CHALMERS

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Bachelor's Thesis within Industrial Design Engineering


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DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE

CHALMERS UNIVERSITY OF TECHNOLOGY
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Cover: Visualization of the final concept *AccelARate* placed in *The Future Car*.

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# Foreword

As technology continues to rapidly advance, exploring its future applications is an intriguing subject. Our client, ZEEKR, asked us to investigate the future usage of cars and how *MagSafe*, *Modularity*, and *Bring Your Own Device* could be leveraged to enhance user experience.

We are grateful to ZEEKR for providing us with this exciting opportunity to write a bachelor's thesis on this fascinating topic. Working with a professional company in the car industry has been an enriching experience, and we have gained valuable insights that we will carry into future projects. We would like to express our gratitude to our two supervisors at ZEEKR, William Björsdorff, and Chang Cai for their guidance and support throughout the project. We are also grateful to Florian Konrad for his supervision and guidance.

We also extend our appreciation to our supervisor at Chalmers, Sanna Dahlman, for her assistance and valuable insights, which supported us in carrying out this project.

Finally, we would like to thank our examiner Lars-Ola Bligård for his professionalism and trustworthiness throughout the project. Your support and guidance have been very useful.

Victor Andersson, David Boman, Anna Englund,
Axel Malmberg, Edvin Nisbet, Emma Sellgren,

Gothenburg, May 2023

# Sammanfattning

Denna rapport beskriver ett kandidatarbete som syftat till att undersöka framtidens användande av bilar. Frågeställning för projektet löd **"Hur kan *modularitet*, *MagSafe-teknologi* och *BYOD* förbättra det framtida användandet av bilar och öka användarvärdet?"**, vilket är en relativt bred frågeställning för att möjliggöra en mer djupgående undersökning av ämnet.

Projektet var från början avsett att vara ett produktutvecklingsprojekt, men utvecklades snarare till ett projekt riktat mot research för att undersöka framtiden av bilar och hur de skulle kunna användas. För detta ändamål krävdes en omfattande undersökning om framtiden för att förstå kontexten som en produkt skulle kunna komma att användas i. Personas och scenarios var ett effektivt sätt att kommunicera den research som gjorts under projektets gång.

Vidare så undersökte gruppen mer specifikt hur arbete i bilen kan se ut i framtiden. Undersökningarna mynnade ut i en fas av produktutveckling där gruppen skapade ett koncept som använder *AR-teknologi, MagSafe-teknologi* och *modularitet* för att ge användaren möjlighet att arbeta i en bil som delas med andra. Konceptet *AccelARate*, löser problem relaterade till integritet/avskildhet, multitasking, vibrationer, ljud och ljus, som är relevant i den givna kontexten. Avslutningsvis så representerar *AccelARate* gruppens svar på den givna frågeställningen.

# Abstract

This report documents the work of a bachelor's thesis, which aimed to investigate the future use of cars. ZEEKR, the client of the project, presented a brief with a given thesis question, **"How can *modularity*, *MagSafe technology*, and *BYOD* enhance the future use of vehicles and increase user value?"**, which was broad and open-ended to allow for in-depth exploration of the topic.

The project evolved into a research-focused one that sought to explore the future of cars and how they could be used. To this end, the team delved deeply into these areas and sought to understand the broader context in which a product could be used.

To answer these questions, the team conducted an in-depth investigation to understand the broader context. Additionally, the team used personas and scenarios to effectively communicate the findings and contextualize the research.

The team focused on working in a car and how it might look in the future. This research culminated in a product development phase, during which the team created a concept that uses *AR technology*, *MagSafe technology*, and *modularity* to enable users to work in a shared car. This concept, known as *AccelARate*, addresses issues related to privacy, multitasking, lights, sounds, and vibrations that are relevant to the context of use. In conclusion, the *AccelARate* represents the team's answer to the research question posed at the outset of the project.

# Excecutive Summary

The purpose of this report is to describe the work of a bachelor's thesis on the future usage of cars. The thesis question under investigation was set to **"How can *modularity*, *MagSafe technology*, and *BYOD* enhance the future use of vehicles and thereby increase user value? Is it possible to enable the car to be more versatile and broaden its area of use, to satisfy the needs and demands of future users?".**

Owing to the latest developments in technology and the car industry, ZEEKR claims in their brief (see Appendix A). that it is of great interest how automobiles could further develop to be more than just a transport as the expectations on the use of a vehicle have increased. Three topics are of interest to the client and are highlighted in the thesis question: *MagSafe Technology*, *Modularity*, and *Bring Your Own Device (BYOD)*. These are relatively new technologies/concepts that make them interesting to investigate further, and for a car company like ZEEKR, it is especially interesting to see how they can be implemented in a future car.

*MagSafe* is a technology developed by *Apple* that enables the wireless charging of devices. Wireless charging itself is not new, but *MagSafe* implements magnets that allow the device to stay in place to ensure more secure and trustworthy charging. This technology requires a device with magnets on the back, which can be found on the *iPhone 12* and later generations. Recently, *MagSafe* has been implemented in accessories such as wallets, cases, and power banks, which can be attached to smartphones via *MagSafe technology*.

*Modularity* is a concept that aims to divide a product into smaller pieces and modules, where each module has a function on its own, and can be combined with other modules to create new functions via a controlled interface. *Modularity* both gives the user more value and is a sustainable way to design products, as modules can be used for many purposes rather than just one.

*Bring Your Own Device (BYOD)* is a concept mainly implemented in workspaces and means that you bring your private computer, phone, or tablet instead of using the company's hardware. This concept allows for greater efficiency and enables workers to continue working at any preferred location. Recently, the concept has also become a norm in cars, where the private device can connect to the car's interface, allowing the user to make calls, get a guided route, or browse a playlist through the car's interface/media player.

Furthermore, technological developments in cars have boomed in the last decade, and autonomous self-driving cars are topical. Cars manufactured in recent years tend to have functions that allow for a low level of autonomy, which can provide passengers with new opportunities for activities rather than driving in the future.

Given this background, it can be concluded that the future of cars is an interesting topic for further investigation and development, which is the purpose of this project. Initially, the project was intended to be of a product-development nature, but as

it continued, it turned out to be a research-based project. The team agreed to work towards a goal where a product could be developed, but since that product should take place in the future 12 years from now, that future had to be explored to understand the context.

The future and what it may hold were explored on a deep level, including how societies look, how people live and what they do, where technology is headed, and how the world looks globally in terms of environment and development. Furthermore, the future of cars was explored to define the context in which a future product could take place. This research resulted in the definition of a future car that describes an autonomous vehicle that is shared among multiple people. To be able to use the vehicle, you need a subscription that makes the car more of a private vehicle rather than public transportation. Furthermore, the car is intended to feel luxurious and is equipped with four seats designed to accommodate the user with a private space, and it has other facilities to debilitate the feeling of public transportation.

To understand the future users and the problems that the product could solve, a persona and a scenario were created based on research and user studies. As the project continued and new research was conducted in parallel, the persona and scenario were continuously under construction, which made the process more iterative. The persona and foremost scenario highlighted the problems and obstacles that occur when you want to work in the car, which was the focus of this task.

When the context was set, including *Our Take on the Future*, *The Future Car*, *a Persona*, and several *Scenarios*, a phase of product development could occur. During ideation, many different areas were explored, but the common denominators were *MagSafe*, *modularity*, and *BOYD*. This phase resulted in a large portion of concepts or partial concepts using different technologies. One of the most prominent and innovative technologies was AR, which was an interesting topic that was further explored. The concepts were combined, further developed, and later evaluated to culminate in a final concept called *AccelARate*.

*AccelARate* uses AR technology to enable a user to work in a car with a high level of privacy, which was one of the most important issues identified in user studies. With a pair of AR glasses, the user can dock a device that they bring on their own and interact with augmented screens only visible to the one wearing the glasses, providing the user with both a work setup and privacy. Furthermore, the concept includes *Duwall*, which is a modular device that provides storage, a side table, a modular table, a wind-up screen divider, and the possibility of charging the device using *MagSafe*. *Duwall* complements AR glasses and increases the user's value when working in a car.

In summary, the project was interesting, iterative and processed various topics and how they could be implemented in future cars. As the future is difficult to predict, it is important to mention that the context of use that has been defined is based on speculations and prognostications, which makes it difficult to say if *AccelARate* is a potential product that will be implemented in future cars, but with the research done, the group reckoned *AccelARate* to be the answer to the given thesis question.

# Contents

# 1

# Introduction

This chapter presents relevant information on the project's background, purpose, issue under investigation, and limitations, as well as on the client, the electric car company ZEEKR.

## 1.1 Background

Over the last decade, the world has experienced significant technological advancements. New interesting technologies are emerging continuously, such as Augmented reality which Amos (2022) opines is a market that is growing exponentially. Wardynski (2023) discussed how technology significantly affects human lifestyle in terms of convenience. People increasingly rely on smartphones and other devices to complete daily tasks in a simpler and quicker manner than before. In addition, he brings up how technology has affected the way we travel, and things like ridesharing apps have provided the opportunity to travel inexpensively to a desired location in a short amount of time.

These methods of easy travel are greatly needed in a world that is heading for large urban growth with efficient transport options. In the World Urbanization Prospects 2018, the United Nations (2019) discussed the matter of urbanization; the world's urban population surpassed its rural population for the first time in 2008 and continues to grow rapidly. As of late 2022, 56% of the world's population has lived in urban areas, and this trend is expected to continue in the coming decades (The World Bank, 2023).

In addition, the automotive industry has experienced significant progress in terms of technological development and digitalization. According to Altran (2016), electric cars are becoming the standard, autonomous self-driving cars are on the rise, and there are new ways to own and use them. These factors contribute to new possibilities for cars and their utilization in the future.

To explore how automobiles could further be developed to be more than just a means of transportation in urbanized cities, the task given by ZEEKR was to investigate how the following terms: *MagSafe*, *Modularity*, and *Bring Your Own Device (BYOD)* may be implemented in exterior or interior vehicle design to make a future car more versatile and achieve improved user experience and value.

## 1.2 Introduction to *MagSafe*, *Bring Your Own Device* and *Modularity*

*MagSafe* is a technology developed by *Apple*, originally made to secure the charging cord for *MacBooks*, but later incorporated into *iPhone* to wirelessly charge as well as to snap/dock the device into the exact right place and attach accessories (Belkin, 2023). This technology is based on a set of magnets that interact with the internal charging coil. *MagSafe* can be used to charge several devices simultaneously in docking devices (O'Hara, 2020).

*Bring Your Own Device*, hereafter referred to as *BYOD*, is mainly implemented in workplaces. *BYOD* means that employees bring and use their private devices at work (Nezu, 2017). This allows for greater efficiency, as the user has prior experience interacting with the device at hand. *BYOD* has not only boomed in the office sphere but has also become common in cars manufactured in recent years, in the form of services such as *Apple CarPlay*, which allows users to connect their *iPhone* to the car and access functionalities such as making calls, reading messages, and browsing their Spotify playlist through the car's interface (Apple, n.d.).

According to Huang and Kusiak (1998) the term *Modularity* aims to identify independent, standardized, or interchangeable units that perform a variety of functions. *Modularity* can take on different forms; it can be used to build a complex product from smaller subsystems that can be designed independently yet function together as a whole. Furthermore, modular products can be defined as single objects with various functionalities. According to Bitovi (2017), modular design is also significant for customers because they can customize the system to fit their needs.

## 1.3 The Client - ZEEKR

ZEEKR is an electric mobility technology and solution brand that focuses on high-end electrical vehicles (Zhejiang Geely Holding Group, n.d.). ZEEKR was established in 2021, and is part of the Zhejiang Geely Holding Group, a Chinese family company founded in 1986. Part of the Zhejiang Geely Holding Group is several renowned brands such as Volvo Car Group, Polestar, and Lotus Group.

ZEEKR's main focus is on the Chinese market, and as of May 2023, they have sold 93 000 of their first model, the ZEEKR 001, in China (Klemensberger, 2023). However, they are expanding and will enter the European market in 2023 with two of their car models, ZEEKR 001 and ZEEKR X, both of which were designed at the Geely Design Center Gothenburg (Undéhn, 2023).

Zeekr (n.d.) calls the 001 "A luxury shooting brake" and according to Klemensberger (2023), it will compete with the Porsche Taycan Sport Turismo, which further declares ZEEKR as a luxury brand.

## 1.4 Purpose

The purpose of this project was to explore how *MagSafe*, *Modularity*, and *BYOD* can be implemented in future exterior or interior vehicle designs to increase user experience.

The project aimed to identify and understand the demands and needs for future users of cars, reach a stage of product development, and deliver a design solution that fulfills and satisfies the identified demands, with *MagSafe*, *Modularity*, and *BYOD* as building blocks.

## 1.5 Thesis Question

During the project, answers to the questions presented below were sought:

- **What are the demands and needs of future car users?**
- **How can *modularity*, *MagSafe technology,* and *BYOD* enhance the future use of vehicles, thereby increasing user experience?**
- **How is it possible to make the car more versatile and broaden its area of use, to satisfy the needs and demands of future users?**

## 1.6 Limitations

The scope of this project was at first quite broad and had a few limitations. The client ZEEKR was open to giving autonomy to focus on what the group found most interesting.

To avoid limiting possibilities regarding the future display of the project's results, it was advised to deliver a universal result rather than branded ZEEKR.

The resulting concept of this bachelor's thesis does not need to be technically feasible this year. The project should focus on possible future scenarios and the usage of cars, and not on how the technology works.

# 2

# Final Results

This chapter provides a brief presentation of the main results and conclusions of this project.

## 2.1 Approach

The character of this project was a prospective design with an emphasis on envisioning the future of cars. To achieve this, several key elements had to be defined to facilitate product development. The first step was conducting extensive research on what the future might look like, in general terms, and also on technology (*MagSafe*, *BYOD*, and *Modularity*), resulting in several definitions that, in combination with user studies, were essential for identifying the demands and requirements that a successful product should satisfy. These definitions included *Our Take on the Future*, *The Future Car*, *a Persona*, and several scenarios. With these definitions, the team was able to develop a product that met the demands and requirements.

## 2.2 The Future and the User's Needs

*By 2035, the world has undergone significant changes owing to technical advancements and the need to combat climate change. Electric and autonomous cars are the norm, and vegetation constitutes a large part of a city's architecture. Smarter, better-planned cities have emerged to accommodate rapid urbanization; automation is widespread, and the population relies on technology more than ever. There are concerns about the impact of digitalization and automation on human well-being, and the importance of satisfying essential human needs such as socializing and exposure to nature is of greater significance than ever.* A visualization of the future in the form of an image board is shown in Figure 2.1.

**Figure 2.1:** Visualization of the future.

*Note.* The images were obtained from Adobe Stock.

*Claire, the persona of the project* (see Figure 2.2)*, represents the average user of the target group. She is a tech-pioneer who appreciates the convenience of new technology; her automated blinds roll up every morning, use AI in her kitchen to plan her breakfast, and her smartwatch is used to verify her identity when entering the on-demand car she orders in the morning to get to the office. Claire strives to live a healthy, balanced life, in a stressful and demanding society while making* environmentally*-friendly choices for social acceptance and personal gratification. She faces challenges in terms of balancing her career with personal interests, such as being out in the woods with her friends and family.*

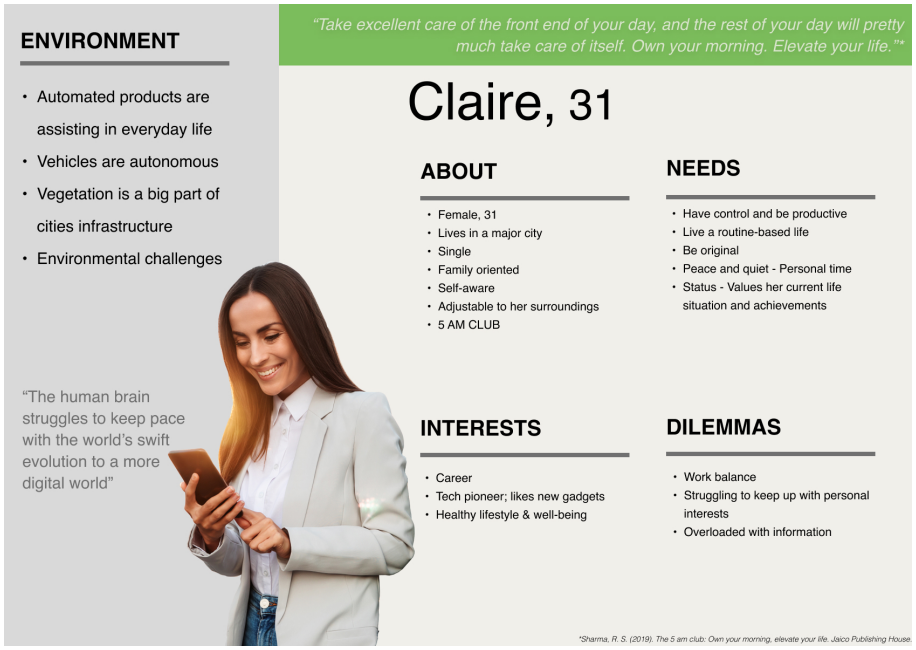


**Figure 2.2:** Claire.

*The car* (see Figure 2.3) *is autonomous and intended for shared use through subscription. The car has four rotating seats and provides a spacious and airy environment with high ceilings to create a more comfortable and attractive space. The car is designed for use in urban areas, focusing on providing a convenient, safe, and enjoyable experience for passengers with a feeling of privacy and luxury. The car's interior is intended to provide personal space for each passenger. In conclusion, the self-driving car described herein is a convenient, environmentally friendly, and efficient option for short rides.*

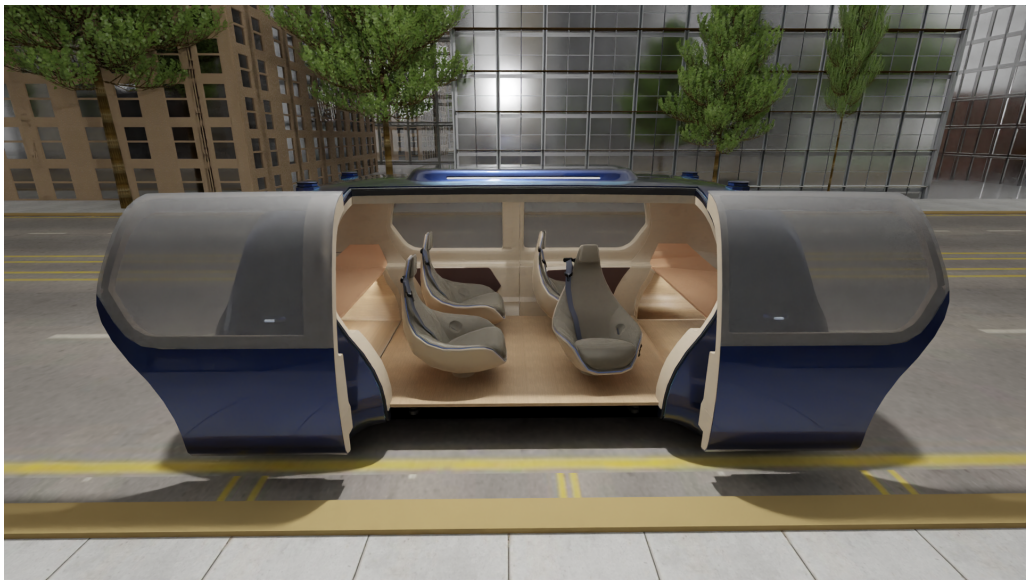

**Figure 2.3:** Visualization of the car without solution implemented.

Based on the envisioned future, the persona and their needs, Work in the car was decided as the focus area.

User studies were conducted on work on an autonomous bus. Analysis of the material resulted in problems that were categorized into four areas: *Privacy*, *Multitasking & Accessibility*, *Sound & Light*, and *Comfort*. To solve the problems and fulfill the personas' needs, requirements and desires were defined and sorted by the problem areas and a *General* category. The most prominent ones are as follows:

### 2.2.1 Privacy

- Avoid disturbing other passengers with one's physical presence
- Enable privacy of one's devices and material

### 2.2.2 Multitasking & Accessibility

- Hold *MagSafe-technology*
- Enable easy setup of workstation when bringing one's own device

### 2.2.3 Sound & Light

- Prevent disturbing sound & light from inside the vehicle
- Prevent disturbing sound & light from outside the vehicle

### 2.2.4 Comfort

- Keep device in place
- Enable good posture

### 2.2.5 General

- Feasible year 2035
- Compatible with sharing

## 2.3 Concept

*AccelARate* uses AR, a technology that allows virtual objects to interact with real-world objects and create intended meanings (Software Testing Help, 2023). AR technology allows users to work in a shared car without requiring a full workstation setup. With the concept of *BYOD*, the user can easily connect to AR glasses via a smartphone or another device and start working with the help of artificial screens only visible through the glasses. The controlling device is similar to the glasses available in the car and is stored in *Duwall*. The controlling device uses a bracelet, *TapXR*, that recognizes hand gestures to control any device of choice.

The *AccelARate* concept includes *Duwall* (see Figure 2.4), a multifunctional and modular console that serves as both a side table and a divider. This provides users with surfaces for belongings, as well as privacy and storage, which in the research phase were identified as the most important problem to solve. *Duwall* incorporates *MagSafe technology*, enabling users to charge different devices and maximize their car ride experience.

The product was seamlessly integrated into the interior of the car and placed between two seats to create a natural and intuitive addition to the existing interior. *Duwall* also has storage for AR glasses and *TapXR*, which includes a cleaning function to ensure that each new user is provided with fresh and clean devices. *Duwall* has a tip-up table to enable the user to perform several task at once, for example using their tablet and laptop.

**Figure 2.4:** Pictures of *AccelARate*. *Duwall* in the car (top), *Duwall* in *Storage Mode* (bottom left) and in *Divider Mode* (bottom right)

## 2.4 Satisfaction of Requirements

This section describes how AccelARate fulfills and satisfies the most essential requirements.

### 2.4.1 Privacy

*AccelARate* allows users to work with private documents without anyone else seeing them using AR technology. In addition, AR glasses provide privacy by shielding users from their surroundings. The *Duwall* divider feature further enhances privacy by allowing users to physically shield themselves from other passengers.

### 2.4.2 Multitasking & Accessibility

*Duwall* allows for multitasking and accessibility through built-in *MagSafe technology* in the table, which provides the option to dock, charge, and work with several devices or materials of choice simultaneously.

### 2.4.3 Sound & Light

The glasses adapt to the surrounding light conditions with the help of *AI technology*, enabling users to work comfortably in any lighting environment. This works similarly to tints on sunglasses

### 2.4.4 Comfort

*MagSafe* eliminates the risk of moving devices. AR allows for the projection of the screen in an ergonomically sound position, preventing bad postures.

### 2.4.5 General

*AccelARate* expresses innovation by utilizing *MagSafe* and *AR technology*. This technology already exists and is bound to be developed in the future, making the solution feasible in 2035. This concept provides the user with the option to work with others and encourages sharing.

# 3

# Essential Knowledge for the Report

This chapter presents information about different significant topics in this project and provides a basic understanding of the circumstances in which the project is based.

## 3.1 Fundamental Facts

This section provides information regarding the client, technology intended to be implemented, existing solutions on the market, trends on what can be expected from the future, Levels of Automation for Self-Driving Cars, and different ways of sharing cars. The chapter concludes with a summary of the most important aspects of this developmental phase.

### 3.1.1 Bring Your Own Device

In recent years, *BYOD* has become a renowned and established concept, mainly implemented in the workplace. According to Nezu (2017), *BYOD* means that employees bring and use their private smartphones, computers, and tablets at work instead of using hardware from the company's IT department. This allows for greater efficiency, as the user has prior experience of interacting with the device at hand. *BYOD* has not only boomed in the office sphere but has also become the norm in cars manufactured in recent years. Services such as *Apple CarPlay* are described by Apple (n.d.) as follows: It allows *iPhones* to connect to the car and enables the user to access functionalities such as making calls, reading messages, browsing their Spotify playlist, etc., through the car's interface/media player/screen.

According to Flynn and Brooks (2023), *BYOD* allows employees not to work at the same spot every day. They also claim that productivity is boosted by *BYOD*, as you are not limited to a 9-to-5 schedule.

### 3.1.2 Modularity

Huang and Kusiak (1998) state that the term *modularity* aims to identify independent, standardized, or interchangeable units to perform a variety of functions.

*Modularity* can take on different forms; it can be used to build a complex product from smaller subsystems that can be designed independently yet function together as a whole. Furthermore, modular products can be defined as single objects with various functionalities.

Bitovi (2017) also mentioned that cars are modular as they are. This invokes interest in how an additional product can implement *modularity* and be integrated into the car without giving the feeling that it is an additional product rather than part of the car.

### 3.1.3 Magsafe Technology

Clover (2022) described *MagSafe* as a system founded by *Apple* that started with the development of wireless charging. The issue with wireless charging is that vibrations caused by receiving notifications when charging risk moving the smartphone, which may lead to disconnection of the device from the charging station. *Apple MagSafe technology* resolves this issue by applying magnets to the system, which helps secure the connection between the device and charging station.

Furthermore, Clover means that when charging with a regular wireless charger (Qi), the maximum reachable power is 7.5 W while *MagSafe* can deliver 15 W, which greatly reduces the charging time. The *iPhone 12* and later generations have magnets on their backs to connect to all *MagSafe* accessories such as cases, wallets, and chargers. Building into *MagSafe technology* is an NCS chip that makes it possible for the *iPhone* to understand the type of accessory connected to it. The smartphone then acts accordingly; e.g. displaying relevant information. The magnetic force of *MagSafe* is strong, which has created new opportunities to incorporate *MagSafe* into products and explore future areas of application.

### 3.1.4 Augmented Reality & TapXR

Augmented Reality, further referred to as AR, and *TapXR* were not provided in the brief as subjects to explore; however, as the project progressed, they became relevant.

According to Software Testing Help (2023), AR refers to the technology and techniques used to superimpose three-dimensional virtual objects onto real-world objects and environments using an AR device. This allows virtual objects to interact with real-world objects and to create intended meanings.

In contrast to Virtual Reality, which aims to virtually replace real-life environments, AR enhances the real world by adding computer-generated images and digital information. This enhances perception by introducing videos, infographics, images, sounds, and other details. To create AR content, a device is used to overlay virtual three-dimensional images onto real-world objects, based on their geometric relationships. The device must be able to calculate the position and orientation of the objects relative to other objects. The combined image was then projected onto mobile screens, AR glasses, and other similar devices.

*TapXR*, developed and described by Tap Systems (n.d.), is a control device with sensors that detects and registers the user's finger movements on the connected device. *TapXR* is used on any surface, such as a table or body part, and allows the user to navigate any connected device of choice, such as a smartphone, tablet, computer, or AR glasses. *TapXR* is compatible with any brand in the current market, such as *Apple* or *Microsoft*.

### 3.1.5 Levels of Automation for Self-Driving Cars

The On-Road Automated Driving (ORAD) Committee (2021) has defined six levels of automation for self-driving cars, ranging from Level 0 (No Automation) to Level 5 (Full Automation). Each level represents a different level of driver assistance and autonomy, as described below:

Level 0 - No Automation: The vehicle is controlled by the driver at all times. Beyond basic safety features such as seatbelts and airbags, there is no automation.

Level 1 - Driver Assistance: The vehicle has some automated features such as lane departure warnings or adaptive cruise control. However, drivers are still responsible for most driving tasks.

Level 2 - Partial Automation: Some driving tasks, such as steering and acceleration, can be handled by the car. However, the driver must remain alert and be ready to take control at any time.

Level 3 - Conditional Automation: Under certain conditions, the car can handle most driving tasks, but the driver must be able to take control quickly if needed.

Level 4 - High Automation: Under certain conditions, the car can handle all driving tasks, such as in a specific geographic area or on a designated route. The driver does not need to be alert or ready to engage.

Level 5 - Full Automation: Under all conditions, the car can handle all driving tasks. There is no need for a driver.

As of 2023, there are commercially available Level-3-autonomous cars in the market. However, in an interview with Vincent and Shrestha (2023), Mercedes Chief Technology Officer Markus Schäfer stated that Level 4 autonomy is "doable" by 2030.

Many automakers and tech companies are investing heavily in this technology, allowing fast-paced development and progress. According to Deichmann et al. (2023) in Autonomous Driving's Future: Convenient and Connected, by 2035, 37%–57% of passenger cars sold will have Level 3+ automation technology, while Level 4 will be the most advanced technology available to consumers.

### 3.1.6 Ride-Sharing and Ride-Hailing

Ride-sharing is defined by Remix (2021) as a way for multiple riders to reach a destination by sharing a single vehicle that is going in their direction. The vehicle makes several stops along its way to pick up and drop passengers. This method of transportation reduces the number of vehicles on the road, thereby decreasing traffic congestion, carbon emission pollution, and fuel consumption. Ride-sharing is an on-demand transportation system that allows riders to share a route and not a vehicle.

Ride-hailing is defined as when a person or group hires a vehicle such as a taxi. A ride-hailing platform was defined by Remix (2021) as Uber and Lyft. Ride-hailing is not like ride-sharing because the driver or autonomous vehicle is hired to go to the same location as the passenger. The vehicle does not pick up passengers going in the same direction as the client if it is not called for, for example, a friend who is supposed to be picked up on the route.

## 3.2 Theoretical Framework

This chapter aims to explain the relevant theory, which has been the basis for work and decisions made when developing a product intended for use in a future car situation.

### 3.2.1 User Experience

According to the Interaction Design Foundation (2022b), *User Experience* (UX) refers to the overall experience that a person has while interacting with a product, system, or service. It encompasses all aspects of a user's interaction with a product, including how easy it is to use, how enjoyable it is to use, and how well it meets the user's needs and expectations.

UX design focuses on creating products and services that are user-centered, meaning they are designed with the needs, wants, and goals of the user in mind. This involves understanding the user's goals and tasks as well as their context, environment, and behavior. UX design also involves considering users' emotions and attitudes, which can have a significant impact on their overall experience.

### 3.2.2 Ergonomics

Physical ergonomic factors are crucial to the user's experience with a product. Three factors were identified as relevant to consider in this project: *sound*, *light*, and *vibrations*.

#### 3.2.2.1 Sound

Berlin (2021) addressed sound ergonomics and argued that unwanted sounds can, in addition to distracting from what needs attention, evoke feelings of anxiety and

stress for those exposed to it.

Banbury and Berry (2005) found that even low levels of background noise (such as that found in an open-plan office) can significantly impair ability to concentrate. They also found that people who were more sensitive to noise had a greater impairment in concentration. Furthermore, background noise can cause difficulties in communicating effectively, particularly in environments where communication is critical.

#### 3.2.2.2 Light

Berlin (2021) described that poor lighting conditions, such as glare or flicker, whether direct or indirect reflections, can cause visual discomfort, eye strain, and headaches, which can lead to decreased productivity.

#### 3.2.2.3 Vibrations

In a moving car, the vibrations caused by the vehicle can create conflicting signals that can lead to motion sickness.

According to the Cleveland Clinic (2021), when working on a screen in a car, one's eyes are focused on a stationary object while the body is moving. This creates a sensory conflict where one's eyes are telling the brain that they are not moving, but the inner ear is telling the brain that you are. This mismatch between what your eyes and inner ear sense can lead to feelings of nausea, dizziness, and other symptoms of motion sickness.

In addition to the sensory conflict created by stationary screens and moving cars, according to Nassiri et al. (2009), vibrations from vehicles can contribute to motion sickness. Vibrations can affect the vestibular system of the inner ear, which plays a key role in the maintenance of balance and orientation. This can further confuse the brain, leading to motion sickness symptoms.

Berlin (2021) stated that vibrations can cause fumbling and difficulties in performing tasks manually.

### 3.2.3 Prospective Design

Johnston (n.d.) explains Prospective Design as a concept/method that focuses on designing for future changes and circumstances, rather than current ones. New and innovative ideas can emerge by exploring future possibilities. Building scenarios is a common way to explore possible outcomes in the future, which helps to understand the trends that will shape the future.

Prospective Design has been a central part of the project, as it focuses on the future 12 years from now, making the method current and adaptable.

# 4

# Process & Methods

This chapter presents and describes the methods and tools used during the project.

## 4.1 The ACD³-Process

Bligård (2015) described the ACD³-model as a framework for development work that aims to clarify aspects that need to be taken into consideration in development. The framework aims to provide a holistic view of the project and make designers reconcile design work at different levels of abstraction.

The model is an iterative process based on the interplay between desires and design. It can be divided into five phases: *Needfinding*, *Design of use*, *Overall design*, *Detailed design*, and *Structural design* (see Figure 4.1).

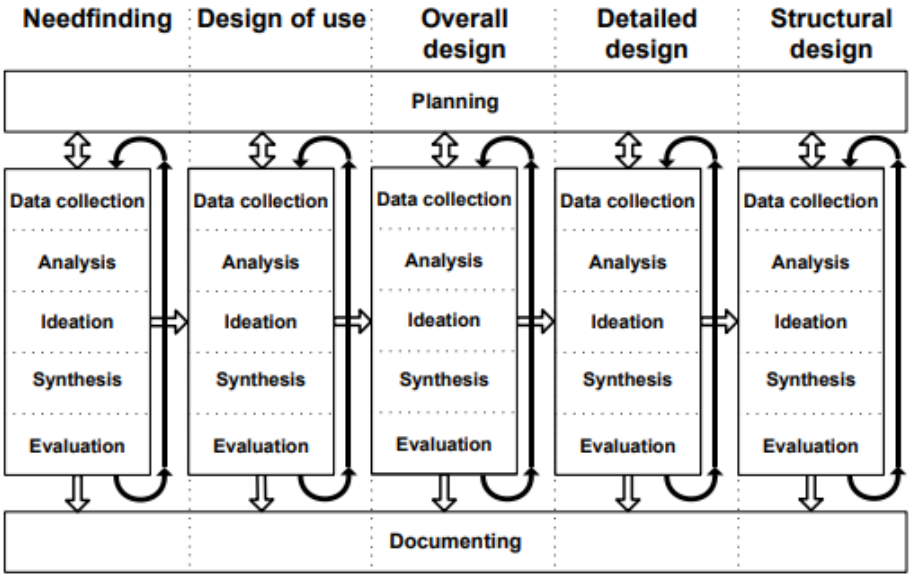


**Figure 4.1:** Bligård et al. (2016) detailed visualization of The ACD³ process.

## 4.2 Trend Analyis

Strumpf (2017) defined a trend as the mean level of change during a long-term event. As suggested by Strumpf (2017), a trend analysis can involve comparing one period to another to understand the impact of the event. This method can be used to generate projections for the future.

## 4.3 Pugh Matrix

Bligård (2015) described a Pugh matrix as a tool to evaluate which of the several solutions best meets a set of requirements, assuming that the solutions meet all specified requirements. The solutions are compared against a reference proposal, which can be one of the proposals, an existing machine, or a competitor's machine. If a proposal meets a requirement better than the reference, it gets a plus; if it is equally good, it gets a zero; and if it is worse, it gets a minus value. The requirements are weighted according to the importance of achieving the goals of the system. The sum is then calculated, and solutions can be chosen or rejected based on the results.

## 4.4 Image Board

According to Westling (2018), an Image Board is a method of visualizing concepts, products, or ideas. By combining different pictures, it is possible to visualize how the final result should look and communicate the feelings and characteristics that it should convey.

## 4.5 User Journey Mapping

User journey mapping is a visualization of the steps that someone goes through to complete a goal. This can be used to represent a person using a product. It can be done in various ways but is normally presented as steps guiding the reader through a journey (Babich, 2019).

## 4.6 Brief & Counterbrief

L-O. Bligård (personal communication, January 24, 2023) claimed that the client would hand the design team a brief of the project, a description of the project, and what they wanted it to result in. A counterbrief was created to ensure that both parts were at the same level. The purpose of the counterbrief is to set the scope of the project, starting point, and ending point.

## 4.7 Gantt-chart

The Gantt-chart is a time plan that includes the phases that the work will go through and optional methods that will be used. Each method and phase has a timeframe for how long it will be conducted (Microsoft, 2010). The purpose of this chart is to structure work and create a plan that can be followed.

## 4.8 Persona

A persona can be valuable aid in the product development process. A persona is a fictional person based on relevant research for the project (Dam and Siang, 2022). Creating a persona makes it easier to understand users' expectations, concerns, and motivations, which makes it possible to create products that satisfy their needs and achieve success (Faller, 2019). A user persona template is typically created to obtain a quick overview of the persona's behaviors, needs, and motivations (Babich, 2019).

A persona was described in Design Process and Method by Wikberg Nilsson et al. (2015) as a fictitious description of a person belonging to the target group. Instead of relying on data and statistics throughout the work, a more vivid description of a person can make a designer focus more on solutions that fulfill a person's needs and wishes. To obtain a realistic and reliable persona, the description must be based on the data and statistics. Moreover, a persona can make one feel empathy for the users and what needs they might have.

According to Faller (2019) a persona is usually described in text consisting of one or two pages. The description of the persona should contain the following categories: behavioral patterns, goals, skills, attitudes, and background information, as well as the environment in which a persona operates.

## 4.9 Scenario

Scenarios will be a central part of this project as they are a common method in the Prospective Design process. Wikberg Nilsson et al. (2015) described the method of "Scenarios" as a way of understanding the users' behavior and driving forces by telling a story of a specific situation. It could either be about the current situation and the problems that exist, or a future scenario telling a story about the ideal situation and user interaction.

The scenario can also demonstrate what happens when the persona uses technology (Dam and Siang, 2022). According to Nielsen's study, 10 Steps to Personas, step nine mentions "Personas have no value unless they enter a scenario. A scenario is like a story, it has a main character (the persona), a setting (somewhere where the action takes place), it has a goal (what the persona wants to achieve), it has actions that lead to the goal (interactions with the system/site/device), and it has obstacles that hinder the way to the goal." (Soegaard et al., 2013).

## 4.10 Target Group

According to Meyer (2022), a target group refers to a group of people or companies that are characterized by having similar desires and preferences. They act according to certain patterns, or exhibit similar needs. In addition, they often match sociodemographic characteristics such as age, relationship status, marital status, education, and income.

## 4.11 Brainstorming

According to Wikberg Nilsson et al. (2015), brainstorming is a procedure for generating a large volume of ideas. The method was originally developed by Alex F. Osborn, but today, there are endless ways to perform brainstorming.

## 4.12 Brainwriting

As described by Wikberg Nilsson et al. (2015), brainwriting is an alternative brainstorming method in which each individual writes down their ideas, for example, on a piece of paper. This was performed during a selected period. After a given time, participants passed their idées to the next participant for additional input. This method aims to utilize the entire group's potential, in which everyone feels involved in contributing to each idea. This has the benefit that ideas do not feel like they belong to a specific person.

## 4.13 Braindrawing

According to Wikberg Nilsson et al. (2015), Braindrawing is a brainstorming exercise similar to other techniques such as brainwriting. In this group activity, each person sketches their ideas and passes them to the next participant, who builds upon them. Each sketch session was timed. The advantage of this method is that it encourages the entire group to participate in and contribute their ideas, and the act of sketching can stimulate new perspectives and different ways of thinking. Additionally, this method fosters a sense of ownership of ideas within the group rather than by any individual.

## 4.14 Mind-mapping

A mind map involves writing down a central theme and thinking of new and related ideas that radiate from the center (The University of Adelaide Writing Centre, 2020). By focusing on key ideas that are written down and looking for connections between them, knowledge can be better understood while retaining information, and gathering new ideas.

## 4.15 List of Requirements

Niederhausen (2019) regarding “Requirements Lists and Specifications”, expressed that in product development and process optimization, there are requirements in a singular document, often in a document or spreadsheet. This requirement states the physical or functional needs of a particular design, product, or process to be satisfied. Recording requirements in lists and specifications is the most traditional method, and the requirements can be categorized, sorted, analyzed, prioritized, and tracked (Niederhausen, 2019).

## 4.16 Morphological Matrix

According to Wikberg Nilsson et al. (2015), a morphological matrix is a method that generates a relatively large number of ideas in a short time. Different solutions can be combined to generate different concepts based on the different criteria or functions that have been identified. This stimulates the brain and generates ideas that are difficult to overcome when focusing only on a big intractable problem.

## 4.17 Six-Thinking-Hats

The Six Thinking Hats is by the Mind Tools Content Team (n.d.) described as a creative problem-solving technique that involves six different colored ”hats” representing different ways of thinking. Each hat represents a particular perspective or focus, such as facts and figures (white hat), emotions and feelings (red hat), creativity and new ideas (green hat), risks and potential problems (black hat), benefits and positive aspects (yellow hat), and overall process and summary (blue hat).

By wearing a hat, a person focuses solely on a particular perspective and generates ideas from that perspective. This technique helps to break down cognitive barriers, reduce personal biases, and encourage more structured and productive discussions.

## 4.18 KJ-Analysis

Bligård (2015) described KJ-analysis as a method applied to compile and obtain an overall understanding of a large set of collected data. This was performed by writing units based on the results of the data collected on small notes. The notes were then placed into groups according to their theme, and a title was created for each group that had been created.

## 4.19 Benchmarking

Wikberg Nilsson et al. (2015) mentioned benchmarking as a way of identifying possibilities that can support further development in the specific area of interest. This was done by mapping the potential in the area on which the research is based, including identifying what has been done and what can be done in the area. The analysis can help gain knowledge about organizations and companies that can bring possibilities that can help distinguish them from competitors.

## 4.20 User Studies

User studies are sufficient to understand a user's needs and struggles with a product. Different methods have been used during user studies to expose conflicts and investigate design opportunities. According to the Interaction Design Foundation (2022a), there are two approaches to user studies: attitudinal and behavioral. Interviews are attitudinal and occur when users listen to words. The behavioral approach involves observing the actions of users.

### 4.20.1 Interview

Interviews are methods for collecting user information to gain an understanding of how users think and reason, resulting in subjective data (Bligård, 2015). Interviews can be structured, semi-structured or unstructured. A structured interview involves asking questions formulated in advance, whereas during an unstructured interview, topics can freely be discussed with the interviewee. A semi-structured interview is a combination of the two: there is a structure in place for the areas of questioning, but the questions can be discussed more freely. Structured interviews are preferred when quantitative data are required, whereas unstructured interviews are favored when qualitative data are required.

### 4.20.2 Observation

During an observation, the researcher observes a certain event under investigation (Bligård, 2015). Observations can be conducted in a real usage setting, also known as "in the field" or in an experimental arranged setting, also known as "in the laboratory." Observations are used by the researcher to gain an understanding of the usage situation and may also reveal behavioral patterns that the user is not aware of, and that may not emerge in interviews or surveys.

# 5

# General Description of Procedure

The project duration was approximately five months. The process was based on the ACD³-model; however, some modifications were made to accommodate this specific project's aim, which was divided into five phases (see Figure 5.1).

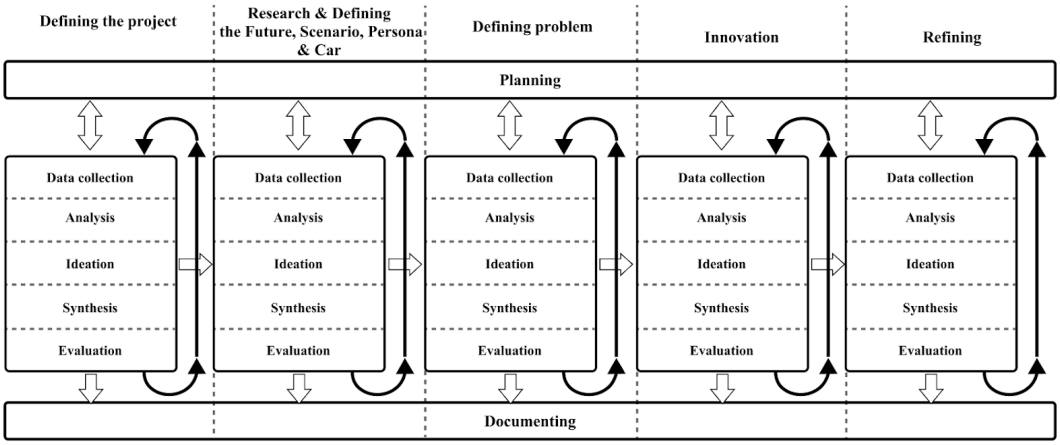


**Figure 5.1:** The process of the project.

Iterations were applied to all phases to enable going back and looking from other perspectives, resulting in a more nuanced process and result. The iteration and its structure were the most eminent parts of the ACD³-model that was applied to this project, but the phases were modified to match the project's Prospective Design approach.

To reach a stage of innovation, the future context and users were crucial to determine in order to identifying problems and desires that a possible concept could fulfill. This led to the following five phases and their order.

- Defining the project
- Research & Defining the Future, Scenario, Persona & Car
- Defining problem
- Innovation
- Refining

## 5.1 Research & Defining the Project

The project was initiated by ZEEKR, who provided a brief (see Appendix A) of their interest in exploring the given areas and what they expected the team to contribute. To ensure mutual understanding, a counterbrief (see Appendix B) was created. It included the team's interpretation of expected deliverables, client limitations, and the working methodology. A Gantt Chart (see Appendix C), which served as a time plan, was also created.

First, the issue under investigation had to be determined because the client's brief included a broad potential thesis question. Different areas (*MagSafe, BYOD*, and *Modularity*) were explored to identify the team's interests and create a narrower question that matched both the expected deliverables and the group's interests. This resulted in the following issue under investigation:

*"How can modularity, MagSafe technology, and BYOD enhance the future use of vehicles and thereby increase the user value? Is it possible to enable the car to be more versatile and broaden its area of use, to satisfy the needs and demands of the future users?"*

Further on in this phase, data had to be collected in order to define the group's take on the future. Apart from *Our Take on the Future* (see Section 6.1.1), it also included defining *The Future Car* (see Section 6.1.2) and a *Persona* (see Section 6.1.3) along with a *target group* (see Appendix N) as well as a first Scenario 1; *Claire's Day* (see Section 6.1.4). Gathering an understanding of the potential future and the context of how humans may travel and use cars in the future are crucial for the development of this thesis.

### 5.1.1 Theoretical Studies & Data Collection

To gather an understanding of the project's main objectives, theoretical studies and data collection were made.

#### 5.1.1.1 Literature Studies

The literature studies began with individual research to obtain several different perspectives in an efficient way. This research was conducted using terms such as *BYOD, MagSafe, Modularity*, and the future of mobility to gain insight into what the project could entail.

Extensive research and trend analysis were conducted to gain insight into what the future might hold and to define three different descriptions: *the Future, The Future Car*, and a *Persona*. Some of the questions of interest during this exploration include the following.

- Where is the world heading and what problems exist?
- What does an urban city look like?
- What do people do, and how do their lives look?
- What do people value in everyday life?
- How has technology developed over the past decade?

Articles and YouTube videos were valuable sources of data on this topic. It should be noted that this was largely made up of predictions and lacked scientific research to support the findings. During this phase, the definition of *Our Take on the Future* (see Section 6.1.1) was continuously refined as new findings arose.

The topic of *The Future Car* was investigated, focusing on different areas of interest, such as what activities could be done in a car in the future. After conducting the research, three specific areas were chosen for further exploration: *working, socializing*, and *relaxing* in a car. Some questions of interest included the following.

- What do these activities entail?
- How are they performed?
- Why is it compelling to engage in these activities in a car, and what might it involve?
- What is necessary to pursue these activities?
- If solutions exist, how do they address the issues, and what do they involve?

During this exploration, the specification of the issue under investigation was under constant reconstruction, as many steps were iterated, and the direction in which the project was headed changed several times over a few weeks. Many discussions were held with the client, and ideas on solutions that solved problems in all three areas were presented during this phase. These had to be archived, as the client suggested additional investigation and implied that ideation lay further ahead.

#### 5.1.1.2 Benchmarking

Benchmarking aimed to research what was currently offered on the market. Multiple car manufacturers have designed concept cars that focus on predicting the future, different scenarios, and users. These were presented and reviewed in a YouTube video by Highlights CNET (2021) which was used for benchmarking. The concept cars provided a lot of inspiration, as they differed from the cars used today.

As the future of automobiles was explored, sketches of the car that were to be defined were made simultaneously so that the group would be united and be able to form a definition of *the Future Car*, which was an expected deliverable in this phase. *The Future Car* had to be iterated several times, which led to early analysis, making discussions and several rounds of sketching possible, which in turn led to a definition that was well founded.

#### 5.1.1.3 Storytelling

To conclude the research that was considered important and of interest, ideation took place in the form of writing short fictional stories of a future context with a potential future user (see Appendix D). By doing so, all group members gained a mutual understanding of the ideas and thoughts of the rest of the group.

## 5.2 Analyzing Data & Defining the Future Context

The aspects established and highlighted in the individual stories, combined with the findings from benchmarking and literature studies, resulted in the following contextual descriptions: *Our Take on the Future*, *The Future Car*, the *Persona*, and the *Scenario 1: Claire's Day*.

### 5.2.1 Defining the First Versions of Contextual Descriptions

Furthermore, the data collected resulted in the definition of *The Future Car* (see Section 6.1.2). It was crucial since the concept to be made would take place in a future car, meaning it has to be clear how the car looks, how it works, how many passengers it fits, how it is owned, and so on.

A *Persona* (see Section 6.1.3) and *Scenario 1* (see Section 6.1.4) were created with the purpose of highlighting the previous findings into something tangible and descriptive. The persona and scenario provided a credible justification for the product that will be presented to those not involved in the project, as it is easier to relate if it is applied in a real environment with a specific user. This understanding facilitates ideation and the creation of a user-centered product that will be relevant in the future to solve future users' needs efficiently.

### 5.2.2 Visualization

Since a major part of the project was to define the future and context in which the product would take place in, it was of great importance that these could be communicated to those not involved in the project. Therefore, the purpose of the visualization was to communicate the message and thoughts mentioned above regarding what the future holds, what future vehicles may look like, who the persona is, and what the scenario looks like. It all creates a story. Pictures are sometimes more explanatory than words, which makes them an effective way of communicating things that are sometimes difficult to describe in text, such as the context and the feelings of the users. With the use of AI software, such as Midjourney and Dall-E, AI pictures and settings were generated to help visualize the thoughts and ideas of the group, mainly regarding a future society and highlights from the scenario and story. These pictures were used to compose imageboards, which, together with bullet points, helped concretize and define the main focus of the project.

## 5.3 Identification of Problems

The purpose of the third phase was to identify problems and needs that may be prevalent during car usage in the future, and to establish guidelines for the design work that was to come in the *innovation* phase. Through the use of research and empirical studies, the phase ended up with *Activities When Riding a Car* (see Section 6.2), a *Set of Problems* (see Appendix E), and a *Specification of Requirements* (see Appendix F).

### 5.3.1 Research of Usage Areas

Research and discussions with the client were conducted to identify the types of activities that would occur in future cars. It was necessary to narrow the scope to find concrete problems and avoid making the work too broad and difficult. Based on the first scenario and the persona and their needs, several different car usage areas considered relevant in the future were discovered or compiled using brainstorming. Mind-mapping was used to identify additional areas that were not found in the scenario. The results provided a list of potential usage areas for cars in the future.

Work was decided as the area in the car to move forward with (motivated in Section 6.2).

### 5.3.2 Development of the Car

When narrowing the project to *Work* in a car, it was necessary to further develop *The Future Car*.

#### 5.3.2.1 Market Research

To gather inspiration for how a future car may look, market research took place in the form of gathering information from articles, YouTube videos, and pictures on the internet.

#### 5.3.2.2 Visualizing The Future Car

A car for the future was collectively determined and then visualized for the first time using hand-drawn sketches and Adobe Illustrator (see Figure 5.2). *The Future Car* was visualized to further aid the reader and make it more comprehensible (see Figure 5.3). The car's sketched and rendered exterior and interior acted as a complement to the explanatory text.

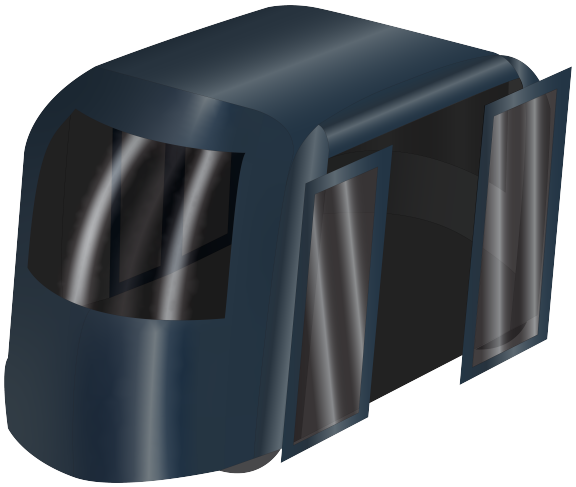

**Figure 5.2:** Sketch of the car's exterior.

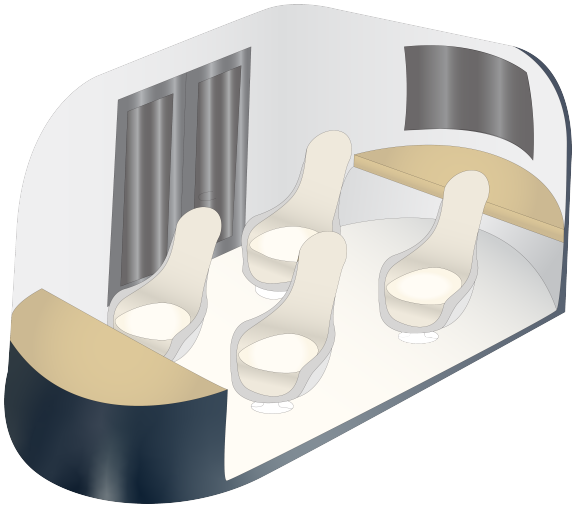

**Figure 5.3:** Sktech of the car's interior.

### 5.3.3 Empirical Studies

To gain insight into what the users' needs are when working in a car and what problems occur when they do not have their own desks, user studies were conducted. As the benchmarking had brought a uniform understanding of *The Future Car* (see Section 6.1.2), the user studies were conducted in an environment similar to it. Because no cars were available like it today, an alternative solution was found.

At the Chalmers campus, an autonomous bus for 15 passengers drove around as part of a project exploring collaboration between autonomous vehicles and goods transportation in an urban environment (Mortensen, 2022; Navya, 2020 ). This vehicle was not designed like the project's *Future Car*, but shared similarities, such as being an autonomous vehicle, which was an important definition of *The Future Car*. Two types of user studies were conducted using the autonomous bus seen in Figure 5.4.


**Figure 5.4:** Picture of the autonomous bus at Chalmers campus.

#### 5.3.3.1 Field Study

The first empirical study was an observation made internally with those involved in the project group, with two of the members working in the bus, and the rest staying in their usual office setting. The objective was to identify the problems that may occur and what a user finds disturbing when working and commuting simultaneously in a public autonomous vehicle. The study (see Appendix G) made it obvious which problems were the most severe, not only from the perspective of those on the bus but also from those in the office setting who noticed disturbances that the riders did not notice themselves. The two teams were able to communicate through an online meeting, making it possible for those in the office to follow those in the autonomous vehicle.

#### 5.3.3.2 User Test

The interview (see Appendix I) was conducted as follows. One participant was invited to the car and given tasks while simultaneously attending an online meeting in which the study coordinator held a presentation. The participant's multitasking ability was tested as they had to listen, take notes on paper, and send an email, all while being able to handle a computer in a moving autonomous vehicle. Simultaneously, they were exposed to various distractions that impeded concentration. While the participant performed the tasks, two moderators searched for difficulties and factors that caused frustration.

During and after the test, the participants were asked questions regarding their experience working in a moving vehicle, acting as an interview. The interview questions were planned ahead and structured, but the participants were encouraged to talk about any experiences that could be valuable to the team, making the interview partly unstructured, but also more nuanced (see Appendix H).

The outcome of the empirical studies was a better understanding of what situations occur when working in a car, and what problems and possibilities do appear. These data were later used as the basis for the upcoming problem definitions.

### 5.3.4 Needs & Specification of Requirements & Desires

To concretize the requirements/demands that the product must fulfill to tackle the identified problems, a *Specification of Requirements & Desires* was defined (see Appendix F). This helped the coming innovation phase by clarifying what ideation could focus on, as well as helping generate ideas.

#### 5.3.4.1 Problems Found from User Studies

The data collected from the user studies and interviews resulted in several problems that were summarized and compiled into four problem areas (see Appendix E): *Privacy, Multitasking & Accessibility, Comfort* and *Sound & Light.*

#### 5.3.4.2 Defining Scenario 2: Problems in the Future

With the newly found set of problems in mind, a new scenario was created (see Section 6.3.5). The second scenario implements working in *The Future Car* (see Section 6.1.2, it is based upon the first scenario (see Section 6.1.4). The main differences are their focus and purpose. The first scenario is about Claire and how technology affects her, whereas the second scenario is more detailed and emphasizes the possibilities of sharing vehicles, which also introduces problems that it may bring. The purpose of the second scenario was to communicate the current findings and put them into a story or context to an external part. To make the rewritten scenario and situation more tangible and easier to understand for external parties, it was visualized with the use of a storyboard (see Section 6.3.5).

#### 5.3.4.3 Specification of Requirements & Desires

Based on the found problems and *Scenario 2: Problems in the Future*, *Specification of Requirements & Desires* (see Appendix F) was defined. The requirements were classified as either required or desired and were later weighted based on importance. They were categorized by the problem areas: *Privacy, Multitasking & Accessibility, Comfort, Sound & Light* and one additional category*; General.*

## 5.4 Innovation

The goal of the *Innovation* phase was to explore a broad solution space and gradually narrow it down to ultimately deliver several concepts to refine and develop further in the *Refining* phase. The phase began with ideation of all types, in which ideas were based on the identified problems and findings of the previous phases. The ideas were then combined into concepts.

### 5.4.1 Ideation Methods

The following methods were used for ideation.

#### 5.4.1.1 Brainstorming

Several brainstorming sessions were conducted in this project. During each session of 6-8 minutes, a theme was chosen, around which all participants expressed their ideas. Examples of themes were "A product that makes working in the car more effective" or "How can the car encourage human interaction/socializing?", which were based on the personal characteristics of the *Persona*. Once the session was completed, ideas with similar characteristics were grouped and compiled into piles, that is, a KJ analysis (see Appendix J). Unconventional and challenging ideas were encouraged with a focus on quantity rather than quality. This resulted in many different ideas and allowed the participants to develop their creativity.

#### 5.4.1.2 Braindrawing

Braindrawing was performed. Similar to brainstorming, different themes were used during the different sessions to facilitate and stimulate thinking. During braindrawing, all the participants worked on each idea before the session ended. The purpose was to generate more concept-like ideas than those generated through brainstorming. Free thinking was encouraged to maintain a large design space.

#### 5.4.1.3 Brainwriting

Moreover, brainwriting was conducted for the same purposes as brainstorming and braindrawing. Brainwriting was an effective and rewarding approach to generate ideas that might be difficult to visualize or considered feasible, but which turned out to be useful in the end.

#### 5.4.1.4 Six-thinking-hats

To gather further perspectives and ideas, an adaptation of the six thinking hats was used to generate ideas rather than to evaluate them. The premise was that each participant wore a different hat for eight minutes, which meant taking on the role of, for example, a Tech-freak or an Anti-workaholic, and generating ideas with that perspective in mind. This forced the participants to think about things that they may not naturally consider, as biases can easily lead them to get stuck in the same thoughts.

### 5.4.2 Evaluation Methods - To Sift Out Ideas

At this stage, there was a range of ideas, each with a distinct level of development. The crucial task was to filter them thoroughly to ensure that no valuable ideas were overlooked regardless of their complexity.

#### 5.4.2.1 Research

To accomplish this, research was conducted on various techniques utilized by the ideas, including solutions incorporating ball joints, which were revealed to be unreliable, leading to the elimination of several ideas.

#### 5.4.2.2 Voting

Through a systematic process of reviewing and voting on whether to retain or discard ideas, the set of requirements and desires (see Appendix F) was used as a basis. As many ideas were similar, some sketches had to be discarded while retaining the most elaborate versions. Ideas that were considered not feasible or too out of limit were also voting factors. Consequently, a small set of ideas emerged that met some of the established requirements and were deemed to be technically feasible.

### 5.4.3 Generate concepts

Concepts were created by combining the more developed ideas that resulted from the braindrawing sessions with less extensive ones that had valuable aspects or mechanisms worth retaining. This ensured that no ideas were lost, because they were not sufficiently extensive.

For less extensive ideas, a morphological matrix was created to combine ideas into concepts (see Appendix K). The results were concepts that were not considered.

## 5.5 Refining

The innovation phase culminated in a variety of concepts that had to be evaluated and refined to achieve desired completeness. To do this, during the *Refining* phase, methods such as the Pugh Matrix (see Appendix L) were used to evaluate whether concepts were plausible. Decisions were made, which later progressed to a final result visualized to display what the project had resulted in.

### 5.5.1 Combine concepts

In the Innovation phase, many sketches involved a part solution. The sketches were then iterated several times. During each iteration, the concepts were evaluated and the project's aims became more distinct. In addition, concepts of similar characters were merged and combined.

### 5.5.2 Evaluation, Decision & Further Development

After rounds of ideation and sketching, KJ analysis II (see Appendix M) was conducted to identify the areas that were most represented and, thereby, of greater interest to those involved in the project. The analysis resulted in six areas: AR, workstations, modular and/or foldable tables, fixtures, storage and technical partial solutions.

Ideas and concepts were eliminated for different reasons; some were not considered as a whole concept, and some were no longer relevant. This resulted in four concepts being selected for further evaluation and development. The four concepts that had been generated were evaluated in three steps to make a legitimate decision on which concept to further develop. The evaluation was a continuous phase that led to a final decision regarding the concept for further development.

First, the concepts were presented to the client. They expressed their thoughts about the concepts, giving the group new perspectives that were brought for further evaluation. Thereafter, discussions within the project group took place, focusing on the technologies used in each concept, whether they were feasible, and how the team felt about each concept.

Henceforth, Pugh-matrices (see Appendix L) was performed. This evaluation was based on a set of requirements, and the three remaining concepts were compared. One concept was set as a reference and the other two were evaluated to determine whether they fulfilled the requirements better or worse than the reference concept. Based on this, the concepts received points that were based on the weighting of the requirements and resulted in a scoreboard, where the concept with the highest points was “the winner.”

### 5.5.3 Visualization

When the final concepts were refined, ideas had to be communicated to outside parties. The purpose of the visualization was to communicate the project as a whole, including what it resulted in, which could be achieved in various ways. In this project, the most common visualization methods were rendered of CAD models where the car, chairs, and AR glasses were bought and downloaded from the internet.

# 6

# Results - Future Context

This chapter presents the results of the research, user studies, concept development, and the final concept.

## 6.1 Define the Future Context

The following contextual descriptions were necessary for concept development, including; *Our Take on the Future*, *The Future Car*, a description of the persona, a scenario used to describe problems that may occur during the journey, and *Target Group & Desires*.

### 6.1.1 Our Take on the Future

*The year is 2035, over the past decade, the world has undergone major changes in several areas. Technical advancements have changed the way society operates (Weinelt, 2016). Environmental issues are at the forefront of discussion and the world is united to battle climate change.*

*Global temperature has increased at an alarming rate, change is ongoing, and companies are regulated by the government to contribute (NASA, 2023). In recent years, all cars manufactured have become electric, resulting in improved air quality in cities and allowing for progress in the autonomous vehicle industry (European Commission, 2022). The implementation of electric cars plays a crucial role in mitigating the effects of climate change. Furthermore, vegetation of all types can be found on buildings and constitutes a large part of the architecture and infrastructure of cities (Perini and Magliocco, 2012).*

*The car industry is centered more on sharing than ever before. Although it has not yet become a standard, the industry revolves around making cars more compatible with sharing in terms of construction and design. This is a way to counteract climate change by minimizing car usage, which makes it an important question for the industry.*

*Rapid urbanization has called for smarter, better-planned cities as the need for housing increases (The World Bank, 2023). Growing, densely populated cities not only*

*require smart living solutions, but they also rely on well-functioning technology. Automation has been applied in many areas, such as automotive vehicles and coffee shops (Brown, 2021). Technical devices are of greater importance than ever and are a necessity to be part of society. Daily activities such as grocery shopping and cleaning rely on computer functioning.*

*The human brain struggles to keep pace with the world's swift evolution of technology, and the importance of satisfying essential human needs such as socializing and exposure to nature is greater than ever (Korte, 2020). Consequently, people prioritize and appreciate the time spent away from screens and technology.*

*The issue of keeping the population sane with the increasing digitalization and automation of everyday life is critical for the governing bodies. Despite advancements in technology, humans remain the key players in society and are the ones utilizing it. Reliance on computers and robots cannot negate the importance of human well-being. As technological development continues, concerns arise regarding whether it compromises the physical and mental health of humanity.*

**Figure 6.1:** Visualization of the future.

Note. The images were obtained from Adobe Stock.

The data collected through personal research, market research, and literature studies revealed several important insights about the future. Specifically, the data showed that urbanization, environmental issues, digitalization, and other related topics are significant challenges that must be addressed.

The client's encouragement to explore the future raises questions regarding how people live on Earth. The year 2035 was selected as the year of focus. Far enough away for things to have happened but close enough to be able to imagine it/have some idea of what the world will be like and what technology will be prevalent.

A significant portion of the research emphasized the crucial need to consider the environment and understand the potential consequences if we fail to do so. NASA's Climate Spiral graphically displays the progression of global warming, which can be perceived as a concern and undoubtedly a problem that demands attention and resolution in the future (NASA, 2023).

The United Nations (2022) has reported that the current global population is approximately 8.02 billion individuals. The population is projected to continue growing over the next few decades, with an estimated 9 billion people expected by 2037 and 9.7 billion by 2050. Additionally, as trends suggest, the population will continue to grow, leading to urbanization.

The United Nations (2019) addressed the topic of urbanization in the World Urbanization Prospects 2018 report, noting that the urban population surpassed the rural population for the first time in 2008, and has since grown rapidly. As of late 2022, 56% of the world's population resided in urban areas, and this trend is predicted to persist in the coming decades (The World Bank, 2023). The UN projected that nearly 70% of the global population will live in cities and towns by 2050, driven primarily by natural population growth and migration from rural to urban areas, especially in developing countries.

Therefore, it is reasonable to expect that we will reside in increasingly urbanized regions in the future, which presents several challenges, including transportation, environmental, and climate concerns in large cities.

Perini and Magliocco (2012) highlighted the significance of integrating vegetation into urban environments. They suggested that a green envelope presents an excellent opportunity to enhance environmental conditions, reduce pollution and greenhouse gases, improve air quality, and increase biodiversity in urban areas. This emphasis on vegetation integration is essential for the future, making it a natural component to be included in urban design.

With an increasing and more concentrated population, as well as a continued effort to mitigate climate impacts, efficient transportation and infrastructure are required. Deichmann et al. (2023) shed light on the future of car-sharing . They predicted a potential tripling in market size by 2030 from approximately 70 billion today to 200 billion. This makes it a very attractive market to develop. The cars on the city streets will be largely electric. According to the IEA's forecast, approximately 60% of cars sold in 2030 (IEA, 2022) will be electric.

According to Weinelt (2016), the growing importance of digitalization and automation in the future has been widely acknowledged, but it is essential to ensure their correct implementation. Korte (2020) has discussed the impact of digitalization on the human brain, cognitive ability, and behavior through digital media like social media and gaming. Neuroscience research suggests that digital media usage can have adverse effects on the brain and mind, including neurological consequences related to internet/gaming addiction and negative impacts on mental health, language development, and emotional signal processing. This is significant considering the considerable amount of time individuals spend on digital media. Therefore, the development of digitalization should be carefully considered when discussing the future.

### 6.1.2 The Future Car

*The Future Car*, its design, and how it is used evolved throughout the project. The car needed to be defined because the product being developed in the project was intended for use in a future car, which means that it has to be clear what the car looks like. It was also important to define the car to know in what setting user studies should be conducted.

Already at an early stage, it was determined that the car would be shared, and *The Future Car* began to be developed in the form of text, which was continuously updated as new insights and decisions were made, The final definition is as follows:

*The car is part of a service and can be booked if you have a subscription. It picks you up at a designated location using an identification system similar to public transportation. To ensure that all users that utilize the vehicle are decent, they will have to identify themselves when booking and entering the car. When entering the car, you scan your "device" to identify yourself.*

*The project group will focus on a 15-60 minutes long trip, preferably to and from work, but the car is suitable for trips longer than that, up to two hours. The focus comes as a consequence of the different needs and demands that come after one hour in the car, such as ergonomic needs, as well as what you want to do in the car. Furthermore, the tasks that will be performed in the car are related to work and the ride to it, which also relates to our decision regarding limited time.*

*The car has four seats with rotating lounge chairs. The interior of the car was designed to provide a spacious and airy environment. Furthermore, the interior is in a bright natural shade with details in bright wood to create a calming and homely environment that fits a broad target group. The chairs have rounded shapes to enhance privacy. Blue light stripes on the chairs match the exterior of the car and adds some extra life to the color palette. Overall, the design aims to create a feasible and realistic car that meets the needs of various users. The car has doors on both sides of which allows convenient parking and entry of the car on either side of the road.*

*Regarding ownership, the car is not the responsibility of any individual and is shared among multiple people. The service operates using a subscription model that allows users to specify pickup and drop-off locations. Users are required to identify themselves before entering the car, which helps to prevent the presence of suspicious people in the vehicle. Additionally, the car can be booked for private use when a user wants to have a private meeting while riding the car. Ride-sharing is utilized, meaning that multiple riders can reach a destination by sharing a single vehicle that is going in their direction (Remix, 2021). The vehicle makes several stops along its way to pick up and drop off passengers.*

*On the other hand, when multiple people travel, the car finds the best and fastest route that suits all four passengers' destinations.*

*The car is an autonomous electric car of self-driving Level 4, meaning that it can handle all driving in specific geographic areas or on designated routes (On-Road Automated Driving (ORAD) Committee, 2021). It is designed for use in urban areas, and its goal is to provide a convenient, safe, and enjoyable experience for passengers. The modular design of the car seats and accessories allows for customization and personalization of the passenger seats. The car's interior is intended to provide a spacious and comfortable environment with a focus on creating a sense of personal space for each passenger. The feeling of privacy and luxury is important to keep the service attractive to the target group and make them feel like it is not a means of public transport. At the same time, it is important to give users a feeling of an environmentally friendly and efficient choice that gives them the freedom and flexibility they desire.*

*In conclusion, the self-driving car described is designed for shared use and focuses on short rides of approximately 15-60 minutes. The user can book the car and use it for more than just a ride, a possibility to work, or socialize with others. It has a welcoming and accessible environment that gives the user a feeling of easy use but also luxury because the car is equipped with nice seats and accessories that facilitate work in the car.*

In summary, *The Future Car* is intended for shared usage, primarily focusing on brief journeys ranging from 15 to 60 minutes. Users can reserve the car not only for transportation but also for work or socializing. The car's welcoming and user-friendly interior provides a sense of both convenience and luxury thanks to its comfortable seating and airy environment. The car is visualized in Figure 6.2, 6.3 and 6.4.

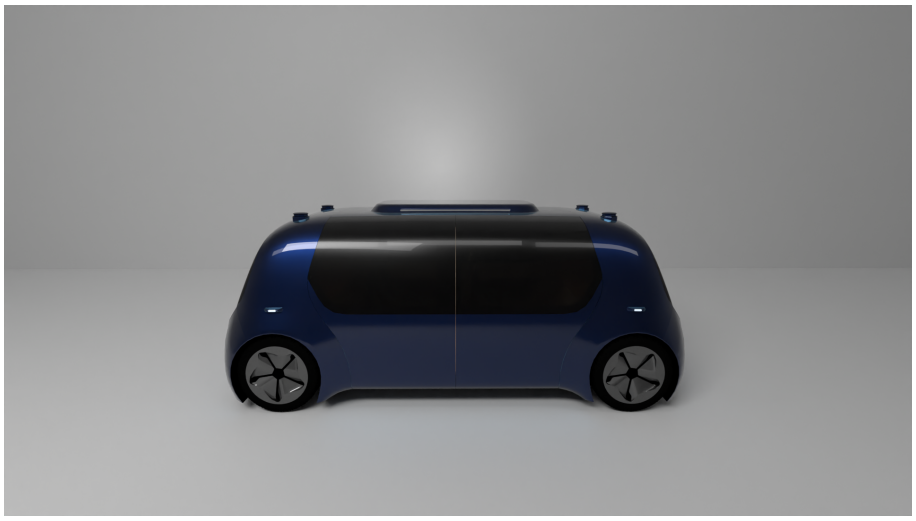

**Figure 6.2:** Exterior of the car.

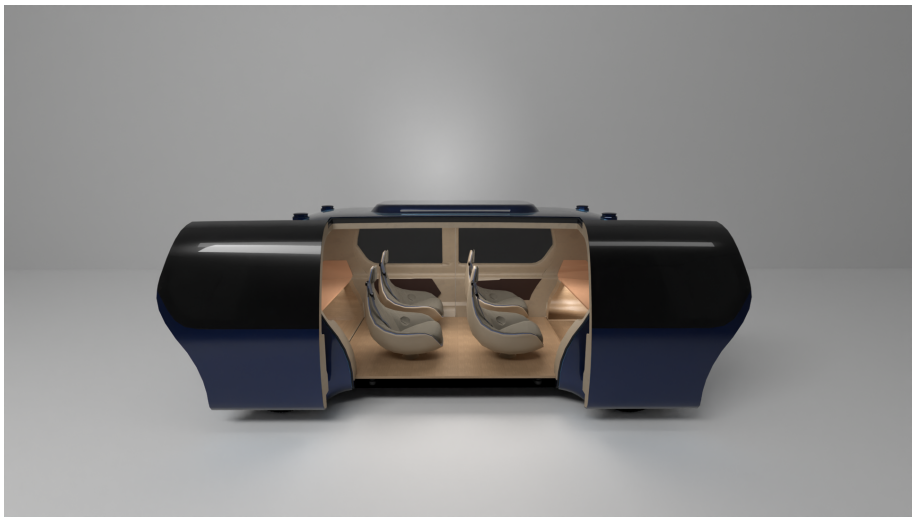

**Figure 6.3:** Interior of the car.

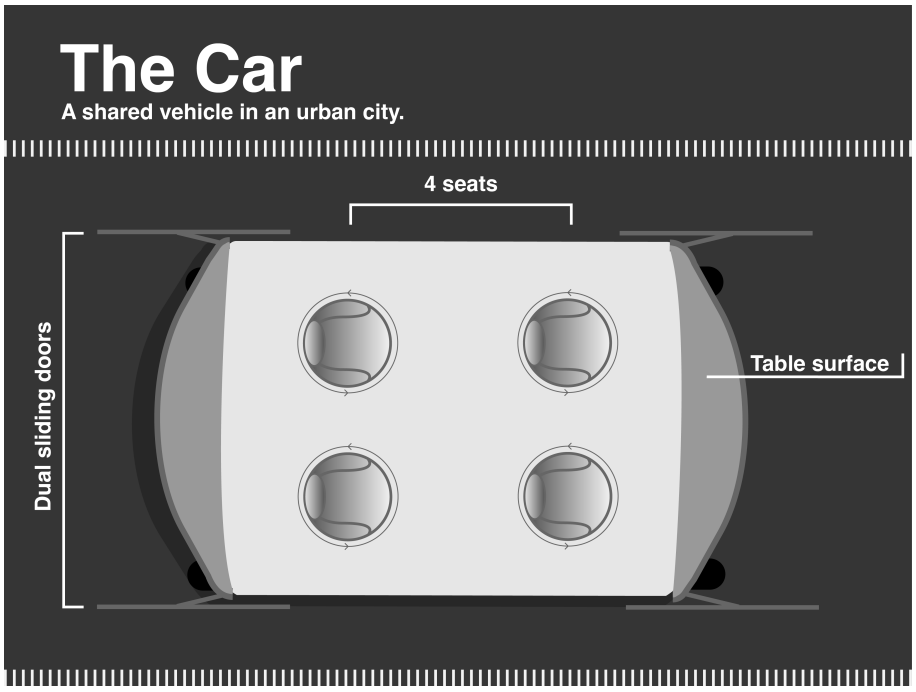


**Figure 6.4:** Top view showing the car's characteristics.

### 6.1.3 Persona - Claire

Everyday problems, characteristics, and interests of a person that could be placed in *Our Take on the Future* (see Section 6.1.1) are illustrated in the Persona, Clarie. Figure 6.5 provides a quick overview of Claire's needs, interests, and dilemmas. Additionally, the environment is explained briefly, as well as a quote from Sharma (2018), to mirror Claire's attitude.

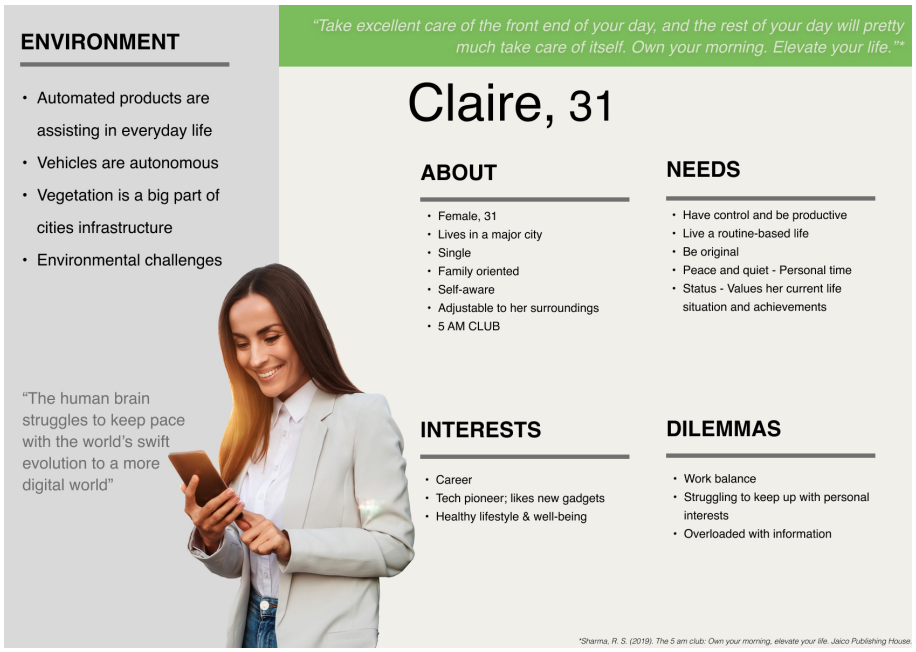


**Figure 6.5:** Claire.

In *Our Take on the Future*, society has undergone significant urbanization and digitalization. Claire represents a highly prevalent demographic; living in a major city, with an interest in technology, and partaking in urban living and the challenges and opportunities a future with big urbanization presents. Since she values her career and cherishes time with her friends and family, she desires a car that provides flexibility by promoting work, for example, by allowing her to answer emails and on her way to visit her family.

Furthermore, *Our Take on the Future* suggests that the human brain struggles to keep pace with the world's swift evolution of technology, and the importance of satisfying essential human needs such as socializing and exposure to nature is greater than ever (Korte, 2020). Therefore, Claire struggles to be overloaded with information.

### 6.1.4 Scenario 1 - Claire´s Day

Scenario 1: Claire's Day was created to provide insight into the daily life of the persona and highlight societal problems that are expected to be at the forefront in 2035. Scenario 1 was later used to identify potential problem areas and aspects that were further investigated and analyzed.

*It is a Friday morning in mid-May. Claire is woken up by the sun streaming through her windows. Her automated blinds roll up at 6:00 AM, which they are programmed to do every morning, to enable her to maintain her lifestyle and make the most out of the day. She feels well rested, energized, and excited about what the day has to offer. In the afternoon, she leaves Toronto to visit her sister on the weekend. However, before she can enjoy an active but also relaxing weekend, she has to get through a day of work at the office.*

*Claire walks out to her newly renovated kitchen which has been fitted with the latest technology in the appliance industry. Before going to bed last night, she decided what she wanted for breakfast in the morning with the help of Artificial Intelligence in her kitchen. The appliances provided help and guidelines to enable Claire to make breakfast. Technology is of great interest to hers, and a hobby she likes spending money on. As Claire's economic situation is stable, money is not a problem for her. Therefore, smart and new solutions that make life easier are a nice way of spending money. Besides the fun part of buying and using new technology, it is also a way for Claire to keep up with the development of the world, and she can easily see how the environmental issues that the world is facing are affected by new technology.*

*After completing her morning routine, she leaves her apartment with her briefcase and luggage, and heads down to the street where the on-demand car she ordered on her smartphone is waiting for her. When ordering a car, Claire chooses whether or not she wants to carpool with other people, heading in the same direction as her.*

*To enter the car, Claire uses her smartwatch to verify that she is the one entering. Once verified, the door she is facing opens automatically and Claire enters the car. She wants to make the most of the 10-minute ride to the office and decide to perform some meditation, which she likes to do when she feels overwhelmed by the current environmental state of the world around which her work revolves. Even though the car is shared with other people, it is tidy and feels personal, which she appreciates.*

*Several meetings are scheduled in the morning, when difficult ethical questions are to be discussed, so Claire knows it will be a rough day. After lunch, one more meeting will take place before 2 PM, when the car will pick her up and head for the destination of the weekend. Her sister lives a four-hour drive from Toronto's city center, and she realizes that the time in the car would be well spent catching up on emails.*

*Claire's boss is fine with her working remotely. Employees at the office are encouraged to work for some days at their location of choice to have more time for leisure activities that promote well-being. Claire appreciates this, as her health is of great importance to her. She loves spending time in nature and has an active lifestyle, but she finds pursuing these interests challenging because almost everything revolves around technology nowadays. Technology and devices are impossible to neglect because they are essential in everyday life, and even though she finds new technology interesting and fun, she is also aware that their use often results in too much screen time, which negatively affects her health.*

*The weekend is about well-being and spending time away from screens and technology. Claire's little sister, Natalie, is an active person just like her sister. They grew up in the countryside, where they spent many hours exploring the nearby forests and mountains. Natalie decided to settle down in the countryside with her family while Claire moved to Toronto to focus on her career. However, she still loves coming to the countryside to recharge her batteries, enjoy nature, and spend some well-needed family time.*

*As the clock approaches 2 PM, Claire receives a message from her smartphone that the car awaits her by the office entrance. She booked extra space for her luggage beforehand, so she only has to grab her briefcase and head down to the car. Once again, the car recognizes her through her smartwatch and allows her to enter. When she enters the car, she grabs the gadget beside her and pulls up the setup that is optimized for working.*

*During the first two hours of the ride, Claire catches up with some work; she enjoys the opportunity to be productive while still sitting comfortably. She also appreciates that the car can take different forms depending on what she wants to accomplish during the ride. Once the clock passes 4 PM and Claire decides to end her workweek, she chooses the relaxation setup. She picks up her device and presses play on her favorite TV show, thanks to the design in the car she can watch the show on a big screen, and the car feels like her living room is at home.*

The scenario takes place in Toronto and as Cox (2022) explained, it is the densest urban area in North America and will remain so for an extended period.

There is a large focus on how Claire, as a driven person, can reach a good balance between work and personal life, as society mainly revolves around work, leaving little time to recharge. It was desirable to communicate the feeling of both liking and using the technological advancements that facilitate life, but also the need for natural and non-technological activities, such as a weekend out in the woods with her family. Because these two wishes are adversarial, it was of great interest to see how they could be fulfilled.

According to Hansen (2019), in his TV series "Din hjärna," the human brain is not suited to the modern world and still behaves as if living in the savannah. Our generation has experienced a significant lifestyle shift, causing the brain to struggle to keep up with it. This has led to increased time spent using technology and less time for physical activity. Scenario 1 aims to highlight this problem while still including technology as it is a large part of society. Instead, it illustrates how technology may be utilized to create more time for activities that are good in terms of health and well-being.

This scenario highlights the elements that mirror personality traits. Her automated kitchen is a good example of how she uses current technology to simplify everyday life, as well as the smartwatch that is used to identify herself when entering the car. Moreover, the scenario communicates to the reader the context of the year 2035, where progress will be headed. The fact that she used a car-sharing service further established that she cares about the environment, which is of great importance. An example of a technological advancement is that Claire uses her smartwatch to identify that she is entering the vehicle. Kassai (2020) discussed the matter of identification in the future and predicted that digital devices and also biometrics, which are explained by Kaspersky (2023) as biological measurements or physical characteristics can be used to identify individuals and will play important roles in identification in the future. Therefore, it is not unlikely that smartwatches in combination with fingerprints will be used as a means of identification when using car-sharing services in the future.

### 6.1.5 Target Group and Desires

The target groups and desires (see Appendix N) served as a summary of *Our take on the Future*, *the Persona*, and *Scenario 1* to make all what had been found and defined more comprehensible.

## 6.2 Choice of the Area of Interest - Work

*Work* was chosen as the area / activity to proceed with.

*Work* implies tasks that can be performed at a desk or on a computer; that is, not manual labor. For example:

- Writing and responding to emails
- Creating or editing documents or spreadsheets
- Conducting research or analysis
- Participating in virtual meetings or conference calls

However, several other areas were found to be of interest and were investigated; *socialize* and *relax* being the two most relevant potential alternatives.

*Work, Relax,* and *Socialize* were similar in many ways. One may want to socialize and relax at times when performing work, but there is no desire to work in a setting intended for relaxation or socializing. Consequently, *Work* was considered a more versatile activity, which is one of the reasons for moving forward with it.

Furthermore, Work is of interest because remote working has become increasingly prevalent in recent years. Therefore, it is relevant to explore how this can be utilized by providing the ability to work in a car.

Finally, in *Our Take on The Future* and the Pesona, it is concluded that work plays a big part of life and that there will be difficulties balancing it with leisure activities and personal life. A car that provides the possibility to work would therefore serve as an efficient solution to this problem.

## 6.3 Identified Problems When Working in a Car

Based on user studies, problems that may occur when working in a ride-sharing vehicle were defined and grouped into four problem areas.

### 6.3.1 Privacy

- The risk of disturbing or getting disturbed by other passengers
- Lack of private space while completing work tasks in the presence of unknown people.

### 6.3.2 Multitasking & Accessibility

- Difficulty to quickly set up one's workspace
- Difficulty to perform several tasks simultaneously
- Difficulty accessing one's own devices while focusing on work tasks at hand.

### 6.3.3 Sound & Lights

- Difficulty focusing due to sunlight hitting the screen of the device or directly hitting the user's eyes
- Difficulty to focus due to noise from other passengers or the outside
- Difficulty to concentrate due to many impressions

### 6.3.4 Comfort

- Inability to focus on the task at hand due to device moving because of speed fluctuations
- Difficulty maintaining good ergonomics as a result of working in an unstable sitting position.

### 6.3.5 Scenario 2 - Claire's Ride from Hell

The second scenario was designed to provide a more detailed and specific situation in which the identified problem areas were incorporated.

*After completing her morning routine, she leaves her apartment with her briefcase and luggage and heads down to the street where the on-demand car she ordered on her smartphone is waiting for her. When ordering a car, Claire gets to choose whether she wants to carpool with other people, heading in the same direction as her, or not. Thus, it is similar to a bus ride. However, the car does not feel like a bus, but more like a luxury shared vehicle, which makes it an environmentally friendly choice. Owing to the constantly increasing population, shared vehicles have become*

*the standard; it would not work if every family or person had their own. This has contributed to a new market of vehicles that do not "imply" public transport, but rather a feeling of efficiency and contribution to a better society, while at the same time cherishing users' privacy to make them feel like it is a vehicle of their own.*

*To enter the car, Claire uses her smartwatch to verify that she is entering; she is accepted because she has a subscription to the service that gives her the right to utilize the car. She enjoys the verification, as it helps her find her assigned seat and reminds her if she forgets something when leaving the car.*

*Once verified, the door she is facing opens automatically and Claire enters the car. It feels welcome because of its easy access and airy design. The ceiling of the vehicle is high, and four relatively big chairs enclose the person sitting in it, which gives Claire the feeling that she has her personal space. The company carefully chose the number of chairs to balance efficiency and privacy. When ordering the car, the option to put in the need to be at their desired drop-off location at a certain time is given. The AI in the app service calculates the possibilities to host most passengers in the car while still ensuring that everyone arrives at their desired time to drop off. Because of this, not all seats may be filled, and this also contributes to being a preferred transport rather than a bus.*

*The ride to Claire's office is about 45 minutes long, due to a lot of traffic in the morning. She sees this as a perfect opportunity to get some work done, as it allows her to leave work a little earlier, which gives her more time to engage in leisure activities in the evening. Even though the car is suited with modular tables and nice ergonomic seats, she faces some problems while riding the car. The tables are sometimes too small for all of her equipment and devices, such as laptops, tablets, and papers. Meetings can also be tricky because the vehicle and its passengers are quiet, and Claire does not want other passengers to think she is disrespectful or disturbing by being on the phone or in an online meeting.*

*Since Claire is working with confidential documents, she puts her computer on her lap in hopes that other people in the car will not see it. This fixes the problem regarding privacy, but introduces new ones. The ride was bumpy, and the car jostled around as it navigated the city. Claire tried to focus on her work, but the constant movement made it difficult to concentrate. Suddenly, the car made a fast turn, causing Claire's laptop to slide off her lap and crash into the ground.*

*Claire's heart sank as she realized that her attempt to hide her confidential work documents instead led to a catastrophic start to her day. The rest of the day was affected by this event, because she had to find a place to fix her broken laptop. She could easily buy a new one, but this does not lay right with her values about contributing to a better environment.*

*As Claire walked out of the car, she felt frustrated. She wanted to do some work, but it did not turn out the way she thought it would. Even though she likes the service and the vehicle, she wants it to be more compatible with work. At the end of the day, she pays a lot of money for a subscription to this service.*

To communicate Scenario 2 - Claire's Ride from Hell, a user journey mapping is shown in Figure 6.6.

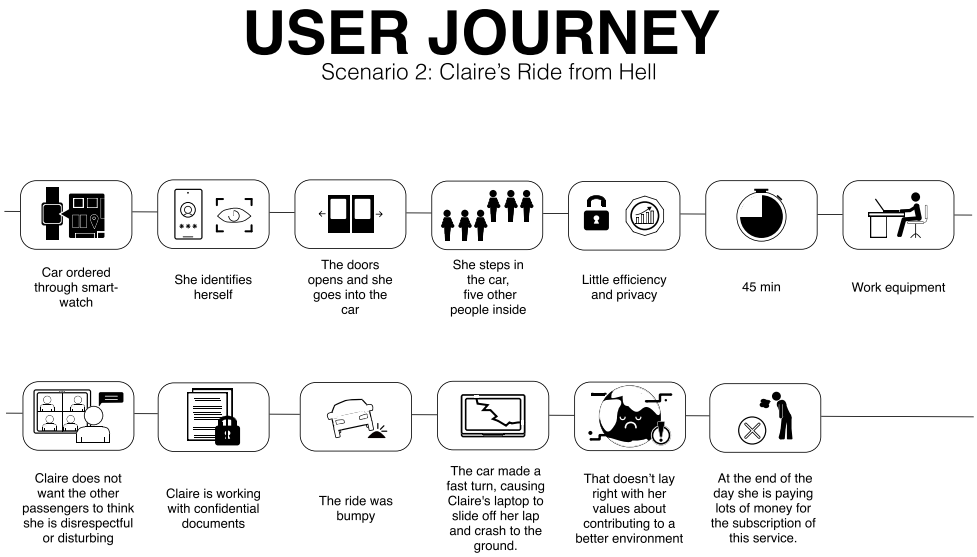


**Figure 6.6:** User Journey Mapping of Scenario 2 - Claire's Ride from Hell.

## 6.4 Specification of Requirements & Desires

The list of requirements and desires (see Appendix F). acted as a guideline for both ideation and evaluation during concept development. They are based on work done to define contextual descriptions and problem areas.

### 6.4.1 Privacy

- Avoid disturbing other passengers with one's physical presence
- Enable privacy of one's devices and material
- Enable a feeling of being in your own private office

During the user studies, it was observed that when someone entered the vehicle, participants either lost the focus of the task at hand or felt inclined to talk to the person entering. One reason for this was that the vehicle gave the impression of a public space. While Claire, who lives in a big city, wants to partake in urban city life, she still desires to be able to perform work in the car in a calm, private setting without having to worry about someone seeing what she is doing. Another desire is the need for peace and quiet and personal time, which commute to work can facilitate as long as it feels pleasant and private. On this note, a user study participant expressed that having the option to show whether they were open to conversation would be desirable.

### 6.4.2 Multitasking & Accessibility

- Hold *MagSafe-technology*
- Enable human control
- Enable easy setup of the workstation when bringing one's own device
- Provide enough but not redundant information
- Enable work-related tasks, e.g. online meetings, browsing the internet
- Enable easy setup of the product
- Enable *BYOD*
- Be modular / Enable *modularity*
- Enable multitasking

Claire wants to be able to work during her way to the office. During the user studies, it was observed that it took up to three minutes for participants to prepare for the task. Consequently, a quick-start procedure to get started is desirable. Another situation that emerged during the user studies was the difficulty in performing several

tasks simultaneously, that is, using a laptop and taking notes on paper simultaneously, as a result of limited space. To Claire, being able to perform different kinds of work during her trips is necessary, whether to use her phone, laptop, or both simultaneously. This calls for the effective use of several devices at once. As she is a tech pioneer who strives to be productive, the car ride is an opportunity to charge her devices using *MagSafe*. Claire also wants to be in control and have the ability to choose how much what and information she is presented with, which also was a need that became prevalent during the user studies, that is, being able to monitor one's devices at all times.

### 6.4.3 Sound & Light

- Prevent disturbing sound & light from inside the vehicle
- Prevent disturbing sound & light from outside the vehicle

Participants had to squint because of reflections of the sun on their device screens. Being disturbed by the noise of other passengers, and therefore not being able to focus on the task at hand, was also a relevant aspect. It was also revealed that light from the outside environment has both positive and negative aspects. Natural light was appreciated, but the ability to regulate the amount of light was desired. The route the vehicle took had many stops, and many people joined the ride during user studies. In addition, when the vehicle stopped, it made a distracting sound, implying that the doors were closing.

### 6.4.4 Comfort

- Keep the device in place
- Enable good posture
- Be space efficient

Many non-ideal seating positions have been observed, primarily affecting the neck and back. These positions were often caused by the participants having laptops on their laps. As Claire spends approximately 15-60 minutes in the car, being able to maintain good ergonomics is essential. To maintain the car's luxurious feeling, a solution should not take up too much space and should still keep the car spacious. Another observed aspect was that the participant tried to elevate the laptop by lifting their heels off the ground, which resulted in an even more unstable sitting position. During sudden braking of the vehicle, participants shifted their focus to hold onto both devices, which caused them to pause the task at hand.

### 6.4.5 General

- Be feasible in 2035
- Express innovation
- Have an intuitive design/interface
- Can be shared
- Use digital technology when possible

To be considered feasible, the product must meet the requirements for the year 2035, which is the defined timeframe for the future. Innovation are essential elements for a product to feel futuristic. The innovative solution aligns with Claire's personality as a technology pioneer. In the future, where sharing is a norm, if the solution should be approachable and easy to use by many different people, an intuitive design is necessary. In the future, where sharing will become the norm, an intuitive design is essential to ensure that the solution is approachable and easy to use for many different people. In the future, digital solutions will become increasingly popular, which is in line with the trend of utilizing digitalization as much as possible. The use of digital solutions is an environmentally friendly approach.

# 7

# Results - Concept Design

This chapter describes the concepts that were developed, and how they were evaluated and gradually eliminated to identify the best possible solution.

*The Specifications of Requirements & Desires* were summarized in a statement that shaped Concept Development. *"The solution aims to facilitate work in the car while at the same time give the user freedom to design and control their own experience in the car."*

## 7.1 Four Concepts

The many rounds of sketching and evaluation resulted in the following four concepts: *Augmented Workstation, Multifunctional Divider, Privacy Pod*, and *Gimbal*.

### 7.1.1 Augmented Workstation

*The Augmented Workstation* (see Figure 7.1) utilizes AR glasses and BYOD. The user connects their devices of choice to the AR glasses. This enables the user to view their virtual screens, while they will only be visible to the person wearing the glasses, resulting in no worries about privacy when working.

In addition to glasses, a table with integrated *MagSafe technology* is part of the concept, which allows the user to safely dock and charge their devices. Furthermore, the table features a device used for the efficient and ergonomic navigation of what is projected in the glasses.

The AR glasses are available in the car, allowing easy access and a fast setup. The user can simply wear the glasses and start working immediately.

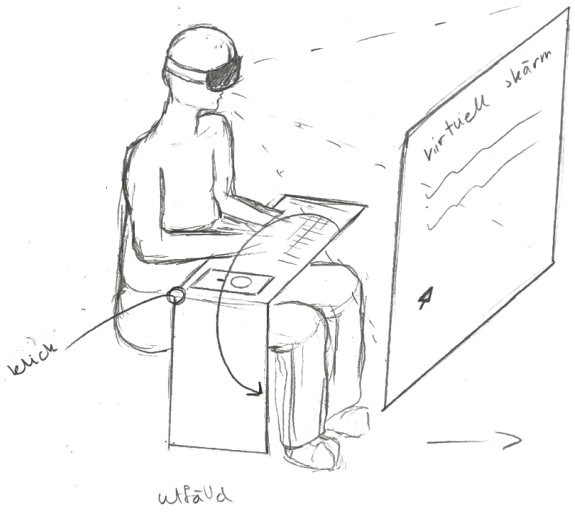


**Figure 7.1:** Sketch of *the Augmented Workstation.*

### 7.1.2 Multifunctional Divider

*The Multifunctional Divider* enables users to isolate themselves from other passengers. This is accomplished with a screening wall that allows for height adjustment, resulting in a reduction in disturbing noise and light as well as increased privacy.

*The Multifunctional Divider* offers storage on the screen wall, on which the user may dock their devices, with the use of *MagSafe*. Furthermore, tables can be folded up to provide a work area. Figure 7.2 shows two versions of *the Multifunctional Divider* with the same functionality but different designs.

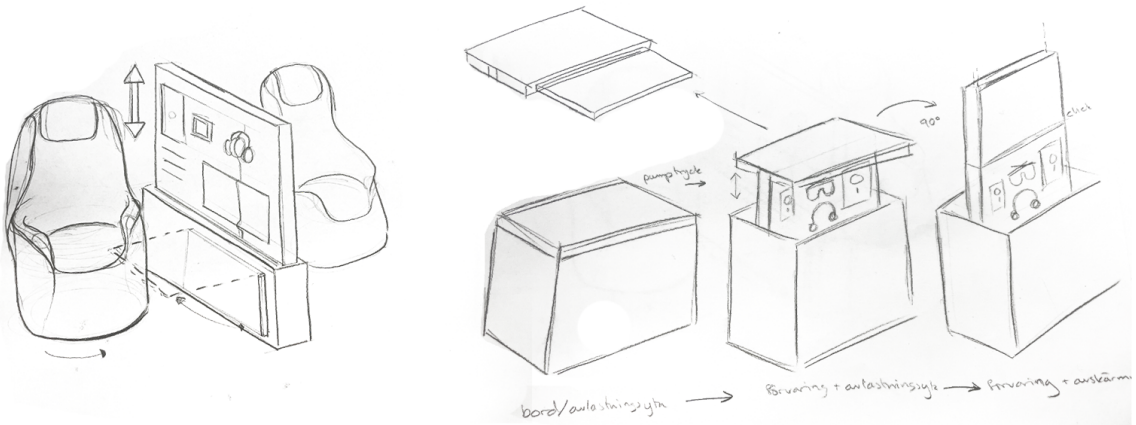

**Figure 7.2:** Two sketched versions of *the Multifunctional Divider.*

### 7.1.3 Privacy Pod

*The Privacy Pod* is designed to prioritize user privacy and concentration. Inspired by office pods, the concept features a folding desk with *MagSafe technology* for the user's devices and provides the opportunity to work on confidential material or participate in online meetings without being disturbed or disturbing others. The windows provide natural light and a view while the environment is adapted for work. Made from a pleated and flexible material, the pod can be easily folded and stored when not in use, creating more space when not needed (see Figure 7.3).

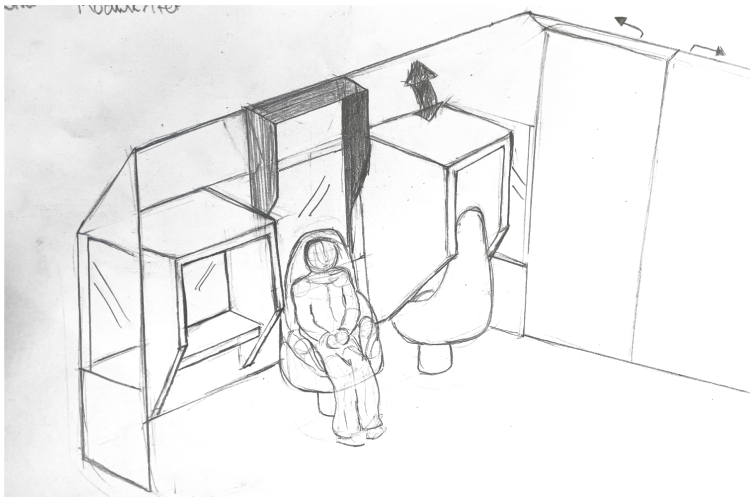

**Figure 7.3:** Sketch of *the Privacy Pod.*

### 7.1.4 Gimbal

*The Gimbal* concept (see Figure 7.4) consists of an arm and a table with integrated *MagSafe*, which allows the user to dock and charge devices without the risk of moving. The arm is equipped with *Gimbal* technology, which means that small built-in motors carefully balance and compensate for the movements of the car. This results in the table remaining leveled at all times, regardless of how bumpy the drive is.

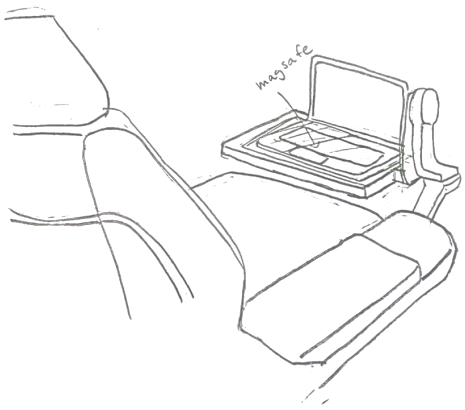


**Figure 7.4:** Sketch of *the Gimbal* concept.

## 7.2 Motivation for Chosen Concept

To choose one concept to continue with, an evaluation was performed.

### 7.2.1 Discarding Concept Gimbal

The *Gimbal* was discarded, as it only solves problems regarding vibrations and the risk of devices sliding off the table. It poorly fulfilled other requirements and was therefore not considered an adequate concept. For example, *Gimbal* does not solve any privacy-related requirements, which are of high priority. The fact the concept uses complicated technology to solve a not so complicated problem was also an important factor.

### 7.2.2 Choice- and Evaluation of Concepts

Pugh matrices were conducted to evaluate the three remaining concepts: *Augmented Workstation, Multifunctional Divider,* and *Privacy Pod* (see Appendix L).

Two Pugh matrices were made, and both times, *the Augmented Workstation* received the best score. When the concepts were presented to and discussed with the client, the interest in *the Augmented Workstation* was great as it was considered to have great potential, and many aspects that could be of interest to explore further. AR has many possibilities, and it is likely to be a widely used and prevalent technology in the future, making *the Augmented Workstation* a relevant solution in Claire's technology-centered everyday life.

Furthermore, *the Augmented Workstation* satisfies many of the Requirements and Desires, especially in terms of privacy and expressing innovation. With all this consideration, *the Augmented Workstation* was chosen as the concept for further development.

Consequently, *the Privacy Pod* was discarded, however, *the Multifunctional Divider* was not. This concept had interesting elements that solved issues that *the Augmented Workstation* could not solve, such as physical privacy, mainly in terms of screening from other passengers. Furthermore, *the Multifunctional Divider* solves ergonomic-related issues, such as disturbing sounds and lights from other passengers and the outside. It also allows for further implementation of *MagSafe* and *modularity*, as well as the possibility of offering storage.

Therefore, *the Multifunctional Divider* was considered to be a good complement to *the Augmented Workstation*, leading to the decision to merge them into one final concept.

# 8

# Results - Final Concept *AccelARate*

This chapter describes the final concept *AccelARate*.

## 8.1 Explanation of *AccelARate*

The final concept, *AccelARate*, is designed to provide the user with a private and space-efficient work setting. It consists of AR glasses (see Figure 8.1), the control device, *TapXR*, and *Duwall*, a divider positioned between each row of seats.

**Figure 8.1:** The AR glasses.

### 8.1.1 AR Glasses & *TapXR*

The user docks their device with *MagSafe*, which connects it to a pair of AR glasses and a *TapXR*-device provided in the *Duwall*. The AR glasses allow the user to project the screens of their devices to the glasses (see Figure 8.2). This enables privacy and an easily modified virtual workstation that does not require any space and can have tailored presets, making the setup quick and easy. The projected information can be shared with other users wearing AR glasses in the car. The content displayed in this view can easily be navigated using *TapXR*. Additionally, the AR glasses can be dimmed and fill the same function as a pair of sunglasses (see Figure 8.3).


**Figure 8.2:** Visualization of projected screens.


**Figure 8.3:** Visualization of projected screens in dimmed condition.

### 8.1.2 *Duwall*

*Duwall* consists of a modular wall and a foldable table, both with integrated *MagSafe*. The user controls the height of the wall with their device. The *Duwall* functions as a storage compartment for the AR glasses, the *TapXR* and personal belongings. This is accomplished with the use of *MagSafe-technology*. *Duwall* can also provide privacy by acting as a physical divider between passengers. The wall can be in *Divider Mode* (see Figure 8.6) or in *Storage Mode* (see Figure 8.8), allowing the users to perform tasks of varying nature, such as talking to other passengers or having an online meeting.

Each *Duwall* includes two walls, one for each user to control, making the user not reliant on the preferences or actions of other passengers.

The foldable table is stored alongside the *Duwall* when not in use. To unfold the table, the user simply pulls it up and folds it, making it leveled and perpendicular to the console (see Figure 8.4). The table also serves as a flat surface for the *TapXR* to be used on. Although other surfaces may be used, such as a leg, the table provides the user with an ergonomically sound working position. The table is connected to a rail, which enables it to be used regardless of which way the chair is facing (see Figure 8.5).

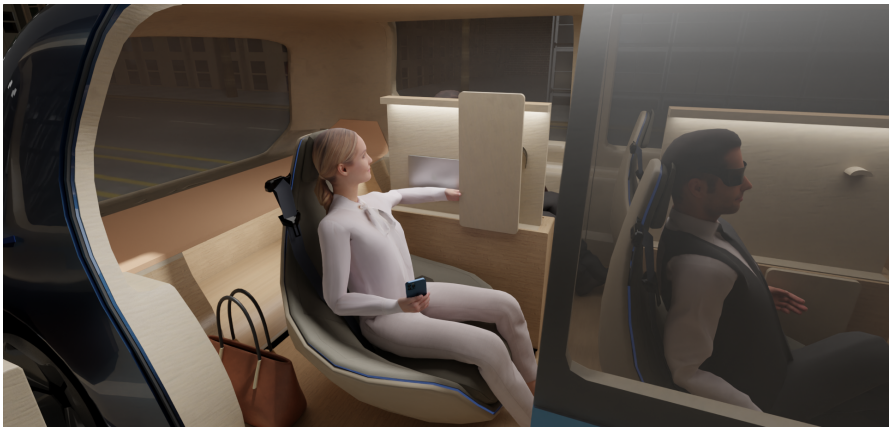

**Figure 8.4:** *Folding up desk.*

**Figure 8.5:** *Rail that table slides on.*

Furthermore, the console has a cleaning system for the AR glasses and the *TapXR*, as they are shared among users. When a user arrives at their destination and exits the car, the *Duwall* goes into *Storage Mode* and the devices are cleaned, providing the next user with clean devices.

### 8.1.3 Ways of Using AccelARate

The components of AccelARate work in synergy to facilitate various constellations and work related activities in the car. The seating positions and interactions between users may vary, here are some examples of possibilities.

***Full Privacy*** (see Figure 8.6). All passengers work individually while not disturbing each other. All *Duwalls* are in *Divider Mode*, and all passengers wear their glasses.

**Figure 8.6:** *Full Privacy.*

***Company.*** Passengers sitting on the same side of the car face each other to socialize, while the *Duwall* is in *Divider Mode* (see Figure 8.7). The AR glasses can be used to share information.

**Figure 8.7:** *Company.*

***Everyone Involved.*** All passengers partake in socialization. All *Duwalls* are in *Storage Mode*, providing an open space where all passengers see each other (see Figure 8.8). Information can be shared with one or more individuals using AR glasses.

**Figure 8.8:** *Everyone Involved.*

### 8.1.4 Design & Shape

*Duwall* is given a simple, minimalistic expression to align with the rest of the car's interior, which projects a warm and gentle feeling while feeling futuristic. This is necessary to not cause the user extra stress as a result of unnecessary impressions. That is one of the primary desires of users in the hectic future. The design of *Duwall*'s table follows the mental model of a foldable table in a vehicle which makes it easy for first time user's to use it efficiently. The AR glasses have a simple and sunglasses-like design to make them attractive to the user and make them want to wear them.

## 8.2 Scenario 3 - Claire's dearest AR glasses

Scenario 3: Claire's Dearest AR Glasses includes *AccelARate* used in the car. The scenario highlights how *AccelARate* enables user value and provides further information on the intended future context and is visualized in Figure 8.9.

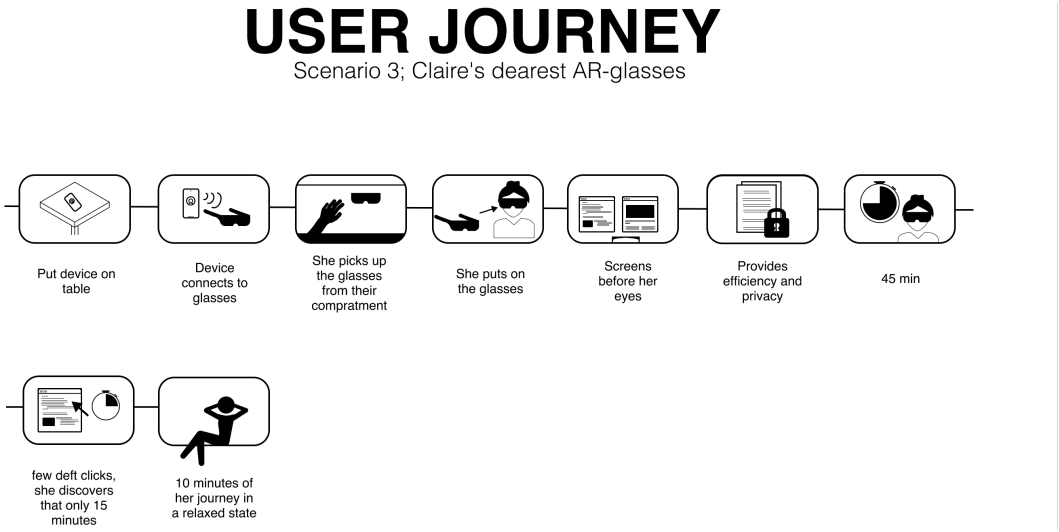


**Figure 8.9:** *User Journey of Scenario 3.*

### 8.2.1 Claire's dearest AR glasses

*After completing her morning routine, Claire leaves her apartment with her briefcase and luggage, and heads down to the street where the autonomous on-demand car she ordered on her phone is waiting for her. When ordering a car, Claire chooses whether or not she wants to carpool with other people, heading in the same direction as her. Thus, it is similar to a bus ride. However, the car does not feel like a bus, more like a luxurious shared vehicle, which makes it an environmentally friendly choice. Owing to the constantly increasing population, shared vehicles have become the standard; it would not work if every family or person had their own. This has contributed to a new market of autonomous vehicles that do not "imply" public transport, but rather a feeling of efficiency and contribution to a better society, whilst at the same time cherishing the users' privacy to make them feel like it is a vehicle of their own.*

*To enter the car, Claire uses her smartwatch to verify that she is entering; she is accepted because she has a subscription to the service that gives her the right to utilize the car. She enjoys verifying herself as it shows that she is a decent person just like the others in the car, which establishes respect among the passengers, contributing to the feeling of luxury since not all people are verified to ride the vehicle. Once verified, the door she is facing opens automatically and Claire enters the car. It feels welcoming because of its easy access and airy design. Claire puts down her belongings next to her chair, she places her coat on the hook on the wall next to the available seat.*

*The ceiling of the vehicle is high, and there are four relatively large chairs that enclose the person sitting in it, which gives Claire the feeling that she has her own*

*personal space. The number of chairs was carefully chosen to balance efficiency and privacy. When ordering the car, an option to put in the need to be at their desired drop-off location at a certain time is given. The AI in the app service calculates the possibilities to host most passengers in the car while still ensuring that everyone arrives at their desired time to drop off. Because of this, not all seats may be filled, and this also contributes to being a preferred transport rather than a bus.*

*The 45-minute ride to Claire's office is often bogged down by bustling morning traffic. Despite congestion, she finds solace in the cozy and secure confines of the car, which is designed to provide a comfortable and safe environment for commuters. The vehicle is equipped with Duwall placed between two chairs, Duwall has two modular tables and an optional wall divider making the seat more private, allowing Claire to transform the space into a makeshift office. This convenient setup enables her to get some work done during the journey, which in turn allows her to leave work earlier and indulge in leisure activities in the evening.*

*After rummaging through her handbag, she pulls out her device (phone, smartwatch, computer) and places it at the center of Duwall's table. The MagSafe implemented in the table firmly secures the device using magnets and, once connected, the information from her device, Internet connection, and workspace is seamlessly transferred to her glasses. When the divider wall is automatically pulled up its accessible for Claire to reach to the equipment provided by the car: the AR glasses and the controlling device TapXR. The AR glasses are even charged since the last passenger placed them right to the walls charging setup.*

*Her fellow passengers engage in various tasks, some working diligently like Claire, while others take the time to unwind. The glasses she wears provide a sense of security, as only Claire can view and interact with the screens displayed in front of her. The bright, sunny day casts a warm glow over the car, prompting some passengers to wear sunglasses. Sunlight makes it slightly harder for Claire to concentrate on her screens, so she adjusts the tint accordingly. The AR glasses still allow her to appreciate her surroundings, as she gazes out at the bustling sidewalks and towering skyscrapers that pass by. The screen she views through the glasses remains in a fixed position in space irrespective of where she looks.*

*As time marches on, Claire wonders how long it will take to reach her office. With a few deft clicks, she discovers that only 15 minutes remain on her ride. Suddenly, the car takes a sharp turn, avoiding a cyclist, making Claire feel a force pulling her towards the right. However, her equipment remains secure, a testament to the car's thoughtful design. The magnets holding her device are strong enough to hold it in place, but not strong enough to make it difficult to remove.*

*Deciding to spend the remaining 10 minutes of her journey in a relaxed state, Claire lifts her device effortlessly from the table and detaches it from the magnetic grip. She stows it in her bag before removing her glasses and placing them on the multifunctional divider wall. Because the equipment has been placed on the wall they are secured and with wireless charging on the wall the equipment will be charged, making it possible for the next users to use them. She folded the foldable table away from the chair and turned her seat to get a better view in front of the big window, sitting in a relaxed position. Reclining in her seat, she savors the tranquility and safety of her surroundings, allowing herself to unwind while looking at the environment the car sweeps through until she arrives at her destination.*

## 8.3 Fulfillment of Requirements & Desires

Below is a presentation of how *AccelARate's* fulfill the *Specification of Requirements & Desires* presented (see Section 6.4 and Appendix F).

### 8.3.1 Privacy

When wearing the AR glasses, the user is the only one who sees the projected information, ensuring visual privacy. Physical privacy is solved by *Duwall*, which, if desired, can make the user feel separated from other passengers and give the user a feeling of being in their own private office.

### 8.3.2 Multitasking & Accessibility

*AccelARate* uses *MagSafe* to allow users to easily setup, dock, charge, and work with multiple devices simultaneously. Because information is transferred from the user's personal device, the user has control over what is projected in the glasses. The ability to customize the workstation physically and virtually provides the user with full control.

### 8.3.3 Sound & Light

The ability to dim the AR glasses gives the user the ability to control the exposure to surrounding light. *Duwall* also works as a shield for the screen light of other passengers' devices, which may be more prominent under poor light conditions.

### 8.3.4 Comfort

The AR Glasses enable the user to maintain proper back and neck ergonomics, since the user chooses where to view what is projected in the glasses, for example, at the eye level directly in front of them. The table serves as a surface for maintaining good ergonomics when using the *TapXR*. *MagSafe* solves the issue of having to hold onto the devices. Furthermore, the ability to easily tuck in the table and the fact that the work setting *AccelARate* offers is mostly virtual results in great space efficiency.

### 8.3.5 General

*AccelARate* is designed to be shared, making it environmentally friendly and contemporary by the year 2035. *AccelARate* combines AR glasses, *TapXR*, and *MagSafe* technology, which results in an innovative and digital concept that is intuitive to use for anyone because they use their own devices with which they are familiar. Although the AR glasses and *TapXR* are shared, they are cleaned to further promote and enable sharing.

# 9

# Discussion

This chapter discusses the results of the project and how well the final concept fulfills its purpose and aim. The procedure, technical aspects, sustainability, ethics, and further developments are also discussed.

## 9.1 Purpose & Aim: How Well Are They Satisfied?

The purpose of the project was to explore how *MagSafe*, *Modularity*, and *BYOD* can be implemented in future vehicle designs to increase the user experience. Exploration was successfully conducted, whilst the group also reached a stage of product development and delivered a design solution, which was the aim of the group.

The future, the future of cars, their usage and the demands and needs of future users were thoroughly explored as it was a crucial part of creating a trustworthy context, thus making the final product fit in contemporary of the defined context, that is, in the year 2035. However, the exploration and consequently the final concept includes the aspects given from the client and that were of interest; *MagSafe*, *Modularity* and *BYOD*. In addition, the group has explored other technologies such as AR and *TapXR*, to enhance and complement the *MagSafe*, *Modularity* and *BYOD*, and thereby satisfied the purpose of the project with a high degree of satisfaction.

## 9.2 The Result

A significant portion of the project time was used for research and definitions related to the future and future car-usage, rather than only focusing on aspects related to product development. This required more time than expected, which meant that there was less time left for physical design product development. This insight forced the project group to change the approach of the project and its purpose to be more exploratory and prospective.

The result was broader than that of a typical product development project. The result of this project is more than just a product; the future context: *Our Take on the Future*, *The Future Car*, and the *Persona*, is of the same importance as the final concept, *AccelARate*. Without the context, the product is not relevant,

which underscores the importance of focusing on the context given to disclosing the project.

The research part of the project focused more on prospective design than on current issues and user needs. As a result, methods such as personas, scenarios, and user stories were crucial, since by defining them, the findings of prospective research could be communicated effectively.

In Section 1.6, it was mentioned that the group aims to deliver a universal result rather than branding it as ZEEKR's. Although the group has worked independently and with areas of their own, it is important to remember that the project has a client with their own interests and goals. The final result may reflect the client's visions, thoughts, and brand, even if the client's name and logotype did not end up on the solution.

Upon reviewing the final results, it can be concluded that although the intention was to focus on *MagSafe*, *BYOD*, and *Modularity*, other technical solutions, mainly AR, are crucial for the final concept. The inclusion of AR was a result of research on users' future needs, which showed that AR is a highly topical technology.

## 9.3 The Procedure

The process of this project differs from traditional product development and took shape as the project progressed. This was due to several reasons. Typically, research focuses on identifying current problems, preferably by user studies, whereas in this project, the focus is on exploring the possibilities that can exist in the future.

Generally, user studies are a good basis for making decisions in a product development project. Since this project did more thorough literature studies and research, rather than user studies, the validity of the project's results can be discussed.

However, user studies were conducted, but in a matter leaning more towards "in the laboratory" than "in the field", resulting in less validity. The group originally intended to conduct a higher number of user studies, to examine a broader study of what users value when riding in an autonomous vehicle, and what is needed when working in a vehicle.

Another reason for not conducting a higher number of user studies was that the project research was more theoretical since its context is set in the future. The user studies were meant to provide insight and different perspectives on what the future may hold. As a result, the research focused more on the future and possible outcomes that were innovative and futuristic.

Nevertheless, the project group has shown good judgment by the research conducted, literature studies together with user studies was sufficient to arrive at a legitimate result.

Iteration was made continuously during the whole project. Many things had to be investigated and defined, such as the contextual descriptions. Defining the context was initially particularly challenging as the thesis question was not finally set in the beginning of the project. As more data was collected, all documents, including the persona and the scenario, were continuously updated throughout the entire project.

At the same time, the project changed direction several times as new findings emerged and new interests were discovered. The continuous iteration of the project was experienced by the project group members to have both advantages and disadvantages. The advantage of this high level of iteration was that these documents were thoroughly worked through several times using research. However, it had some drawbacks, since some phases (research and defining problems), took longer than expected. Even though the continuous iteration made it possible to work on these important documents thoroughly and get an understanding of the context and future car-usage, it also had a downside as the project was more about defining the future, rather than making it a product development project.

That being said, the process, and especially the large amount of iteration has been educational even though it was challenging. The project group was forced to determine what the next logical step should be in the process which contributed to a feeling of a "real" mission from a client rather than being a school project.

It is also interesting that some methods that usually are ideation methods, such as brainstorming and brainwriting, in this project also acted as research methods. As the future is difficult to predict and determine, brainstorming was an effective way of seeing possible outcomes of the future as it opened up new perspectives thinking outside "the box". As sketches were made, new ideas and thoughts on the future emerged, which led to a new iteration of research, thus keeping the project alive.

When identifying the persona's needs and requirements it was important to look at the basic human needs that will remain in the distant future, but also explore new needs and desires. In addition to this market research had to be performed to identify how behaviors in the future could change, exemple, how humans will live, or how they will emotionally feel. This phase went through continuous iteration during the project.

## 9.4 Technical Aspects

A physical prototype was developed to obtain an understanding of the measurements of the final product. A more advanced prototype of *AccelARate* would have been interesting to conduct because it could test the technical aspects of the product. This can develop a product and make the technique and product more practical. Certain conditions and technical solutions that make the final result feasible are assumed to work in 2035. This is based on research but also on assumptions regarding technical improvements that made it possible to proceed with the project. For example, cars are fully automated and do not require a driver.

The project group found it difficult to test products and concepts because of the limited availability of the technology used, such as AR technology, which is not yet widely accessible to the general public. Based on this research, the group believes that this technology will be available to the public by 2035, and thereby the concept will be practicable. Although there is little technical knowledge about the practicability of the results, this is not seen as a problem that reduces the validity of the results, as it was not the focus of the project.

Because the product is feasible in the future, 12 years from now, there is an important consequence that has to be taken into consideration: it is difficult to perform tests on the product in the right context and environment. This results in a relatively poor understanding of how the product works, what users think about it, and what improvements are topical.

An alternative way to conduct tests would be to create a similar environment and build a prototype with which the interviewees could interact. This would have been beneficial and may have generated feedback on the product, such as on ergonomic aspects and how the concept is perceived. It was not possible to produce or execute the project within a limited amount of time. The relevance of feedback is debatable, as future context plays a crucial role in product perception. A vehicle would have been able to build a context around, but future behaviors and future society are harder for the interviewees to obtain an equitable perception of, which contributes to less relevant feedback, as the user today cannot understand the situation of a person in the year 2035.

In the final concept, the AR and *TapXR* techniques could have been examined in greater depth. This would not only have helped build the final concept of facts and research, but also give the group a better understanding of how technology and concepts work. This could lead to the discovery of possible areas of use and even more innovative concepts. Many assumptions were made regarding how the technology works and how it may work in the future, because of the hypothetical/theoretical nature of the project. A broader investigation and testing of the technology involved in the final concept would be an area for improvement that could have been further developed if the project timeline had been extended.

## 9.5 Sustainability & Ethics

The ethical aspect of safety in the car was a dilemma in the beginning of the project. According to Ito et al. (2001), everything and every item within the interface of a car are possible causes of unsafe maneuvering. All problems related to concentration disturbances affect not only the safety of the specific car, but also the safety other drivers and vehicles in traffic. The research concluded that a an autonomous vehicle would minimize this safety hazard.

After the determination of focusing on autonomous vehicles for this project, the project group began to explore how a subscription, such as car-sharing, could be of greater use in the future. Car-hailing is popular in today's society, therefore car-

sharing is not so far away from acceptance. Since car-sharing is an economically and environmentally sustainable choice for Car-hailing it enables, in this concept, four different unrelated persons to use the same car ride to take them from destinations A to B, by sharing only one vehicle. The carbon monoxide emissions will decrease and less fuel will be used than if these four parties would take four separate rides, as for Car-hailing. The team determines that this kind of subscription is relevant in the near future since it collides with societies' aim to reach a more sustainable way of living.

The project has chosen the autonomous car to be driven by electricity, but since the ongoing transition to electric cars plays a crucial role in mitigating the effects of climate change, this sustainable aspect shall not go neglected. The car industry will still contribute to a large portion of the carbon footprint, one reason for this is that electric car batteries rely on raw materials such as cobalt and lithium. The mining of these materials is linked to environmental and human rights concerns (Tabuchi and Plumer, 2021). The group has understood the challenges with this aspect in regards to sustainability and ethics

The choice of electric vehicle does not solve environmental issues on its own but it does contribute to a change in the right direction. The National Grid (2021) states that the way electricity is harvested should be considered when charging plug-in vehicles, such as electric cars. With more electric cars on the roads, the electricity demand has increased. Consequently, the challenge is to produce a sufficient amount of electricity, preferably from renewable energy sources. If the demand cannot be met solely through renewable energy sources, the electricity supply must still rely on fossil fuels, which is what the electric car industry strives society to drive away from.

## 9.6 Future Development

An important aspect to further investigate is how the final concept and car design affect the safety of the car. In the event of a car crash, will an unfolded table withstand the impact and remain in place? Alternatively, will the user collide with the table and sustain injuries? It would be beneficial to explore the layout of airbags and other safety measures to ensure a trustworthy concept that aims to be reality in the year of 2035. Additional investigations in safety requirements need to be researched, tested and evaluated to enlighten these matters and improve safety in the concept car.

The final product, *AccelARate*, is an aid that will ensured humans of the future to have more time for leisure activities, since the project has opened new possibilities in the way the actions that occur to benefit the future human, by creating a pleasant, efficient, and ergonomic aid so humans can perform work tasks more flexibly than ever before. Regarding improvements of the product, *AccelARate*, future evaluations by the users would take place. To conduct a new user study the product could use more defined semantic words and scales, making it possible to evaluate the product

and the user experience of it, not only in terms of functionality but also improve the appreciation for the product's design in the future context. Though it should be mentioned that it might be difficult to execute an evaluation like that, as there are no users present in today's society that can fully familiarize and characterize themselves in the context created for this project. An evaluation made by "anyone" that could act as a future and potential user could therefore also lack validity to the final product and its concept in the development phase.

The effect of AR glasses on the user and nausea is a natural step forward and should be examined. This was discussed in the second part-time presentation, which raised many marks on interrogation. However, when discussed with the client, it was not of great interest, as they claimed that the project was not about researching how AR glasses affect nausea, but rather how the future of cars can look. Therefore, this issue was not addressed, but it is still a relevant topic to consider if further development would take place.

There was a discussion about whether the AR-glasses and *TapXR* should be aids included in the subscription of the car or if it should be a device to bring on your own. Benefits of offering glasses and *TapXR* in the car are for example that the user does not have to remember to bring another device for daily use, and all passengers within the subscription will have the same opportunities. The concept becomes complete and useful if the glasses are part of the concept, *AccelARate*. However, there are aspects that are more beneficial if the glasses are to be brought by the user themselves, especially regarding hygiene. It is debatable whether people would use a pair of glasses that anyone within the subscription can use, or if they will think of it as unhygienic. The concept tackles this problem using a cleaning system that cleans the glasses after each use. The final technology of the cleaning system has not been determined yet, therefore it has to be investigated in the future development.

The *TapXR* is also chosen to be a part of the concept and is offered in the car, just like glasses. *TapXR* enhances the user experience of the investigated concepts, *MagSafe*, *Modularity*, *BYOD* and AR and is a crucial part of the final concept which makes them a natural device to offer in the car. It would not have been legitimate to offer a device (glasses) but not a controlling device, making it possible to maneuver the device. By offering them both in the car, the concept will be unity, improving the user experience.

Moreover, *AccelARate* does not solve the problems related to disturbing sounds in the surroundings, nor enables the users to hold online meetings without bringing their own pair of headphones. The current concept, *AccelARate*, does not address this issue. Even though the findings of sound were relevant in the user study, the aspect of sound was abandoned in the final product, *AccelARate*, since it did not have a specific solution other than being a personal *BYOD* device in the *AccelARate* product. This is due to several relevant topics that were discussed in the project group.

Firstly, a big trend in today's society is that people like to have their own headphones, as well as different types of headphones depending on the activity conducted

with the headphones. There are several types of headphones on the market providing the personal choice depending on the activity and the users need, as in-ear, on-ear, headphones with or without a cord etc.

Secondly, to share a pair of headphones was seen by several in the project group as repulsive. Because of the cleaning aspect, this device needs more hygienic cleanse since the use of headphones is even more personal due to e.g earwax. Bringing your own headphones anywhere is today a convenience for people in the society. This results in a conclusion of this device as a typical *BYOD*, as it already is an important and personal device.

The third aspect was a discussion regarding how people react to sounds in their surroundings. The aspect was a result from the user study, compiled by the interviewee that led to the following discussion. One person finds a certain sound or frequency troublesome when trying to concentrate on work tasks and thereby affects their efficiency, while other people are more comfortable with background noise while performing work tasks in the selective environment for the project. They experience it as cozy and can disconnect that stimulus in a different way than the first person described. The interviewee was a person that did not get disturbed by sounds as easily as others, the person described the sound made by the surrounding people as a rather pleasant working environment. The sound register is troublesome if people are speaking directly to the interviewee, then it becomes a problem regarding the working condition. But as the interviewee expressed (see Appendix I), then headphones are of great use.

In conclusion one could argue that providing a solution for sound is rather complicated with these aspects mentioned. One potential area for improvement would be to explore the implementation of, for example, a sound barrier or headphones into the AR glasses. Another potential area for improvement is to provide different types of headphones in this design of the *AccelARate*, but that might create disturbance with the aids in *AccelARate* rather than sufficient for the user, since the person would still prefer their own headphones.

In the same way that headphones are a *BYOD*-device, the AR glasses and *TapXR* might as well be a common *BYOD* in the year 2035. This means our prediction of implementing AR glasses and *TapXR* as a part of the final concept, might not be relevant in the year 2035. In this project they have been decided to be a part of the solution rather than a device to bring on your own.

# 10

# Conclusion

A completely new version of the product development process was explored by the project group owing to this project. With three years of prior education in various aspects of product development, the group has now had the liberty to freely conduct this project and contextualize the methods in reality. The project has been a great training on how these methods can be applied and used.

The conclusions of the study and a discussion of the project are presented below.

## 10.1 Future of Cars & its Users

The future is challenging to predict, but assumptions based on trends and literature studies can provide good qualitative prognostications of what it will look like and how people will behave. Creating contextual descriptions, scenarios, and personas is highly beneficial for defining the future and communicating it to all parties participating in the project.

The description of the future and future users, answers the thesis question that goes; "*What are the demands and needs of the future car users?*"

The conclusions regarding how the future can unfold are presented below:

- Urbanization contributes to higher and denser populations in urban cities.
- Environmental problems affect how cities look and people travel.
- More vegetation was implemented in the city infrastructure.
- Car sharing is implemented more frequently in people's everyday lives.
- An increase in automated products will assist everyday life.
- Newly manufactured cars are autonomous vehicles.

Conclusions regarding future users and their needs are presented below:

- Digitalization will continue to contribute to people being fed with a large amount of information, and the need to take a break from screens will arise.
- The user will need efficiency in their everyday life to be able to pursue personal interests, therefore the need to perform work tasks efficiently, "on-the-go" is an even greater need.
- A striving to live a healthy, balanced lifestyle in a stressful and demanding society.
- Wants to make environmentally friendly choices; for social acceptance and own gratification.

## 10.2 Final Concept

The final concept satisfies the demands that have been identified and, as a result, the purpose of the project is fulfilled. The concept further answers to the second and third thesis questions that goes; "*How can modularity, MagSafe technology, and BYOD enhance the future use of vehicles, thereby increasing user experience? Is it possible to make the car more versatile and broaden its area of use to satisfy the needs and demands of future users?*".

The main demands that the final concept meets are presented below:

- Implementation of *MagSafe*.
- Keep devices in place.
- Enable human control.
- Enable work-related tasks, such as online meetings and browsing the internet.
- Provide an easy workstation setup.
- Control level of privacy while working.
- Maintain good ergonomics for users.
- Avoid disturbing other passengers.

## 10.3 Development Opportunities

The areas to further investigate and develop are presented below, in order to reach a deeper phase of refinding the product.

- Implement a sound barrier or another solution that solves problems related to disturbing sound, into the final concept.
- Perform a user study to the final concept and evaluate the outcomes.
- Explore how safety aspects of the car are affected by the final concept.
- The final technology of the cleaning system with hygienic aspects of the product need to be determined.
- If the AR glasses could cause nausea or other troublesome consequences for the user.

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# A

# Appendix A - Brief

Kandidatarbete
Examenskod IMSX16-23-17

CHALMERS | Institutionen för INDUSTRI- OCH MATERIALVETENSKAP

*Modular design of the seat back*

## Magsafe and modularity

**Design context**
In today's automotive world, users have extended expectations on the use of a vehicle rather than only being a transport, hence we see an increased interest of modular thinking in interior and exterior vehicle design that can improve the overall user experience. In addition, Bring Your Own (BYO) device has been embraced like never before according to the proliferation of the internet of things (IOT). This is of great importance for GEELY to find solutions for.

The image above are the examples of the modular design of the seat back. Detachable hanger solution that can also be used as a phone / tablet holder; another example is an attachable desk on the seat back.

**Can Magsafe technology enhance the vehicle modularity and create new possibilities for add-on products and increase user value?**

**Magsafe exploration**
1. Pros o MagSafe? e.g. High reliability power and mounting interface
2. Cons of Magsafe? e.g. Limited power transfer, heat generation, currently the QI standard doesn't give battery charging level feedback.
3. How are the above likely to change in the future… e.g. Look back at how it has already improved

**Magsafe and modularity design**
1. What functionalities can Magsafe technology / Wireless mechanical interface support with?

2. How might Magsafe enhance the modularity concepts?

3. How can Magsafe benefit the BYO device experience in vehicle? For example, horizontal rotation feature, content sync between devices etc.

Deliverables: Use cases, concept & solution, and Mockup

# B

# Appendix B - Counter Brief

**Initial guidelines from the commissioning company**

Zeekr and Geely give us the possibility to explore the future of vehicles and how they will be used. The exploration should focus on what we as a group find interesting and something that could lead to new perspectives for Zeekr as a company. As we understand it, the brief suggests that the project is not necessarily a finished, physical product. The focus should primarily be on content, a story and findings through the process, that later on could lead to a new concept.

The target group for the solution is not given, defining it is rather a part of the assignment and may change throughout the project. The advice given was to utilize the skills of each team member to deliver the best possible outcome and let the skills determine the workflow and the direction of the project.

Some key words to lean on through the process are *futurism*, *modularity*, *Magsafe-like technology* and *user centered design*.

We understand that we cannot distribute any material within the project to parts outside the scope of the project without speaking to our supervisors at Zeekr.

**Limitations regarding guidelines from Zeekr**

- There are no limitations regarding placement of the solution in the vehicle, as long as it is not located on airbags. In other words, it should not affect the safety of the passengers.

- As the group starts working, the goal is to have a broad perspective on where and which car models or country the solution should be applied. E.g. not to a specific car model for Zeekr and not only Zeekr, as well as no boundaries to the Chinese market.

- Make the solution universal. Do not show logos nor a typical profile that is characteristic for Zeekr's brand, as it can come in conflict when used in the group members' portfolios.

**Expected deliverables**

Zeekr is our client and should be treated professionally. The group seeks to deliver both clients' demands and the university's requirements without them interfering or affecting each other. Methods to use are not expected to be proposed or delivered by the client. It is however of interest to discuss these matters, to reach the best possible outcome of the project.

The project is broad and the group is given freedom to explore different opportunities and options. The expectation of the group is to deliver a strong story where a need for some sort of concept is contextualized, however, the concept might not be realized in the form of a physical product. We will share and discuss our findings based on our story. We are encouraged to open a window and discover something new that the client might not have thought of yet. To enhance the story and our findings, a picture, video or sound will assist us and strengthen our outcome.

Although freedom gives us great opportunities to explore different areas of interest, the group has a more specific goal in mind: to develop and deliver a product. For this to be possible, some boundaries, and most importantly, framing of a question will be necessary for the project to succeed.

For the thesis the main issue chosen is, ***"How can the future use of vehicles be enhanced by means of modularity and magsafe-technology and thereby increase the user value?"***

As the project develops the issue will narrow down to a more niched direction that is suitable for the groups interests and researches. To be discussed at the meeting 31/1 at Geely.

**Availability to the client and its contacts/connections**

Our goal is for every group member to spend approximately 20 hours per week on the project. Furthermore, the main means of communication between the team and the client is going to be email.

We strive to have weekly meetings with representatives at ZEEKR, especially in the beginning of the project. The meetings should focus on discussions regarding the work and findings through the process and can be held either at Geely's office or online, preferably in person. Half way through the project, a bigger meeting should take place, to see where the project is heading.

**Possibility to build prototypes externally**

Could the client provide us with workshop possibilities?

This will be asked at the next meeting. If not, the facilities at Chalmers will be sufficient for the project.

### Description of our way of working

The team consists of six students from Chalmers University of Technology that all have a background in Industrial Design Engineering. The group's weekly progress is documented in a separate document. Every group member has a designated week to be the secretary. The weekly secretary also has responsibility to see that the group follows the plan that has been written in the dairy. That does not necessarily mean to manage the team as a project leader, but to see that the team is united and works in the same direction. Every group member has the responsibility to lead the team and progress forward. To have a united time plan we will make sure to update the shared calendar.

Furthermore, specific roles have not been assigned to each group member. We believe that everyone has different strengths as well as weaknesses to improve throughout the project. As time passes, we are certain that the roles will fall into place naturally but we still consider challenging ourselves to strive for improvement of great importance.

We have decided that both ZEEKR and our supervisor have a main contact person each in the group. The reason behind this decision is to avoid information getting lost in emails.

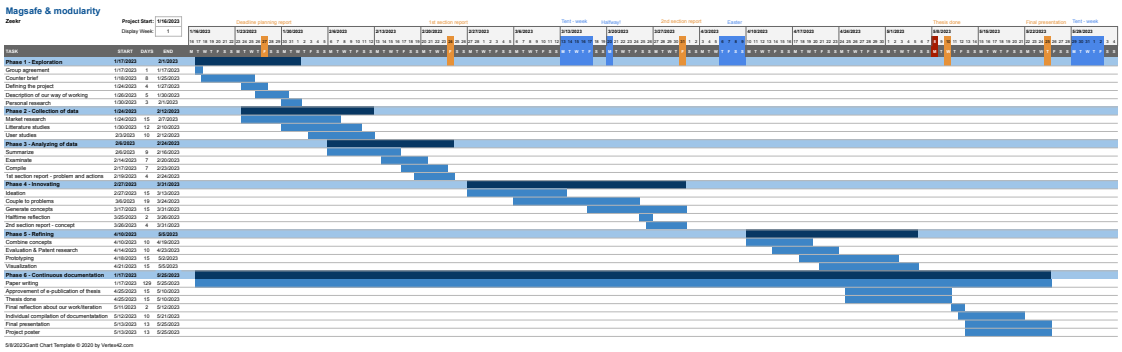
The budget for the project is about 2000 SEK.

### Time plan

Link to Gantt-chart.

# C

# Appendix C - Gantt Chart



# D

# Appendix D - Individual Stories

## D.1 Story I

The year is 2040. Urbanization and smarter cities have flourished. The environmental issues have become the center of how society functions and behaves. The infrastructure has an increased efficiency in how people get around and provides flexible transportation that enables more than just a form of transport. Because of this more people rely on on-demand autonomous cars to get around and fewer people tend to have their own cars.

Carl is a 32 year old engineer who works with innovation in a prominent environmental company situated in Hong Kong. Even though living in the heart of an urban city Carl has a big interest in exploring the nature. With a stressful job that requires a lot of office-attendance, his chance of a life living outside the city is merely an impossible task. To pursue his interest he likes to get out of the city and go hiking on the weekends.

It's a Saturday morning and Carl wakes up in his high-rise apartment. He starts his day by ordering a fully automated breakfast from his smart kitchen. He orders a large breakfast high in carbs in order to enable him to endure a long day of hiking and climbing with his friends. The day before he prepared all of his equipment that he would need for the day.

After breakfast Carl orders a spacious vehicle that will transport him out of the city and will have room for equipment for him and his three friends. He does this via an app on his smartphone where he has also set the destination for the journey. 15 minutes after ordering his car arrives. The car is already customized with the settings and features Carl usually prefers. In the car he plans his routes that he and his friends are going to take while climbing, he does this with the help of the car's holographic GPS.

The autonomous car takes them through scenic routes, with stops at breathtaking views for photos and rest breaks. They arrive at their destination, a remote mountain trail, and the car parks itself in the designated area.

The group gear up and begin their hike, using the latest in wearable technology to track their progress and monitor their health. The trail is challenging, but the

stunning views and fresh air make it all worth it. Along the way, they come across some wildlife and use augmented reality displays to learn more about the species they encounter. As they reach the summit, they are rewarded with a panoramic view of the surrounding wilderness. They take a break to rest, eat a packed lunch, and reflect on their journey. On the way back, they capture memories with photos and videos that they later share with their friends and family.

When they return to the car, they find that it has recharged itself using sustainable energy sources and is ready to take them back to the city. As they reach their homes, Carl and his friends feel refreshed and grateful for the experience. They make plans for their next outdoor adventure before saying goodbye.

## D.2 Story II

Celine is a 32 year old woman living in Boston. She is a sustainability manager at a company within production of electronic devices. Her everyday life is pretty hectic since her role at the company is rather demanding, sustainability is one of the most important questions and challenges at the company. It is the year 2030 and the world temperature has risen far above what is ok, and a change is on the way and all companies have been regulated by law to contribute to a change. Celine is happy for this since it is one of her matters of heart, but the big interest is not only a benefit. She puts high demand on herself, and see her role as an important one as she has an impact on the future.

As the workday ends, Celine is about to go home. The office is located in the core of Boston and she lives a 15 minutes drive from there. She lives in an apartment building that is futuristic, for example many devices are shared between the ones living in the building, such as a car. During the last couple of years a revolution has occurred in automatization and many professions have been moved from humans to robots. That has led to new professions such as private drivers to maximize the use of products and thereby reduce the consumption of e.g. cars. A single car is shared between the whole house, and a driver makes sure that everyone gets to use it.

When Richard, the driver, comes up to Celine's building's entrance, Celine is ready to get into the car and get a 15 min break before coming home to a toddler requiring all her attention. Luckily, her toddler has a nanny during day time as Celine and her husband Todd work a lot. This week Todd is away on a work trip in Canada, and Celine has to take care of everything by herself; work, apartment, toddler, cooking etc. Her 15 min break in the car is her only chance to relax.

When she gets in the car, she feels like home even though the car is shared with 30 other people. The interior is changeable and can easily get customized to the user, it is like walking into Hannah Montana's closet, you choose what kind of person and state you want to be in. Today, Celine wants to feel present, she wants to talk to her best friend and for some time just focus on what is real and not everything online and on social media. Honestly, she is pretty tired of the influence social media has on her life, and have therefore started to prioritize real socializing the past year.

She pulls up her smartphone, attach it to the gadget beside her, she says *call Alice* and immediately the big screen comes down from the roof. When Alice answers, it feels like they are in the same room, they both feel very present and connected, even though Alice lives in LA and is in another state and time. They chat for the whole ride home, and Celine feels energized and ready to take on the evening, whatever it has to offer.

## D.3 Story III

2039, ID: Anders, 37. Location: Lyon, France — 2.5 m. population

Anders, a 37-year-old man living in Lyon, France, is a family man with a wife and two children. He works at a big banking firm and a few years ago he was offered a promotion which called for a relocation to the banking group's office in France. Consequently Anders and his family moved to Lyon.

The job is demanding and requires him to attend the office at least three days a week, mainly for interpersonal meetings. During recent years working from home has become the norm among the population due to the widespread adoption of remote work - he wishes to be able to do the same in the near future.

Anders' wife, Maria, is also in the banking business. However, she does most of her work from home. Consequently, the family only owns one car, on recommendations from the government. In instances of her needing a car, it's easily accessible through the neighborhood's car-pooling-system. Maria can book a car at any time and have it show up at their driveway 15 minutes later. Once entering the car, Maria docks her device of choice, making the car's interface and settings change to her preferences and allowing comfortable use and charging of the device.

Anders has a 30-minute commute to the city center where the office is situated, but thanks to the family's self-driving car, which requires no supervision, he is able to work on the way to and from the office, freeing up more time to spend with his family. He has come to an understanding with, though it sounds cliché, that family is what's most important.

As the world seems to become more automated and reliant on technology, Anders has realized that he relishes time spent away from screens and technology more and more as he grows older. Though he attends online meetings on a daily basis he has come to the conclusion that face-to-face-interaction is way superior. He has read recent reports regarding the decline in mental health among adolescents and young adults, the boom of smartphones in the early 21st being an underlying cause. New evidence shows that the negative effects of excessive screen time, partaking in social media in particular, are more alarming than expected.

On the other hand, trends show that an increasing amount of blue collar employees are laid off or out of jobs which makes Anders thankful for technology and the career it has enabled for him. He feels fortunate to be educated and able to retain a job

position that won't be replaced by robots or Artificial Intelligence, not in the near future at least...

The discussions regarding technology and how it should be exploited has been a hot topic for many years. There are ongoing debates about if the government should limit the amount of technology implemented in education, especially during kids' early years in school. Consequently, this has led to Anders and his wife deciding that the kids are allowed only 1 hour of screen time per day; and they are only to bring their smartwatches to school to be able to take the bus and access the school building.

On that matter, Anders used to take the kids to school, but as of recently, the school is offering automated self-driving minibuses who pick up kids in the neighborhood. The buses are accessible only by those whose smartwatches are connected to the system, which makes it impossible for unauthorized people to enter the bus. This allows Anders to leave for work early and consequently end the workday earlier which lets him spend more time with the kids in the afternoons.

## D.4 Story IV

The aim of the scenario is to determine the needs and behaviors of the future

The scenario is about YAN, a 28 years old who lives in Peking Tokyo and his goal is to fill in a deadline for the work he has to do. He is a programmer for cleaning robots. starting pointen är att han lämnar sitt café efter tagit en kaffe

THE story

The year is 2034. Yan is arriving at the café. It's early in the morning and cold outside. He is very stressed since he knows the deadline for his project is due today. He chose to take his coffee at this exact spot since he knows that the coffee takes exactly 5 minutes to get ready. This is the quickest of the coffee places in this area. They have automated the place well and the staff is friendly even though he is not always like that to them. The place is one of many where they have automated the process. Yan lives about 5 minutes away from the coffee place so he has an automated order through an app on his smartphone. The order is always sent to the coffee shop each day he leaves his apartment. This way he can just go past the place and grab his coffee and leave without wasting any time waiting. A lot of customers do this. Therefore they do no longer have any chairs. The coffee place is just a small window into a building where you can talk to the barista and grab your coffee. The barista is not doing the coffee, her job is servicing the machines and talking to people. His boss knows that Yan need to get into work today since due day to present his work. Therefore a car is already on its way. This is one of few days he is acctually visiting the office. He works more or less always from home since the office does not have any working space; it consists of only meeting spaces and labs. He looks down at his smartphone and sees that the car should arrive in about 5 minutes. This means that some work can be done in the meantime so he

pairs his computer, that he carries in his backpack, with his smartphone. This is done by a simple touch on his smartphone. Some work is done on his smartphone before the car arrives. The car recognizes him as usual and opens its doors and he steps in.

# E

# Appendix E - Set of Problems

**Problems**

- Computer sliding off lap/table due to speed fluxion; has to hold onto laptop
- If you are in a call everyone near you hears what you say(privacy)
- Setting up the work station takes too much time
- Hard to focus, bumpy ride, noise, light
- Difficult to perform several tasks at once; i.e. using the laptop AND writing; limited space
- Bad ergonomics, when working:
  - Hunched over posture / neck
  - Unstable sitting poisition in order to keep laptop in lap
  - Rotated seating position to have room for legs
- The setting
  - Has to squint due to light
  - Noice

**Important desires**

- Accessibility
- Ergonomics
- To be able to focus

**Optional desires**

- Efficency
  - To store luggage

# F

# Appendix F - Specification of requirements and desires

| Category | Criteria | (R)equired/ (D)esired | Priority 1 - 3* | Note |
|---|---|---|---|---|
| **Privacy** | Avoid disturbing other passengers with one's physical presence | R | 2 | |
| | Enable privacy of one's devices and material | R | 1 | Not showing private information |
| | Enable a feeling of being in your own private office | D | | Through customization |
| **Multitasking & Accessibility** | Hold MagSafe-technology | R | 1 | |
| | Enable human control | R | 1 | |
| | Enable easy setup of workstation when bringing one's own device | R | 2 | Of BYOD amd belongings |
| | Provide enough but not redundant information | R | 2 | To prevent information overload |
| | Enable work-related tasks, e.g. online meetings, browsing internet | R | 1 | |
| | Easy setup of product | R | 2 | Of the product itself |
| | Enable BYOD | D | | |
| | Being modular / Enable modularity | D | | |
| | Enable multi-tasking | D | | Being able to use several devices at once |

| | | | | |
|---|---|---|---|---|
| **Sound & Light** | Prevent disturbing sound & light from inside the vehicle | D | | |
| | Prevent disturbing sound & light from outside the vehicle | D | | |
| **Comfort** | Keep device in place | R | 3 | When bringing one's own devices |
| | Enable good posture | R | 2 | |
| | Be space efficient | D | | |
| **General** | Feasible year 2035 | R | 3 | |
| | Express innovation | R | 3 | |
| | Have intuitive design / interface | R | 1 | |
| | Can be shared | R | 2 | |
| | Use digital technology when possible | D | | |
| | Having room for storage of devices and personal belongings | D | | |

* 1 = Highest priority, 2 = Medium priority, 3 = Least Priority

# G

# Appendix G - Field Study

| Area | Noted Problems | Comment |
|---|---|---|
| Physical Ergonomics | 1. Bad positions, bad neck position.<br>2. Legroom, roomy car, a positive<br>3. The light disturbs<br>4. Nausea due to the position of the screen | 1. Important for a pleasant working environment<br>2. Important to be able to control light entry<br>3. Some of the turns may upset the sense of balance, since looking down and not being able to focus on the road |
| Cognitive Ergonomics | 1. An overwhelming work environment, a lot of impressions.<br>2. Sound | Work efficiency suffers |
| Storage | "Where do I put the jacket and the bag?" | |
| Technical problems | Discharged computer/phone | |
| Social | Important to implement a do not disturb mode, for a facilitated good working time.<br>"Like a note at the hotel, "clean my room, or do not disturb"." | |
| Efficiency | Multitasking suffers<br>1. The computer moves a lot during braking.<br>2. Unfixed computer, must focus to hold it. | Might be since aids as mentioned below are not available<br>• Workspaces?<br>• Relief surfaces? |

# H

# Appendix H - User Study Template

**User studies with a person without the project group**

Location: Autonomous Vehicle, line 68 around Johanneberg.

**1. User study: Work with the computer** Exercise:

1. Accepts GDPR.
2. Enter Zoom meeting, details are given by the interviewer.
3. Send an email to this address about the weather on Friday.

**During the exercise:**

a. Did you feel moments of disturbances?

b. How was your working situation (ergonomics) perceived?

c. How was your experience working like this?

d. Any concrete ”physical” thing that you miss?

**2. User study: meeting and presentation via Zoom**

Presentation:

Hello, we are planning to give you a brief presentation about Peru, and in the meantime, we would like you to take notes on what you find important.

Slide 1: Hello and welcome to my presentation about Peru! Peru is a country in South America that shares borders with Ecuador, Colombia, Brazil, Bolivia, and Chile. The country is known for its rich culture, history, and nature. One of Peru's largest cities is the capital city of Lima, which is one of the oldest cities in South America. It has many historic sites and monuments, including the Cathedral of Lima and the San Francisco Monastery.

Slide 2: Another popular destination in Peru is the ancient city of Cusco, which was the heart of the Inca culture. From here, you can also visit the famous Machu Picchu ruins, which is one of the most visited tourist attractions in South America.

Slide 3: Peru also has a very rich food culture, with dishes such as ceviche, lomo saltado, and ají de gallina that are popular both in and outside the country. Additionally, Peru is one of the world's largest coffee producers and has a growing wine industry.

Slide 4: When it comes to nature, Peru has a lot to offer. The country has a large portion of the Amazon rainforest, making it one of the most biologically diverse places on earth. Moreover, the country has a long coastline and many mountainous areas, including the Andes, which is home to some of the highest mountains in South America. In summary, Peru is a fascinating destination with a rich history, culture, and nature. If you're looking for a place to visit in South America, Peru is definitely a country to consider. Thank you for listening to my presentation!

Checkpoint questions:

1. Which countries border Peru?
2. What is the capital of Peru?
3. Which historic city in Peru was the heart of the Inca culture?
4. What is Machu Picchu?
5. What are some popular dishes in Peru's food culture?
6. What type of nature is found in Peru?
7. Why is Peru an interesting destination to visit in South America?

Answers to checkpoint questions:

1. Answer: Ecuador, Colombia, Brazil, Bolivia, and Chile.
2. Answer: Lima.
3. Answer: Cusco.
4. Answer: Machu Picchu is a famous ruin in Peru that is one of the most visited tourist attractions in South America.
5. Answer: Ceviche, lomo saltado, and ají de gallina.
6. Answer: Peru has a large portion of the Amazon rainforest, a long coastline, and many mountainous areas, including the Andes, which is home to some of the highest mountains in South America.
7. Answer: Peru is known for its rich culture, history, and nature and has a variety of popular destinations such as Lima, Cusco, and Machu Picchu. The

country also has an exciting food culture and is one of the world's largest coffee producers.

During the presentation:

a. What did you find problematic?

b. Did you feel moments of disturbances?

c. How was your working situation (ergonomics) perceived?

Any concrete "physical" thing that you miss?

# I

# Appendix I - User Study

**User studies with a person without the project group**

Location: Autonomous vehicle, line 68 around Johanneberg.

**1. User study: Work with the computer** Exercise:

a. Did you feel moments of disturbances? Observation: The test subject sits with both legs firmly on the ground, gripping the computer on both sides. The person is typing on their computer to send an email. During sudden braking of the vehicle, the person loses concentration and assumes a more rigid position to hold onto both the computer and phone. A strong braking caused by pedestrians at a crosswalk interrupted the activity, and the focus shifted to holding onto both devices. However, after the second stop, the person was able to successfully send the email.

   - How is this moment of disruption experienced? ”Small-scale when it slowed down,” the person took a small break from the email.

b. How was your working situation (ergonomics) perceived? “Nice with natural light, so far it feels good (answered the person after a short time), but would need something to regulate the light with, in case less sunlight is desired.”

c. How was your experience working like this? ”OK”.

d. Any concrete ”physical” things that you miss? “I like that it is very open but would have appreciated a table, otherwise nothing concrete”

**2. User study: meeting and presentation via Zoom** During the presentation:

Questions and answers during the checkpoint questions:

1. Which countries border Peru? “I didn’t get a chance to take notes.”
2. What is the capital of Peru? “Lima”
3. Which historic city in Peru was the heart of the Inca culture? “I didn’t get a chance to take notes, due to the beeping of the vehicle.”
4. What is Machu Picchu? Took notes, but failed.

5. What are some popular dishes in Peru's food culture? "I only wrote down one dish, Ceviche"

6. What type of nature is found in Peru? "Diverse nature, due to the Amazon."

7. Why is Peru an interesting destination to visit in South America? Took notes, but failed due to noise from the vehicle.

Observation: It is difficult to hold the computer while the person is writing on paper, resulting in an uneven position. It is not possible to write well on paper while the person is writing in their lap.

At first, the test subject was unable to take notes due to the lack of a good surface to write on. The person was able to answer and note down three out of seven questions, but the problem was that they could not note down everything they wanted due to the difficulty of writing in their lap. The test subject repeatedly stated that they were unable to keep up with taking notes during the task.

a. What did you find problematic? "Could hear fine, something to write on would be good, Some kind of table behind the paper."

b. Did you feel moments of disturbances? "When it beeped, I could not hear for a hundred percent, also due to the poor internet coverage when it could not be connected."

c. How was your working situation (ergonomics) perceived? "I changed position, it was better to sit like this (crossed legs while the person wrote on the leg) but then I had to press hard on the paper. It was difficult to take notes because everything was moving during the journey."

d. Any concrete "physical" things that you miss? "Be able to adjust the brightness, the light that is let in, i.e. the sunlight is very strong. Even with a standing desk, but difficult with movement such as vibrations perhaps?"

    i. Why do you want a standing desk? "At home, I like to vary my position by sitting, but sometimes I stand up and work."

    ii. When you study at home, which conditions do you prefer? "As long as no one is talking to you, have headphones. Mostly if someone talks to me directly I get distracted. A little movement around me is fine, otherwise, it gets boring." "Likes to have something moving in the background."

Observation: Clear and visible disturbances occur during sudden braking, causing the test subject to pause all activities to hold onto their devices. During the test, the person moved the computer to the seat next to them when they needed to take notes on paper. The following question arose: "What would you do if someone was sitting there?" The response was: "Then I wouldn't be able to just put the computer there, but where would I put all my things?"

**Observations noted from the recorded material of the interview**

The most obvious disturbance occurred during rapid braking and the beeping sound the vehicle makes when stopping at stops, which meant that the subject could not hear what was said during the meeting and had to ask the meeting leader to repeat what the person had previously said.

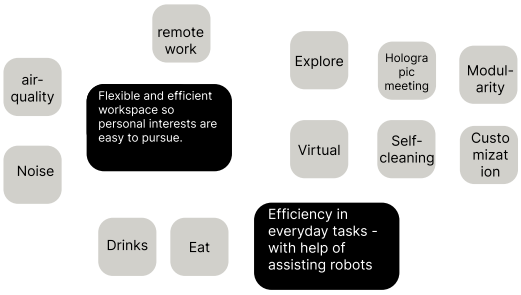
**Noted uncomfortable ergonomic positions:**

- Sits half ”rotated” to accommodate the legs.
- ”Stands on toes” so that the legs lean less so that the laptop does not slide down.
- Need to grab the laptop sometimes to keep it from falling down, in some situations when strong braking occurs this movement becomes almost acute.
- Neck bent forward, does not appear to sit either stable or comfortably
- Need more space and surface for the computer as well as pen and paper to be able to practice the activities correctly and efficiently.
- Gets bright sunlight in the face on occasion, but doesn't seem to be significantly affected beyond the person squinting a few times. Observations indicate that the person is not disturbed by this when the subject looks down at a computer screen or smartphone.

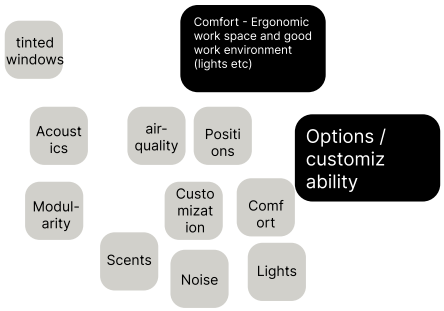
# J

# Appendix J - KJ Analysis I

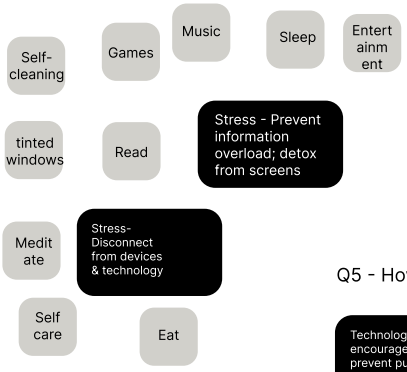
Q1 - How can the car provide opportunities to pursue a diverse lifestyle?



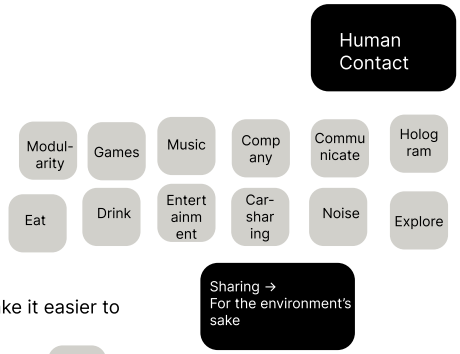

Q3 - How can the car become efficient and comfortable for work ?



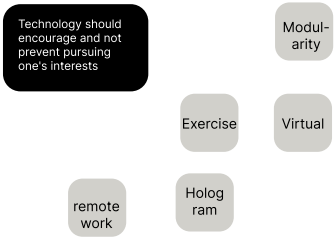

Q2 - How can the car become a setting for relaxation and disconnecting from devices and technology (if desired)?




Q4 - How can the car encourage human interaction / socializing?

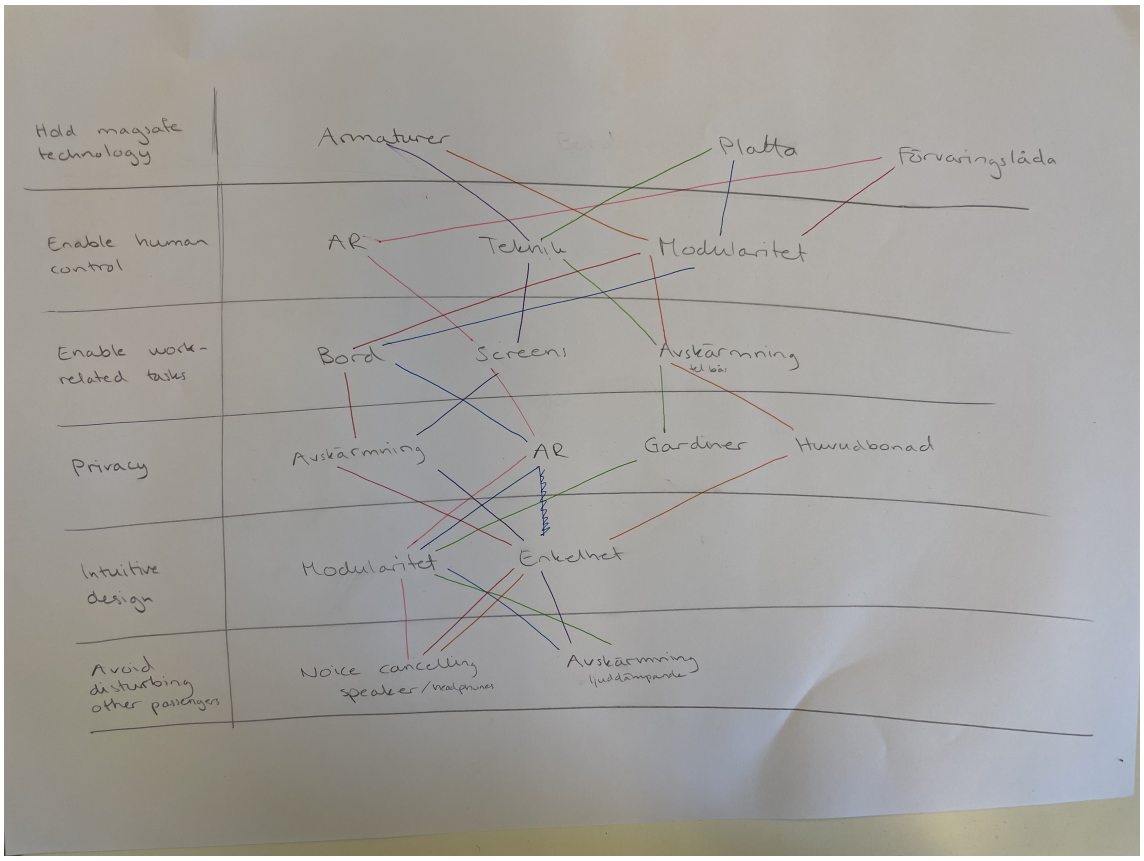



Q5 - How can the car, make it easier to packa?



# K

# Appendix K - Morphological Matrix



# L

# Appendix L - Pugh Matrix

## L.1 First Round

| Area | Criteria | Weight | Augumented Workspace | Multifunctional Divider | Privacy Pod |
|---|---|---|---|---|---|
| Privacy | Avoid disturbing other passengers with one's physical presence | 2 | R | 2 | 2 |
| | Enable privacy of one's devices and material | 3 | E | 0 | 0 |
| Multitasking & Accessibility | Hold MagSafe-technology | 3 | F | 0 | -3 |
| | Enable human control | 3 | E | -3 | -3 |
| | Enable easy setup of workstation when bringing one's own device | 2 | R | 0 | 0 |
| | Provide enough but not redundant information | 2 | E | 2 | 2 |
| | Enable work-related tasks, e.g. online meetings, browsing internet | 3 | N | -3 | -3 |
| Comfort | Keep device in place | 1 | C | -1 | -1 |
| | Enable good posture | 2 | E | 0 | 0 |

| | | | | | |
|---|---|---|---|---|---|
| General | Feasible year 2035 | 1 | | 0 | 0 |
| | Express innovation | 1 | | -1 | -1 |
| | Intuitive design / interface | 3 | | 0 | 3 |
| | Can be shared | 2 | | 2 | 2 |
| Sum | | | 0 | -2 | -2 |
| Ranking | | | 1 | 2 | 2 |
| Further Development | | | Yes | Yes | Yes |

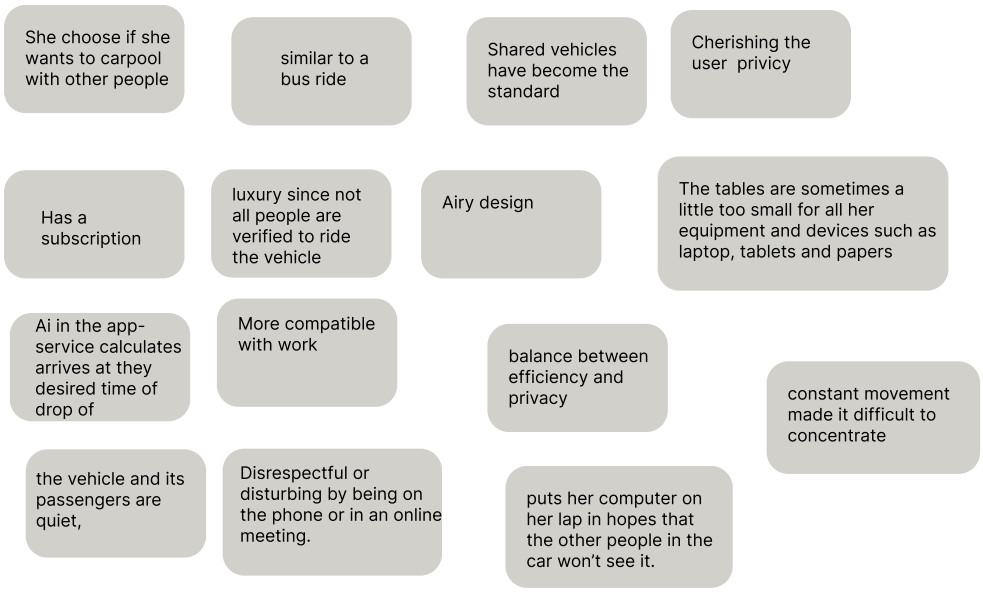
## L.2 Second Round

| Area | Criteria | Weight | Augumented Workspace | Multifunctional Divider | Privacy Pod |
|---|---|---|---|---|---|
| Privacy | Avoid disturbing other passengers with one's physical presence | 2 | 2 | R | 2 |
| | Enable privacy of one's devices and material | 3 | 0 | E | 0 |
| Multitasking & Accessibility | Hold MagSafe-technology | 3 | 3 | F | 0 |
| | Enable human control | 3 | 3 | E | -3 |
| | Enable easy setup of workstation when bringing one's own device | 2 | 0 | R | 0 |
| | Provide enough but not redundant information | 2 | -2 | E | 0 |
| | Enable work-related tasks, e.g. online meetings, browsing internet | 3 | 3 | N | 0 |
| Comfort | Keep device in place | 1 | 1 | C | -1 |
| | Enable good posture | 2 | 2 | E | -2 |
| General | Feasible year 2035 | 1 | 0 | | 0 |
| | Express innovation | 1 | 1 | | -1 |
| | Intuitive design / interface | 3 | -3 | | 3 |
| | Can be shared | 2 | -2 | | 2 |
| Sum | | | 8 | 0 | 0 |
| Ranking | | | 1 | 2 | 2 |
| Further Development | | | Yes | No | No |

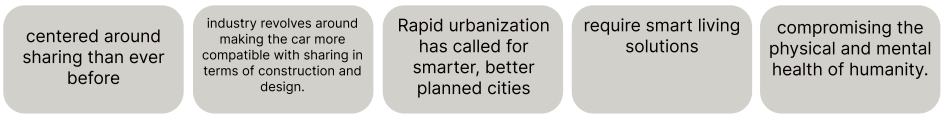
# M

# Appendix M - KJ Analysis II

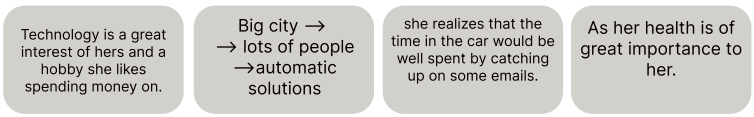
## Draft story

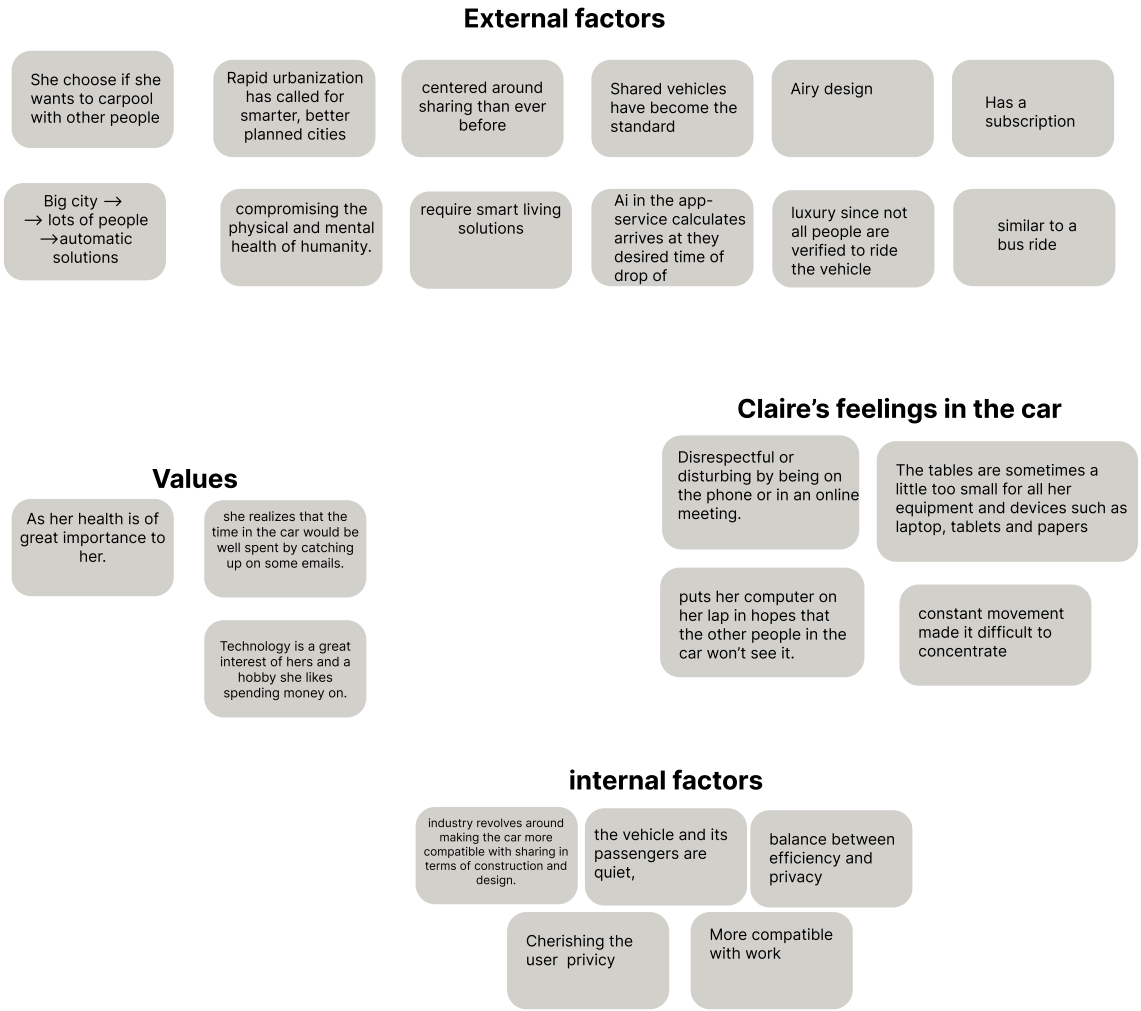



## Context




## Scenario




External factors
She choose if she wants to carpool with other people
Rapid urbanization has called for smarter, better planned cities
centered around sharing than ever before
Shared vehicles have become the standard
Airy design
Has a subscription
Big city → → lots of people →automatic solutions
compromising the physical and mental health of humanity.
require smart living solutions
Ai in the app-service calculates arrives at they desired time of drop of
luxury since not all people are verified to ride the vehicle
similar to a bus ride
Claire's feelings in the car
Disrespectful or disturbing by being on the phone or in an online meeting.
The tables are sometimes a little too small for all her equipment and devices such as laptop, tablets and papers
puts her computer on her lap in hopes that the other people in the car won't see it.
constant movement made it difficult to concentrate
Values
As her health is of great importance to her.
she realizes that the time in the car would be well spent by catching up on some emails.
Technology is a great interest of hers and a hobby she likes spending money on.
internal factors
industry revolves around making the car more compatible with sharing in terms of construction and design.
the vehicle and its passengers are quiet,
balance between efficiency and privacy
Cherishing the user privicy
More compatible with work

# N

# Appendix N - Target Group and Desires

### TARGET GROUP

### DEMOGRAPHICS

- Age: 25 - 40
- Gender: female, male, non binary
- Upper middle class
- Environmental-aware and tech pioneer
- Living a city-based lifestyle

### NEEDS

- Strives to live a healthy, balanced life in a stressful and demanding society.
- Wants to make environmental-friendly choices; for social acceptance and own gratification

### CHALLENGES

- Hard time balancing career with personal interests outside of work, but at the same time the daily life is overloaded with information.
- Struggling to keep up with friends, and personal interests.

**WHAT THE USER DESIRES - Based on scenario**

The main points are based on the scenario, see the following pages for elaboration

**TIME EFFICIENCY**

- Flexible and efficient workspace so personal interests are easy to access.
- Efficiency in everyday tasks - with help of assisting robots
- Access to technology

**COMFORT**

- Ergonomic work space and good work environment (lights etc)

**PERSONALIZATION**

- Options / customizability
- Technology should encourage and not prevent pursuing one's interests

**HEALTH**

- Prevent information overload; detox from screens
- Disconnect from devices & technology - Prevent mental issues - Be stress free

**SOCIAL ASPECT**

- Human contact - should feel natural
- Sharing - For the environment's sake

**WORK**

*Though, before she can enjoy an active, but also relaxing weekend, she has to get through a day of work at the office.*

*Several meetings are scheduled in the morning where difficult ethical questions are to be discussed...*

*Claire's boss is fine with her working remotely. The employees at the office are encouraged to work some days at their location of choice, to have more time for leisure activities which promote their well-being.*

*Before going to bed last night, she decided what she wanted for breakfast in the morning with the help of the Artificial Intelligence of her kitchen.*

*Smart and new solutions that make life easier are...*

*Claire catches up on some work, she enjoys the opportunity to be able to be productive whilst still sitting comfortably.*

*When she gets into the car, she grabs the gadget beside her and pulls up the setup optimized for working.* **Bullet points / Main takeaways - What the user desires:**

- More time to work outside the office
- Efficiency in everyday tasks / Assistance
- Multitasking
- Human contact
- Comfort
- Ergonomic work space and good work environment (lights etc)

**RELAX**

*She wants to make the most of the 10-minute ride to the office and decides to perform some meditation, which she likes to do when she feels overwhelmed by the current environmental state of the world which her work revolves around.*

*Technology and devices are impossible to neglect since they are essential in everyday life, and even though she finds new technology interesting and fun, she is also aware that the use of it often results in way too much screen time that affects her health in negative ways.*

*She also appreciates that the car can take on different forms depending on what she wants to accomplish during the ride.*

*She picks up her device and presses play on her favorite TV show, thanks to the design in the car she can watch the show on a big screen and the car feels like her living room at home.*

**Bullet points / Main takeaways - What the user desires:**

- Be stress free / Maintain mental health
- Comfort
- Prevent information overload
- Disconnect from devices & technology at times
- Access to technology, but in moderate amount
- Options / customizability

**SOCIALIZE**

*The issue of keeping the population sane with the increasing digitalization and automation of everyday life is critical for governing bodies. Despite advancements in technology, humans remain the key players in society and are the ones utilizing it. The reliance on computers and robots can not negate the importance of human well-being. As technological development continues, the concern arises whether it is compromising the physical and mental health of humanity.*

*This weekend is all about well-being and spending time away from screens and technology.*

*. . . environmental issues that the world is facing are affected by new technology*

*When ordering a car, Claire gets to choose whether she wants to carpool with other people, heading in the same direction as her, or not. That is, making it similar to a bus ride.*

*Even though the car is shared with other people, it is tidy and feels personal, which she appreciates a lot.*

**Bullet points / Main takeaways - What the user desires:**

- Human contact
- Feeling in control
- Disconnect from devices & technology → Prevent mental issues
- Sharing - For the environment's sake
- Sharing - For the people's sake - Socializing
- Sharing should feel natural

**DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE**
**CHALMERS UNIVERSITY OF TECHNOLOGY**
Gothenburg, Sweden 2023
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