during usage will come entirely from burning fossil gasoline.

2. Design the Product with High Separability

Modularising the system in a separate base and unit makes the product quickly disassembled, facilitates the reuse of components, and allows for a longer product life as parts can be upgraded.

3. Design Components That Can Be Reused to Be Recycled

Information regarding reuse and recycling of the system gives when installing the app. Disassembly guidelines and proper material markings can assure that a more significant percentage of the device is appropriately reused and recycled.



Figure 85 Enzo placed in a car, (Annvik S)

10. Discussion

In this chapter the discussion is presented, the discussion includes an evaluation of the project where the major parts in the thesis is discussed with comments and opinions.

10.1 Introduction

Many insights were realized during the project and reviews below. This chapter also takes up the fact that the project was very time controlled and how it affected the project as a whole.

10.2 Form and functionality

During development, I realized there was a lot of different aspects to consider when developing a HUD. In the beginning, the focus was to create a form language. Further in the project, insights that many more requirements were needed to be considered, like size, fitment, safety, and ergonomic aspect. Moreover, there have been two essential conflicts during the development. The first one mainly focuses on designing out from functionality or esthetic elements, and the other is if a set-based or point-based approach was the best to use. A need to divide the product into a base mount and a unit resulted in choosing a set-based approach. The base mount driving aspects contained functional design guidelines, and the unit operating requirements contained esthetic design guidelines. The design freedom was small for both modules. After decisions about developing the base mount out of a standard part, the design freedom was small and created more interest in developing the unit than the base mount. This led to two separate developing processes and expressions of the modules. Using a pin-point based approach could lead to a better overall impression of the product.

I feel satisfied with the form results, although it has been a struggle to balance the fact that the product needs to melt in and almost be visible and, in the same way, have a prominent character that stands out to competitive products on the market.

10.3 Technical aspects

I started this project with an open mind, and during the process, the technical aspect has constrained and influenced the process and design decisions, which narrowed down the design freedom.

To guarantee the right size and scale of the system, research within user interaction also constrained the aspects. Since the user will interact with this product in many ways, the product must fulfil user-friendliness. Requirements regarding safety aspects delimited the freedom of design.

10.4 Constraining aspects

Considering the company's position, cost and time limit was early introduced in the project as very critical. However, my freedom as a designer and take decisions was very accessible. This aspect influenced the whole project from start to end regarding choosing methods, approaches, and focus more. Comparing to other projects, the development process was concise, corresponding to the whole projects time frame.

10.5 Method

As this was one of my first projects focused on the visual aspects, I thought about the suitable method. As a result, many different methods were applied, existing, adjusted, own made methods were used and communicated with Boid to keep me on the right track.

Increased knowledge and close knowledge gaps workshops, interviews, and research gathered from different sources lowered the risk of missing information that contributed to the requirement list. Moreover, the company contributed with an extensive knowledge base that gave me insights but was also a risk of miss latent needs and objectives.

10.5.1 Development method

The most driving aspect of choosing the suitable method was time. When the project started, the manufacturing company and the stakeholders already waited after a proof of concept.

Analyzing the company's brand, values, mission and brandmarks and the technical requirements gave an extensive ground for translating all features and information into design guidelines for later brainstorming. A structural approach was used when analyzing all the data and drove the project forward. The data was compiled into frameworks as product profile character, imageboard, mood board and personas. These frameworks were used to communicate the striving idea and feeling and were used a lot as a reference during the product development process.

Early in the project, the brainstorming session yielded personal decisions about what is attractive or not. Taking personal decisions and missing structural evaluation left out an essential understanding of the market. Since the two segments are very different, this evaluation would help differentiate the two segments and what the segments found attractive.

The evaluation of the concept was through rating and personal assessment. During the evaluation, sometimes the feedback was examined optimistic because details were not finished, or the viewer had no idea how the finished picture would look. With continual communication with stakeholders, structural feedback and systematic evaluation have been made. However, this approach lacks some objective height but works well for fast decision-making.

Prototypes have been made to raise credibility in decision making and for validation. The prototype was tested in several car models and gave many answers to both general and specific problems. The systematic verification method lowers the risk of failure, and that all ideas have been tested from the start.

10.5.2 Project management method

Agile design sprints have been the key in this project to develop fast and validate new creative ideas. In the beginning, a GANT schedule was created, and while working with the company, much new information changed the direction and changed plans many times, making it hard to work after a GANT schedule. Then agile design sprints were used and were appreciated in this situation of the project.

10.6 Process

My role as an industrial designer entered the project late comparing to the ongoing process. From the start, the time has been pressured and limited. At the same time, information and requirements about the hardware changed over time. Many fast decisions managed the project, making it difficult to keep up and negatively affecting the design. This resulted in some negative aspects, where poor processes lead to poor decisions.

The collaboration with Boid has been very beneficial and a big helping hand during the process. It has also been an excellent experience to have their guidelines in this significant context. This has made me better prepared when starting similar projects in the future.

10.7 Validation and realisation

The final concept has high reliability due to refinements of prototypes, calculations concerning hardware fit, usage of standard components and no new developed materials are used. Before the product is industrialised, the hardware production company needs to review the design before guaranteeing it can be produced.

There are no calculations on cost or life span that can lead to a very high price or significant environmental impact, and adjustments need to be done before industrialising.

10.8 Sustainability and Ethics

This project has not contained studies of the HUD life span or sustainable aspects. The chosen materials can be disassembled and reused. Although the hardware components will have a worse effect on the environment, the integrated circuit (IC) is especially bad. Minimising the use of IC could make the product better for the environment and societies affected by material extraction and refinement.

Ethics

Ethical dilemmas were raised at the beginning of the product's development process, which was considered during the whole process. The ethical aspects have high importance since it concerns safety aspects that can save lives.

Although there are no directly defined rules regarding accessories in the car, it can not cause any damage. Also, the product does not need to achieve international certification standards to be legally sold to customers. Still, it is crucial to guarantee that the system not causes some accidents or even leads to someone else's death.

The developer's responsibility is to guarantee the system attachment is safe, which has been working with since early in the process. Guaranteeing the HUD's safety has been a trade-off between novelty and safety during the design development. All base concepts were tested, and some of the concepts were ruled out due to safety. It was hard to predict if the security aspect was enough to test with prototypes or if simulations were needed during the project.

10.9 The result

The project mission was to develop a proof of concept through a well-crafted form language. The final design fits in several different car models thanks to its adaptable base mount and the design based on the company's brand identity and values. I am satisfied with the final concept, although lack of knowledge has problems in visualizing the final picture and features that impact the final result.

11. Recommendations

This chapter presents the areas that the project developer recommends to investigate further or develop.

The attention has been to build a form language that evolves into a product design that can later be industrialised. The working progress has gone from an idea to an image of an actual product. The following will give recommendations of what actions need to be done before industrialising the product.

Evaluating the final concept with user stories to guarantee all functional and environmental requirements are full-filled—an observation of how the user would handle the final con-

cept.

Since there was no time to focus on a cost calculation and life cycle assessment (LCA), this needs to be studied before industrialising the final product.

Evaluation to assure the safety and ethical aspects are fulfilled.

12. Conclusions

In the light of discussion and reporting of results, the following conclusions and recommendations can be made in this chapter.

Regarding the project purpose of setting the industrial design and taking the prototype into a proof of concept following chapter will conclude the project's conclusions.

The form has its foundation from the core values of the company. The design provides several characterised elements, and the form language can be used in coming products. The design bases on the unit waist where the split lines meet and angled up and down. This creates a soft and identical feeling that can use in newly developed products. The repetitive lines on both sides make the design symmetric and smooth. The speaker lines create an identity of the company and make the design stick out. The work between balancing the design of an invisible product and a product with unmistakable character has been challenging. Translating the brand characteristics together with users has been valuable when designing a product with evident brand characteristics.

During the evaluation, both the ergonomic, functional and safety aspects are fulfilled. The base mount adapts to different dashboards, and the designed base guarantees the system stays in its correct position. The developed design is user-friendly; the unit connects to its base through the magnetic attachment and can easily be taken in and out from the car. The combiner glass can be angled to fit different drivers, and the mobile app helps the driver

install the electronic devices to the vehicle and how to use the system. The material choice and texture has a more matte finish to reduce the appearance of the collection of dust. The product split line through the waist makes the design prepared for production. Although simulations or more tests need to be done before assuring the whole system is safe.

The sizes of the unit have been reduced compared to the prototype. The colour and texture makes the product fit into its environment and match the surface of the dashboard.

The sustainable aspects have not focused on this project, although an analysis of the chosen materials and manufacturing process is recommended before launching the product. Nonetheless, the company must consider the life span perspective as the brand wants to be perceived as green and sustainable focused. This is fundamental to be more substantial to their credibility and trustworthiness.

The mission is to start manufacturing a low-cost small series of 20 units to be realisable in the future. However, after releasing the first units, the product needs to be re-evaluated for further refinements and advantages the design brings on the market.

Designing a successful HUD, the key factors have been translating the requirements

and brand identity into design guidelines with users. When summarizing the conclusions, the project result ended as expected. However, more time is needed before resulting in an industrialised product. The new product design has a form language that can be used for other design versions and products where the company's values and translated design features are expressed and utilised.

13. References

This chapter presents the used references in the project.

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15. Appendices

Table of Content

Appendix A.

Evaluation of concepts

Appendix B.

4 views of concept Lego

Appendix C.

4 views of concept Modern

Appendix D.

4 views of concept Leftsharp

Appendix E

Paper prototypes

Appendix F.

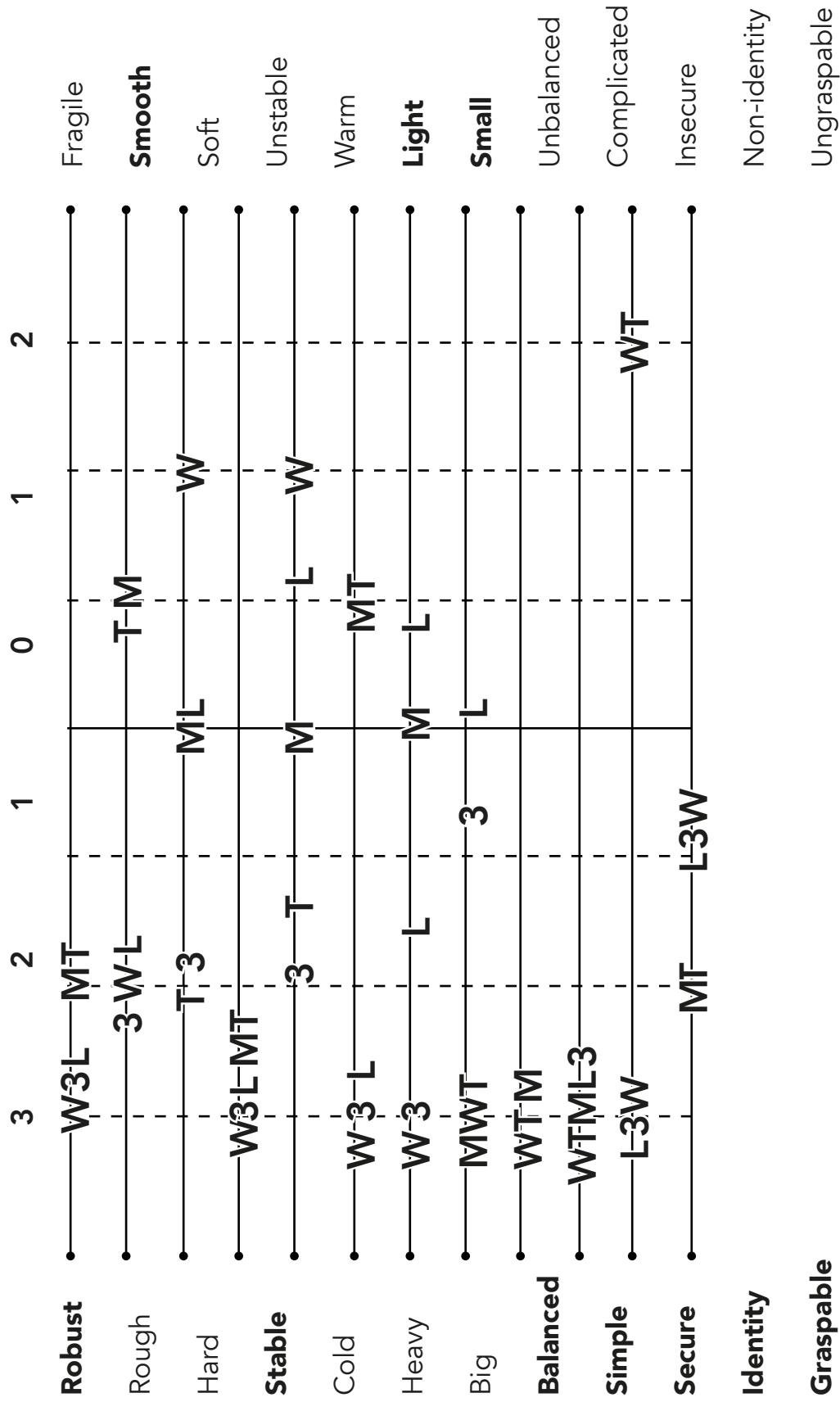
Evaluation of final concept Enzo

Appendix G.

Technical information about Enzo

Appendix A.

Evaluation of concepts



Appendix B.

4 views of concept Lego

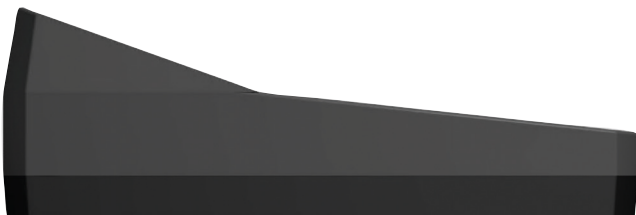
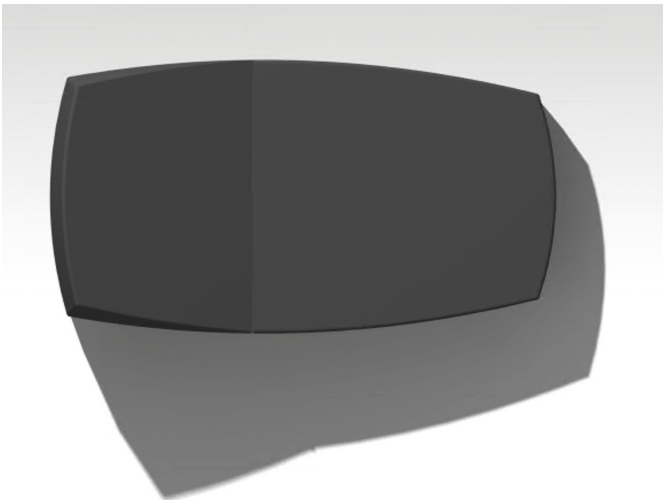
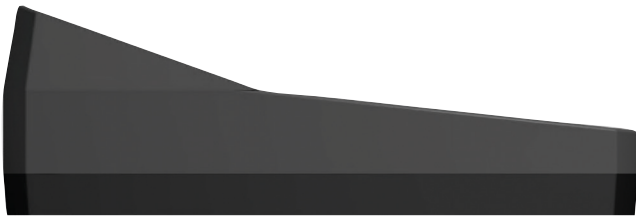
Interview information

user 1 is 21 years old and high technically and car intrested.

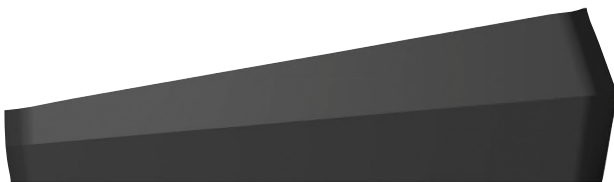
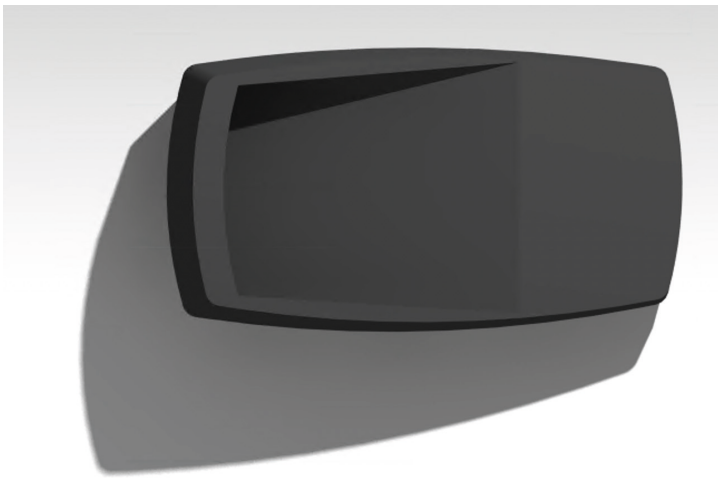
user 2 is 23 years old and working with developing formula cars.

user 3 is 35 years old and have a stressfull life and working a lot.

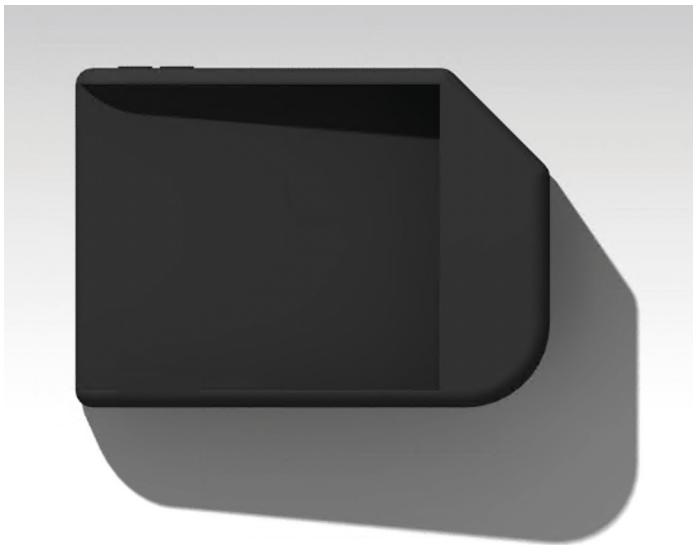
user 4 is 45 years old and have three children.



Appendix C.
4 views of concept Modern

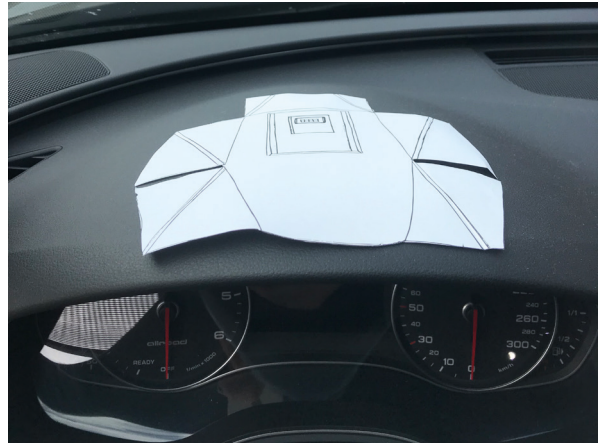


Appendix D.
4 views of concept Leftsharp



Appendix E

Paper prototypes



Appendix G.

Technical information about Enzo

Isometric view
Scale: 1:1

Bill of Material: Minimal concept

Quantity	Part Number	Type	Number
1	Small Optical engine	Part	1
1	CM2125	Part	2
1	Camera	Assembly	
1	Blower fan 20x20x5	Assembly	
1	USB C	Part	3
2	Mems microphone	Part	4
1	Smallest battery	Part	5
1	Ambient Light sensor	Part	6
1	MicroSD and Nano Sim combo port	Part	7
1	GPS antenna	Part	8
1	Headphone jack	Part	9
1	Small Speaker	Part	10
1	PCB	Part	11
1	LTE antenna	Part	12
1	Shell	Part	20
1	Mount	Assembly	
1	Minimal concept_1	Part	13

Bill of Material: Camera

Quantity	Part Number	Type	Number
1	flat cable	Part	14
1	Camera_1	Part	15

Bill of Material: Blower fan 20x20x5

Quantity	Part Number	Type	Number
1	B2005-PILLOW	Part	16
1	LABEL	Part	17

Bill of Material: Mount

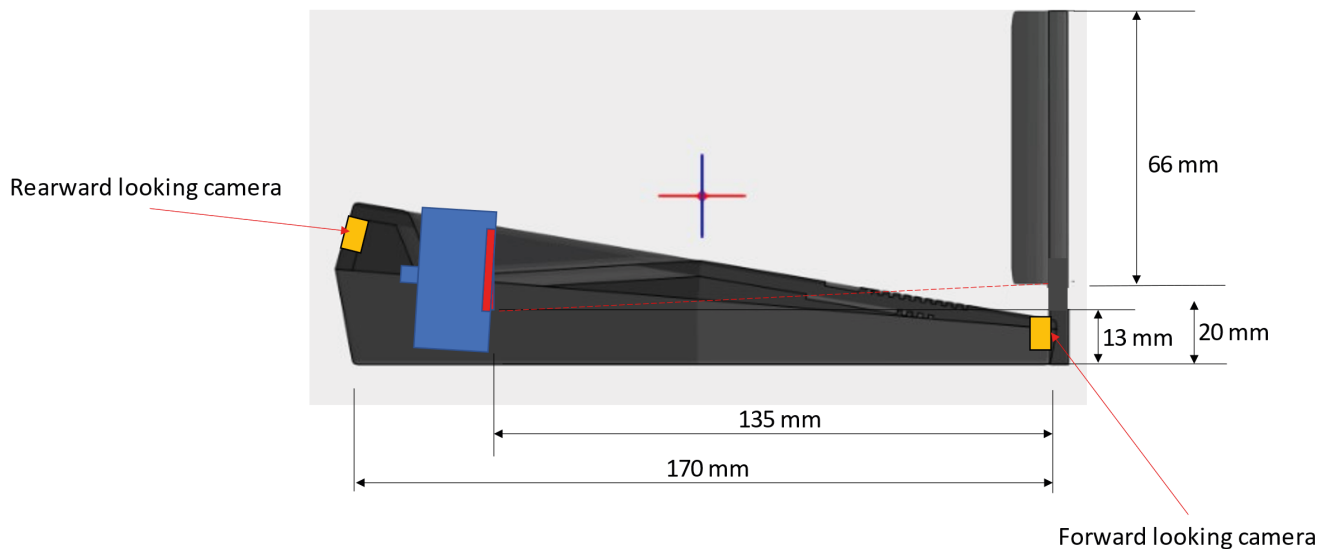
Quantity	Part Number	Type	Number
1	USB C male	Part	18
1	Mount_1	Part	19

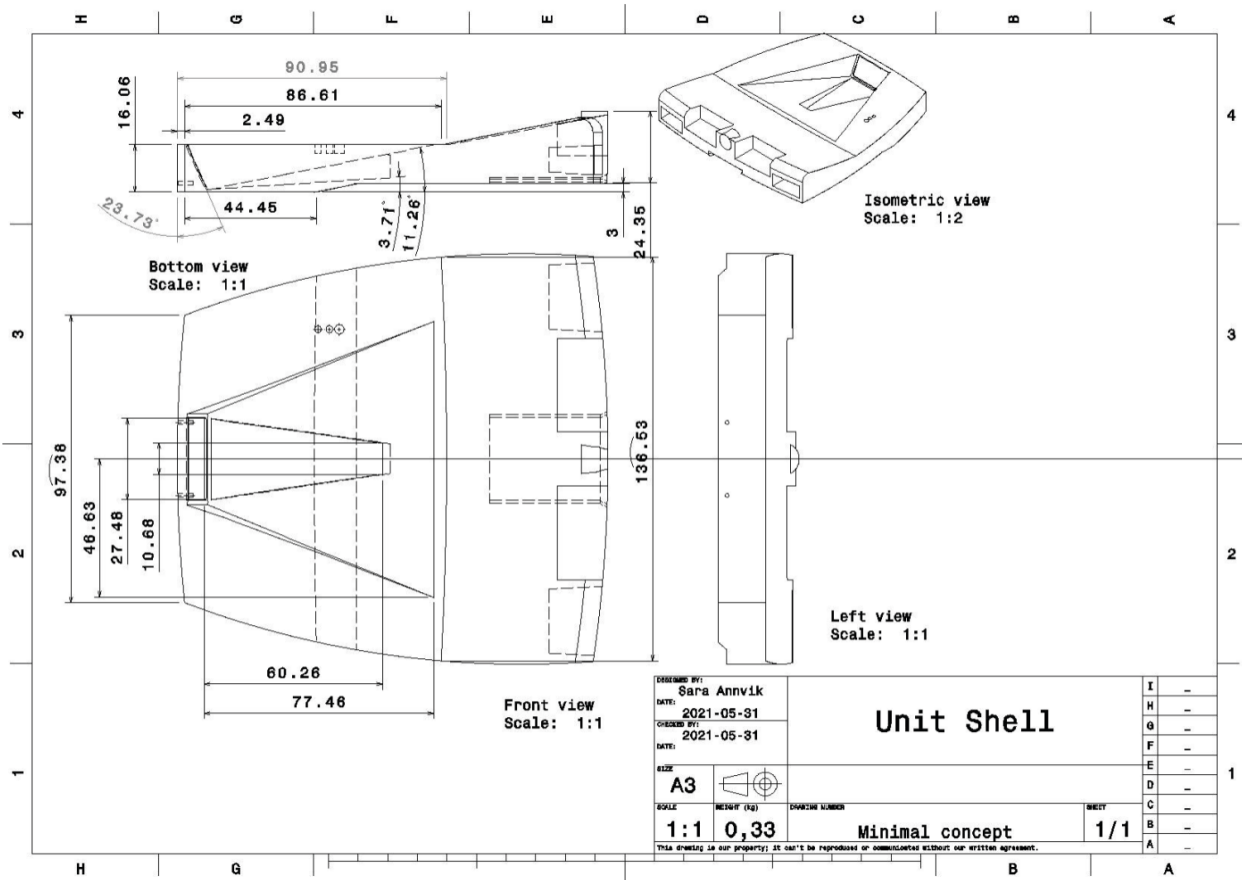
DESIGNED BY: saraann
DATE: 2021-05-31
CHECKED BY: XXX
DATE: XXX
SIZE: A3
SCALE: 1:1
WEIGHT (kg): 0,33
DIVISION NUMBER: Hardware
SHEET: 1/1

Hardware setup 3D
Location for parts

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Enzo device side view





Enzo device bottom view

