Kamrat – The holiday camper for a soft adventure

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DIVISION OF PRODUCT DEVELOPMENT | DEPARTMENT OF DESIGN SCIENCES
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY

2018

MASTER THESIS

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Published by
Department of Design Sciences
Faculty of Engineering LTH, Lund University
P.O. Box 118, SE-221 00 Lund, Sweden

Subject: Technical Design (MMK920)
Division: Product Development
Supervisor: Karl-Axel Andersson
Examiner: Axel Nordin

Abstract

There is a growing demand for environmentally friendly ways of transportation, and therefore the electric bicycle has been booming in Sweden. The electric bicycle is often used as means of transportation to and from work, but has potential to be used in other situations as well. The environmental impact caused by transportation during holidays has recently gained attention. At the same time the demand for *soft adventures*, comfortable and accessible nature experiences, in Sweden has increased according to Visit Sweden. If these different driving forces are combined, an area of use for the electric bicycle could be when on holiday.

This master thesis has the purpose of developing a product that connects electric bicycles with the trend of soft adventures, and in that way encourage people to cycle more.

The design process started by studying the potential users. Based on the functions noticed in the user study, various concepts were developed in several iterations in the shape of sketches, physical models and computer models. These iterations finally resulted in a concept that was further developed, and a final prototype, taking both form and function in consideration, was created. This prototype was then tested and evaluated.

The final concept, called Kamrat, is a foldable holiday camper that is small and lightweight enough to be towed after an electric bicycle. In parked mode Kamrat can be unfolded, which results in a bed for two persons with a tent as a roof. This allows for a comfortable overnight stay in nature.

The accessible and functional design helps and inspires the user to bring its electric bicycle on a soft adventure and thereby holiday in an environmentally friendly way.

Keywords: soft adventure, electric bicycle, camper, vacation, concept development

Sammanfattning

Det finns ett växande behov av miljövänliga sätt att transportera sig och därför har elcykeln slagit stort i Sverige. Elcykeln används ofta som transportmedel till och från jobbet men har potential att användas i andra sammanhang också. Miljöpåverkan orsakad av transport under semesterresor har uppmärksammats på senare tid. Samtidigt ökar efterfrågan på *soft adventures*, bekväma och tillrättalagda naturupplevelser, i Sverige enligt Visit Sweden. Om de här olika krafterna kombineras så skulle ett användningsområde för elcykeln kunna vara under semestern.

Detta examensarbete har som syfte att utveckla en produkt som kopplar ihop elcyklar med trenden soft adventures för att på det viset uppmuntra folk att cykla mer.

Designprocessen startade med att studera de potentiella användarna. Baserat på uppmärksammade funktioner från användarstudien utvecklades en mängd olika koncept i flera iterationer i form av skisser, fysiska modeller och datormodeller. Dessa iterationer resulterade tillslut i ett koncept som vidareutvecklades och en slutgiltig prototyp, som tog hänsyn till både form och funktion, tillverkades. Denna prototyp testades och utvärderades sedan.

Det slutgiltiga konceptet, som kallas Kamrat, är en hopfällbar semestervagn som är tillräckligt liten och lätt för att dras efter en elcykel. I parkerat läge kan Kamrat fällas ut vilket resulterar i en säng för två personer med ett tält som tak. Detta ger möjlighet till en bekväm övernattning i naturen.

Den tillgängliga och funktionella designen hjälper och inspirerar användaren att ta med sin elcykel på ett soft adventure och därmed semestra på ett miljövänligare sätt.

Nyckelord: soft adventure, elcykel, husvagn, semester, konceptutveckling

Acknowledgments

This project could not have been carried out without the help of the following people.

Thank you Karl-Axel Andersson, our supervisor at LTH, for valuable input along the way, all your help in the workshop and for pushing us to go the extra mile.

Thank you Cilla Perlhagen for all your administrative help and positive energy.

Thank you Bert, Carl, David, Jan-Åke, Jonny, Josef, Olof and Peder in the for all the time, input and effort you have provided in helping us build the final prototype.

Thank you Damien and Carl at Design Sciences and Fredrik at LU Innovation for legal advice.

Thank you all the other co-workers at the Design Sciences department, especially floor 4, for valuable input, lovely fika-chats and for making us feel welcome.

Thank you all of our interviewees for you time and dedication.

Thank you Niclas at Alumeco for sponsoring the project with an aluminium pipe.

Thank you Cargobike for sponsoring the project with wheels.

Thank you Pierre at Tältcentralen for sponsoring the project with a tent canvas.

Thank you Thomas at BS Rörbockning for all your help with bending.

Thank you Daniel and Stefan at Thule for your valuable feedback and for sponsoring the project with a hitch arm.

Thank you Malin at Miljöbron and Bodil at Fokus Grönt for your cooperation in the start of this project and for planting an interest in bicycle related products.

Thank you Axel Nordin, our Examiner, and our opponents, Anna Tornvall and Maria Gustafsson, for your valuable input.

Thank you Jesper, Sara, our friends and families for your support during the project.

Lund, May 2018

Beata von Koch and Ola Andrén

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1 Introduction

1.1 Background

The project started with the aim to design, develop and test a product that should encourage people to bicycle more.

When it comes to personal transportation the car is by far the most common vehicle in Swedish cities (Projektengagemang, 2017). In Stockholm, Sweden there are 350 000 people who take their cars to work every day. 111 000 of them could use their bikes instead and still have a commuting time under 30 minutes. This would result in a 20% decrease in car gas emission in the inner city (Johansson and Lövenheim et al. 2017). With the aid of electric bicycles more people could leave their car at home, because the motorized help allows them to travel further in an easier way. If the regular human-powered bicycle would be replaced by an electric bike the environmental effect would be negative, but it has been proven that it more often is the car that is substituted (Hansson, 2015). In this case the electric bicycle could be one part in solving the emissions from commuting, and the e-bike could be used in other ways as well.

When going on vacation the environment takes a big toll. As an example, a flight to London emits 1600 kg of greenhouse gases per person and a flight to Thailand emits 8000 kg (Gummeson & Åkerman, 2014). In comparison the average Swede of today emits a total of 11 000 kg of greenhouse gases per person yearly connected to consumption, and the future goal of Sweden is that each person should limit their total yearly emissions to between 1000 and 2000 kg (Naturvårdsverket, 2017). In a recent study published in Nature Climate Change, carbon emissions connected to tourism have been quantified and emissions are not shrinking but on the other hand rising faster than expected. The authors found that the carbon emissions connected to tourism amounts to 8% of global greenhouse gas emissions, which is higher than earlier predicted. The authors also state that transportation is the main ingredient in tourism that makes it such a danger for the environment (Lenzen et al. 2018, 1-2). Because the emissions related to vacations are so closely bound to transportation, a closer destination often means less greenhouse gas emissions.

One way to have a holiday closer to home is to go on a bicycle vacation. This allows the holiday-maker to travel and emit less greenhouse gas emissions than when on an airplane or in a car. To see nature while cycling also relates to the trending term *soft adventure* which has been identified as a concurrent trend for tourism in Sweden. A soft adventure is a comfortable and accessible nature experience (Visit Sweden, 2016, 3).

2 Methodology

2.1 Goals and limitations

The goal for the project was set to create a product that connects the trend of electric bicycles with the term soft adventure, to encourage people to bicycle on their vacation. In that way an environmentally friendly holiday alternative could be created. The developed product should be designed, developed and then tested.

To be able to test the result of the project and the usage scenario, a goal was set to create one prototype for both function and form. It should work and look as good as possible within the frame of the project. This would allow the final prototype to be evaluated from a user's perspective and an aesthetic view point.

The project started without connection to any company, but one goal was to get sponsors or partners along the way. This was because it was desired to get opinions from experienced companies in relevant industries, as well as to put some external pressure on the project to increase quality and professionalism.

Because it was unknown if the project would receive funding from an external company, the project was carried out with economic limitations. A rule of thumb was to design a product that could be created in the workshops available at Ingvar Kamprad Design Centre (IKDC)-workshop and the Architecture (A)-workshop, at LTH, Lund University. If the final prototype was cheap and easy to create it would hopefully lead to cheaper manufacturing costs when produced in a larger scale.

The final product is intended to be used in Sweden or in climates similar to Sweden.

2.2 Design Process

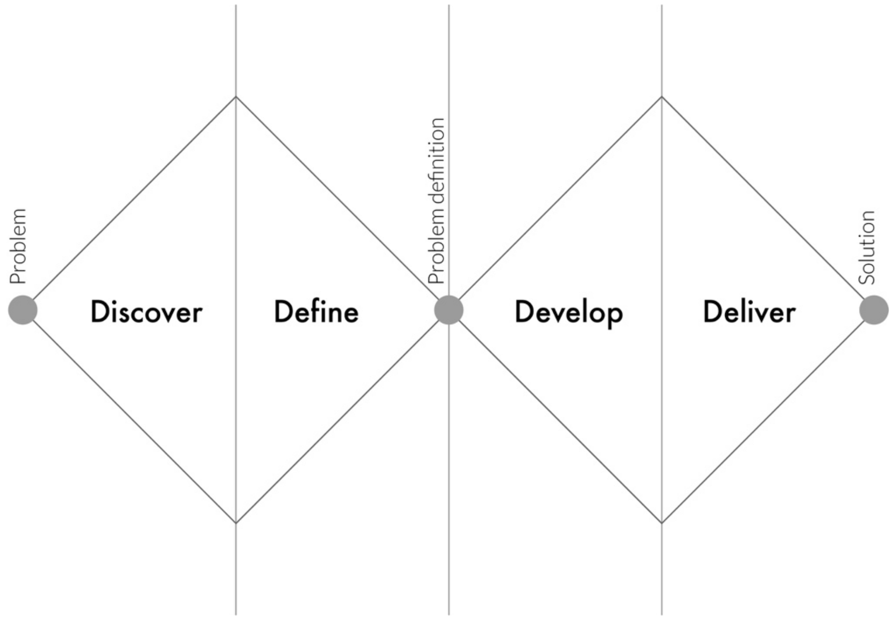

Figure 2.1 The Double Diamond design process.

The *Double Diamond design process*, developed by the Design Council, aims to illustrate the commonalities of the creative process. It was chosen as the outlines of the project. The phases of this generic process are: *Discover*, *Define*, *Develop* and *Deliver*, which will be further described below (Design Council, 2007). An illustration of the process can be seen in Figure 2.1. Within these phases inspiration and methods was taken from other literature. What to do in each phase was also decided by previous experience.

2.2.1 Discover

The first phase of the project had the aim to gather more information about the problem, addressing it with an open mind, gathering insights and identifying possibilities. The goal was to identify user needs and gain inspiration to possible solutions. The basis of the Discover phase was summarized as visiting the users, speaking to them and writing down what was experienced during these interactions.

2.2.2 Define

In the second phase the aim was to determine which possibilities found in the Discover phase to act on. The goal was to frame the fundamental design challenges and functional requirements of the project.

2.2.3 Develop

The third phase had the aim to develop, model, and test different concepts that fulfilled the identified functions. The goal of this phase was to choose one of several concepts to continue with in the fourth phase.

2.2.4 Deliver

In the final phase the aim was to finalize, prototype, test and present the chosen concept.

2.3 Modelling and prototyping

One cornerstone in the design process was to create many ideas to increase the chance of finding the best solution to a given problem. This way of working is emphasized by Jan Landqvist in his book *Vilda idéer och djuplodande analys*. The same author writes about the importance of working with three-dimensional models by prototyping in materials like cardboard and wood. He means that these kinds of real world prototypes can never be totally exchanged by hand sketches or computer models (Landqvist, 1994, 17, 83). This was something that was emphasized in particular in this project, where many models were created in the form of cardboard models complemented by sketches and computer-aided design (CAD) models to test various ideas.

The modelling was done in iterations that were started by developing a concept based on an idea. This was then broadened into many models and the iteration was then finalized by a decision in which way to continue to the next iteration-loop. These iterations were mainly made in the Develop phase of the Double Diamond design process. This way of working was inspired from earlier courses in the program of Mechanical Engineering with Industrial Design. As an example this iterative process was taught in the course *Entrepreneurship and Project Management,* that was included in the program Mechanical Engineering with Industrial Design, where it was used to test business ideas early and many times to prepare the ideas for launch (Lidgard, 2009).

2.4 Planning

An initial planning was made where the activities needed during the design process were put in a sequential order. In the schedule shown in Figure 2.2, the names and time frames for the different phases during the design process were inspired by a compendium of design methodology by Claus-Christian Eckhardt (2012).

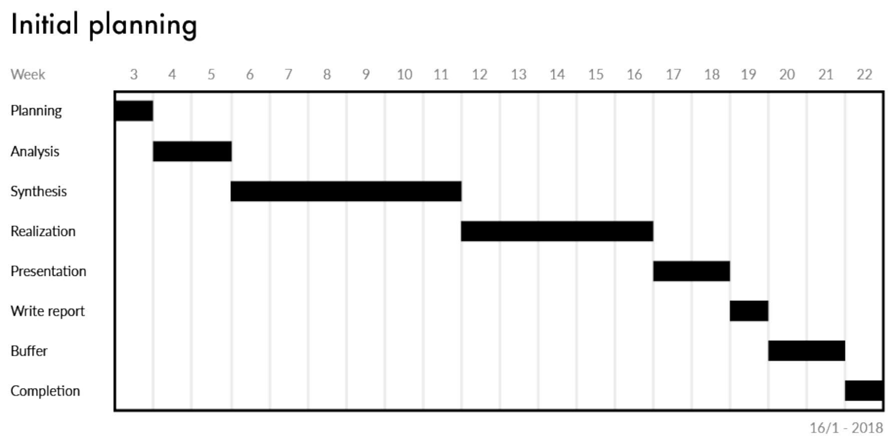

Figure 2.2 Early schedule for the whole master thesis.

The analysis phase of the schedule corresponds to both the Discover and Define parts of the Double Diamond design process. The synthesis phase of the schedule equals the Develop part of the Double Diamond design process, and realization, presentation and report writing phases of the schedule all correspond to the Deliver part of the Double Diamond design process. Therefore, this schedule was a clearer way of understanding how long time the different parts of the design process would take. With the Double Diamond design process, it instinctively looks like there are four parts of a design process that take equal amount of time to complete, which was not the case in this project.

3 Discover

3.1 Bike booms

3.1.1 Historical booms

The Discover phase was started by studying the history of the bicycle to try to understand what this product has meant during its more than 200 years long lifetime. A simplified way of understanding the evolution of the bicycle is to look at the *bike booms* in Europe and the US, which are time periods when there has been a peak in interest and sales of bicycles.

Figure 3.1 Original draisine made-to-measure with staff messenger (Siegrist, 1817)

The first bike boom was in the 1810s when a machine with two wheels became popular under various names such as the *draisine*, seen in Figure 3.1. On this wooden machine a human sat on a saddle similar to on a bike today, but instead of using pedals the user pushed the machine forward with their feet on the ground. The draisine became popular in both Europe and the United States (US), but the bike craze soon faded away partly due to regulations against the use of this device in cities as it was regarded too fast and too dangerous (Oliver & Berkebile, 1974, 3).

In the 1860s the first pedal powered bicycle was created in France by fastening pedals to the front wheel of a metal draisine. The invention became popular in the US but the bike boom died out at the end of the decade because the bicycles were hard to pedal and because they were regulated against in a similar way as the first draisine (Oliver & Berkebile, 1974, 7).

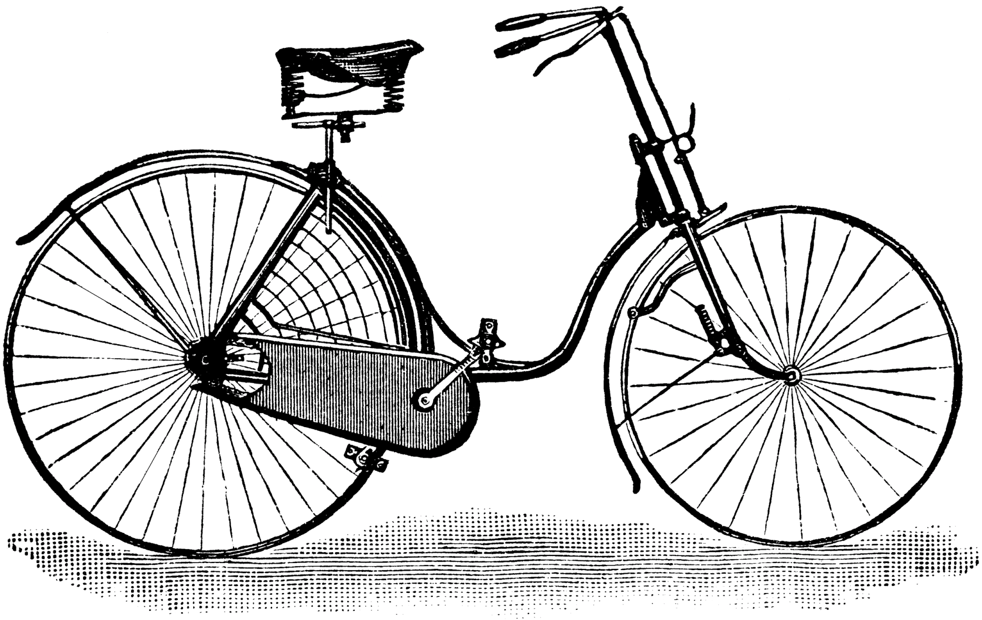

Figure 3.2 A step-through safety bicycle (Safety bicycle, 1889).

In the 1890s the *safety bicycle*, seen in Figure 3.2, became a huge success kicking of another bike boom. This bicycle used a chain-drive transmission from the pedals to the wheel and soon started to use inflatable air-filled tires for the first time. With smaller wheels this bike could have the rider closer to the ground, which was deemed as a safer way of cycling (Oliver & Berkebile, 1974, 20). This new kind of bike gave people the freedom to travel away from their home on their own. This led to a big empowerment for women and helped them become more independent when it came to working, socializing and organizing outside of their home. The women's rights activist, Susan B. Anthony, said in 1896 that cycling had “done more to emancipate women than anything else in the world: it gives women a feeling of freedom and self-reliance" (Roberts, 2017). The invention of the car and the increase of electrified railways taking over the roads previously used by cyclists were factors that led to a lost in interest in bicycles in the early 20th century (Oliver & Berkebile, 1974, 24).

Figure 3.3 Schwinn Stingray Fastback (Syn, 2010).

After the bike boom of the safety bicycle, the bicycle was for a long time considered to be mainly a toy for children and the interest was low in the US. It was not until the 1960s and 1970s that the country saw a new increased interest in bikes, also among adults (Oliver & Berkebile, 1974, 24). Big sales of the new stylized wheelie bikes, with smaller wheels than before, seen in Figure 3.3, started the bike boom which was also propelled by the availability of affordable, derailleur-geared, racing bicycles (Hudson, 2018). Many factors contributed to the boom such as a demand of bicycles for recreation and exercise, an increased awareness of reducing pollution and the positive health effects of cycling (Oliver & Berkebile, 1974, 24).

3.1.2 Concurrent boom

Figure 3.4 Schwinn Tailwind Electric Assist bike (Masoner, 2009).

When it comes to concurrent bicycle related trends, the Swedish government has decided to try to affect the bicycle use as they recently decided to subsidize electrical vehicles purchased after the 20th of September 2017. An electric bicycle can be seen in Figure 3.4. If a person purchases a new electrified bike, moped or motorbike and applies on the web page of Naturvårdsverket, that person can get back 25% of the cost, up to a maximum of 10 000 Swedish krona (SEK) (2018). The government hopes that this will encourage people to choose their new electric vehicles instead of their old combustion engine vehicles, and in that way help people lower their carbon emissions related to transportation (Regeringskansliet, 2017). In the middle of May 2018, more than 30 000 applications for this subsidy had already been made to Naturvårdsverket and around 40% of the programme’s yearly budget of 350 million SEK had already been used (TT Nyhetsbyrån, 2018). Similar programmes have been used in Oslo, Norway, to encourage people to buy electric cargo bikes and in that way allow people to use these bikes instead of cars to transport bulkier goods than a normal bike can handle (Weller, 2017). Paris, France, has taken it one step further and offers subsidies since March, 2018, on various combinations of purchases of new electric bicycles, cargo bikes and even on upgrades of regular bikes to electrically assisted bikes (Teale, 2018).

3.1.3 Key findings

The most important point that was retrieved from reviewing the history of the bicycle was the feeling of freedom that this product has meant to people in different situations and time periods. Women in the 1890s benefited from the bicycles' enabling of movement which gave them an unprecedented freedom of independent transportation. In the 1960s and 1970s the bicycle was liberating in the way of making recreational activities available.

Today the electrical bicycles that are subsidized in Sweden and several other countries give more people the freedom to cycle to work instead of commuting in cars. Subsidies of electric bicycles that start to pop up in different countries as a response to traffic congestion, bad air quality and the environmental impact of cars could also very well be a sign of the beginning of a new bike boom. An electric bicycle boom.

At the same time, bike booms have often ended abruptly due to regulations, new inventions or a sudden loss of interest. The increased speed of electric bikes might lead to it being regulated against, just like the wooden draisine was in the early 1800s.

3.2 Internet communities

To understand potential users and their needs regarding bicycle vacations better, contact was initiated in an internet forum about bicycling. This was a quick and efficient way to get in contact with end users to discover their needs.

3.2.1 Happyride

Happyride.se is a Swedish web page and internet forum about bicycles with around 60 000 visitors per week (Svensk Internet-statistik [SIS]-Index, 2018). To get in contact with possible end users, a forum post about bicycle vacations was posted. The post asked for advise when doing a bicycle holiday and what to think about when staying overnight. In a short time, nine users answered and it lead to new insights about what is necessary for a bike trip.

3.2.2 Key findings

In general, the forum users valued speed and bike experience above sleeping comfort while on bicycle vacation. This input was saved to be used when analysing and formulating user needs.

3.3 Interviews

To gain a deeper understanding of the user target group, telephone interviews were held with five people who had experience of bike vacations. Interviews were held to be able to create a product that gave value to the intended users by understanding who they are and how they have experienced bicycle vacations. Empathy for the users has to be created and this can be achieved by visiting and speaking to the users (Arvola, 2014, 41).

3.3.1 Interviewees

On Edge is a Swedish Facebook group for women with an interest in adventures with 7300 members. This forum was chosen as a contrast to Happyride.se, which has more of a bicycle focus, when looking for interviewees. In order to find people to interview a post with information about the project, and a request for interviewees with experience of bike vacations, was posted in the group. The post resulted in four interviewees, all with different experiences of bicycle vacations. A friend who was not a part of the forum On Edge was also asked to participate in an interview as well, because it was known that he had been on a bicycle vacation through Europe recently.

The interviewees were between 21 and 28 years old, and had been on bicycle vacations with different levels of difficulty, listed below:

- Person 1: A bicycle vacation on Gotland
- Person 2: Two bicycle vacations on Gotland and most recently a bike vacation in Lofoten
- Person 3: A bicycle vacation through Europe
- Person 4: Several bicycle vacations in both Sweden and New Zealand
- Person 5: Several bicycle vacations in North America, France and eastern Europe

The interview questions were unstructured, open and focused on letting the participants explain their experiences in order to explore instead of leading. This is important to avoid bias and to avoid shallow answers (Arvola, 2014, 48-49). A few key questions, focused on the how’s and why’s of a bike vacation, were prepared, but the follow-up questions were different depending on the interviewee and its answers. This enabled the interviews to explore the most interesting area for each interviewee.

The open questions used in the interviews were:

- Please tell us about your bicycle vacation experiences.
- Why are you going on this type of vacation?
- Who are you spending your vacation with?
- What have been positive and negative on this type of holiday trip?
- How do you spend your nights during your vacation?
- How do you transport yourself to the starting point of your vacation trip?

3.3.2 Key Findings

The key findings from the interviews were the importance of a comfortable and warm floor when sleeping and the possibility to put up camp on any surface. All the interviewees had previously used tents on their bike vacations and thought it provided freedom. They valued the light weight of tents and the possibility to bring it easily on the bicycle. Some negative aspects of tents were that they were cold and that the floor was uncomfortable. Two of the interviewees felt unsafe when using tents, due to the risk of animals getting inside the tent. Additionally, the interviewees stressed the importance of affordability. One of the interviewees had previously tried a bicycle trailer for luggage and regarded it as bumpy and explained that it was due to too small wheels.

3.4 Field studies

3.4.1 Malmö field study

Figure 3.5 Ola outside the Cargobike shop in Malmö

To gain a deeper understanding on how people use electric bicycles a trip to Malmö was made to visit two bicycle shops; one with a focus on electric bicycles; EcoRide, and another with a focus on cargo bicycles; Cargobike. A cargo bike is a bicycle with a storage compartment to carry kids or bulky luggage. These types of bicycles have increased in popularity recently (Liljefall, 2017). A picture outside Cargobike's store can be seen in Figure 3.5.

According to an employee at EcoRide, elderly people and people with other physical limitations have the opportunity to use bicycles with the growing popularity of electric bikes. The electric bicycle makes it possible for people to travel further and does not demand the same physical strength as a normal bike. Many people are hesitant towards electric bicycles in the beginning, thinking that they do not need the extra motorized help. However, after starting to use an electric bicycle people often use the full electric assistance all the time, according to an EcoRide employee.

Electric bicycles allow cyclists to carry a heavier load on their bikes and electric motors are also used on many cargo bikes. According to an employee at Cargobike, their bikes are mainly used to transport children, and not heavy luggage, however he sometimes used his own cargo bike for grocery shopping and moving furniture.

3.4.2 Lund field study

Figure 3.6 Beata looking at sleeping pads in the shop Naturkompaniet in Lund

Another field study to bike shops was made, this time in Lund; Lunds Cykel and DeGaVi Cykel. This was done to get an understanding of what recommendations bike shops give to customers interested in going on vacation on their bikes.

The first shop did not have any special products or recommendations except bags fastened on both sides of the back wheel. These bags came in different styles and sizes, but seemed too small to fit everything needed for a camping trip with a tent included. In that case it would be possible to fasten bulky camping equipment on top of the luggage carrier behind the saddle.

The employees of the second shop had themselves been on a bicycle vacation recently, when they cycled all the way from Sweden to Athens in Greece. On that trip they had stayed in hostels along their route, and without booking in advance they had stopped where they felt for it. They had tried to travel with as little luggage as possible and used bags on both the sides of the back wheel as well as a basket on the handlebars. They recommended using special bike pedals and bike shoes for longer trips, which locked the shoes to the pedals and allowed you to use your upward motion of your feet to help push the bike forward.

A Naturkompaniet store was also visited during the field trip. They sell outdoor equipment to both hobby hikers and more serious adventurers. Information about different kinds of tents, sleeping bags and air mattresses was gathered. A picture of different air mattresses can be seen in Figure 3.6. An interesting thing was the difference between dome tents and tunnel tents. A dome tent can stand on its own which lets you put up the tent quickly without the need of fastening many tent pegs to the ground. A tunnel tent cannot stand on its own and is dependent on relatively soft ground where pegs can be fastened. On the other hand, a dome tent often only has a high indoor ceiling in the middle of the tent, while a tunnel tent can have a lot of space throughout the whole tunnel which it builds up. According to the salesperson at Naturkompaniet, the tunnel tent is therefore considered to be more comfortable and it also allows the user to change clothes and move around more inside of the tent.

3.4.3 Copenhagen Bike Show

Figure 3.7 Beata at the Copenhagen Bike Show

A field study was also made to the Copenhagen Bike Show which is the biggest bicycle event in Scandinavia, seen in Figure 3.7. The goal was to see different bicycle products on the market and to try electric bikes.

Figure 3.8 Expensive carbon frame bicycle at the Copenhagen Bike Show.

Figure 3.9 Bicycle bags at the Copenhagen Bike Show.

Bikes with carbon frames for up to 100 000 DKK where displayed in booths next to bags for bicycle vacation. These are shown in Figure 3.8 and Figure 3.9.

Figure 3.10 Beata at the Urban Arrow booth at the Copenhagen Bike Show

Figure 3.11 Beata testing a cargo bike from Urban Arrow at the Copenhagen Bike Show

The booth of the Dutch company Urban Arrow was visited and their freight bike Cargo L flatbed was taken for a test run. Even though it had a weight of 58 kg it was easy to operate. Pictures of the bike in operation can be seen in Figure 3.10 and Figure 3.11.

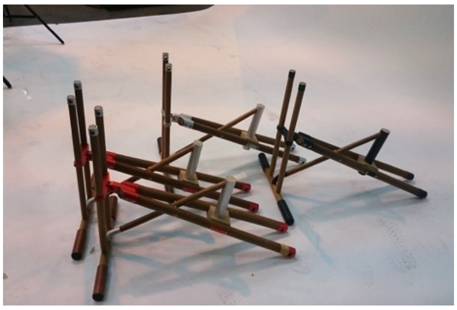

Figure 3.12 Wooden toy at the Copenhagen Bike Show

Figure 3.13 Wooden bicycle frame at the Copenhagen Bike Show

Some booths displaying cargo bikes and toys for children had products partly made of wooden components. Pictures of wooden components can be seen in Figure 3.12 and Figure 3.13.

3.4.4 Key findings

The field trips indicated that the target group of biking is growing, which means that the target group for bicycle vacations also has the opportunity to grow. However, the range of products especially made for bicycle vacations was scarce. Except for lightweight tents and bags mounted on the bicycle, nothing was found.

Another insight from the field trips regarding tents was that few tent pegs and a high ceiling was desired to simplify usage and increase comfort.

The wooden products displayed in Copenhagen set the direction when it came to choosing material and aesthetics for the project. This was because they had a softer and more accessible appearance than the carbon fibre products across the aisle. This felt important for the project since the aim was to inspire more people to use their bicycles, people who was not inspired by the aesthetics of the high performance bicycle world.

3.5 Decision of product type

After a thorough Discover phase with a broad scope of exploring the area of bicycles and bicycle vacations, a decision on which type of product to develop was made. It was decided to create a product to simplify staying overnight outdoors in a more comfortable way than a tent. This was because a need for this was identified from the interviews and because there seemed to be a gap for this in the market, seen on the field trips. The product should be compatible with different kinds of bicycles and therefore be a separate module to be towed behind the bike as a trailer. To allow for an overnight stay, the module was expected to be heavy which could be helped by using an electric bicycle.

Summarized this type of *holiday camper* would allow for a soft adventure in the e-bike saddle and could be imagined to be displayed on future bike shows.

4 Define

4.1 Affinity diagram

The *Discover* phase resulted in many different insights that needed organizing. Therefore, the gathered information was structured using an affinity diagram. An affinity diagram is a way to categorize and thematise qualitative data on post-it notes (Arvola, 2014, 52-54).

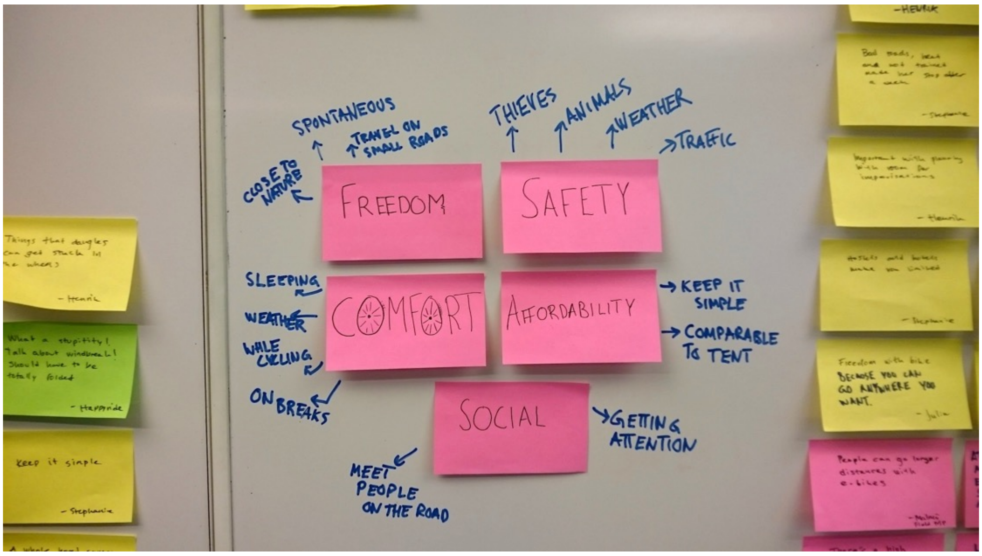

Figure 4.1 Small mind map connected to five key words from the affinity diagram

From the affinity diagram a few keywords were concluded: Freedom, Safety, Comfort, Affordability and Social. These keywords were meant to have in mind during the coming *Development* phase.

4.2 Market

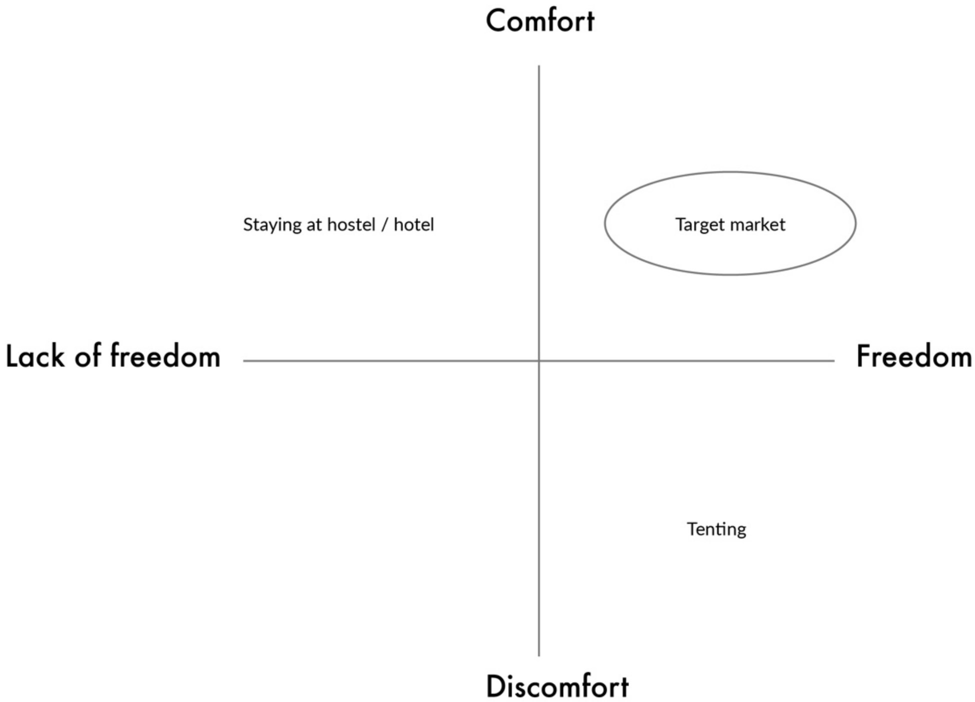

Figure 4.2 Market diagram.

The market for overnight stays on a bicycle vacation has different opportunities. On one hand there is the comfortable package deal vacation where you can rent a bike, have someone else transport your luggage by car and where you stay at a comfortable hotel along the way. On the other hand, there is the adventurous vacation where you bring a tent, bike as many kilometres per day as you can and sleep in the wild. It was decided that the goal of the project was to cater for something in between these two options - to reach the people who want to experience the wild without compromising on comfort. These people were considered to be young people with the urge for adventures, but with limited experience. They are looking for something affordable and are not keen on buying the whole package needed for going by tent. The final product could preferably be rented out on popular vacation spots as an alternative to bringing a tent or staying at a hotel.

4.3 Personas

To clarify the two existing markets for bicycle vacations and to understand the third, targeted, fairly unexplored market, three personas were created based on the findings in the Discover phase. A persona is a description of a hypothetical person based on facts about potential users. Personas were created because they can be used to enhance the design empathy, helping the designer relate to the user (Arvola, 2014, 65-69). The high-performance persona Claes, the laid-back persona Johanna and the combination of them two, the persona Charlie, are all described below.

4.3.1 Claes

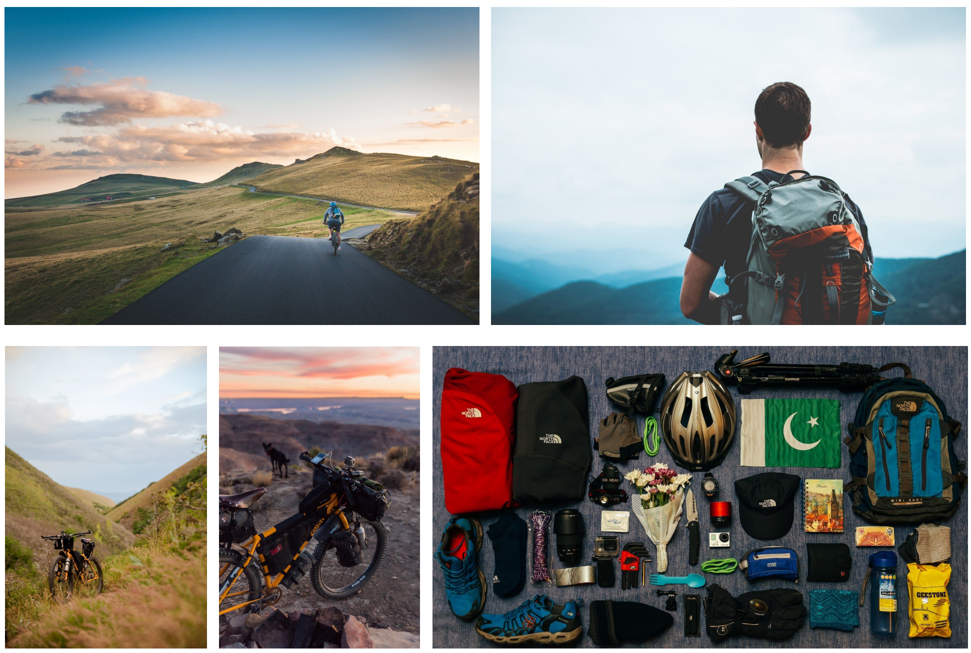

Figure 4.3 Mood board of the persona Claes. Pictures from Unsplash.com.

Claes is an active person who wants speed and efficiency in everything he does.

He always tries to challenge himself with new adventures, and right now he is really into cycling. He has previously hiked a lot, but cycling catched his interest by allowing him to cover larger distances in a shorter time.

Claes likes to travel alone to be able to go in his own speed and to be one with nature. He usually covers around 100 km per day and camps with a tent where he finds a good spot.

He loves the freedom he gets from tenting and has tented so much in is life that he sleeps better in his tent than in his own bed.

Claes is displayed by a mood board in Figure 4.3.

4.3.2 Johanna

Figure 4.4 Mood board of the persona Johanna. Pictures from Unsplash.com.

Johanna wants to bring her family on an active vacation along Göta Kanal.

She loves being out in the nature, but also enjoys the comfort of sleeping in a bed and eat a proper meal without having to bring a lot of extra equipment.

Johanna and her partner have been out camping with tents when they were younger, but when they got kids they valued a more comfortable vacation where they could both enjoy the nature and relax.

Therefore, Johanna became really happy when she found out that there are bike packages with hotels and food prepared after a long day in the saddle.

Johanna is displayed by a mood board in Figure 4.4.

4.3.3 Charlie

Figure 4.5 Mood board of the persona Charlie. Pictures from Unsplash.com.

Charlie wants to take her best friend and her bike and go climbing.

She loves nature and wants to stay as close to it as possible, even during night time.

Charlie likes tenting but not in bad weather - putting up a tent in mud is something she hates. She doesn't like the insecurity of going out into the woods with the risk of rain.

She and her friend also need to bring a lot of luggage and climbing gear which might be too much to carry on their bikes.

Charlie is displayed by a mood board in Figure 4.5.

4.3.4 Comparison

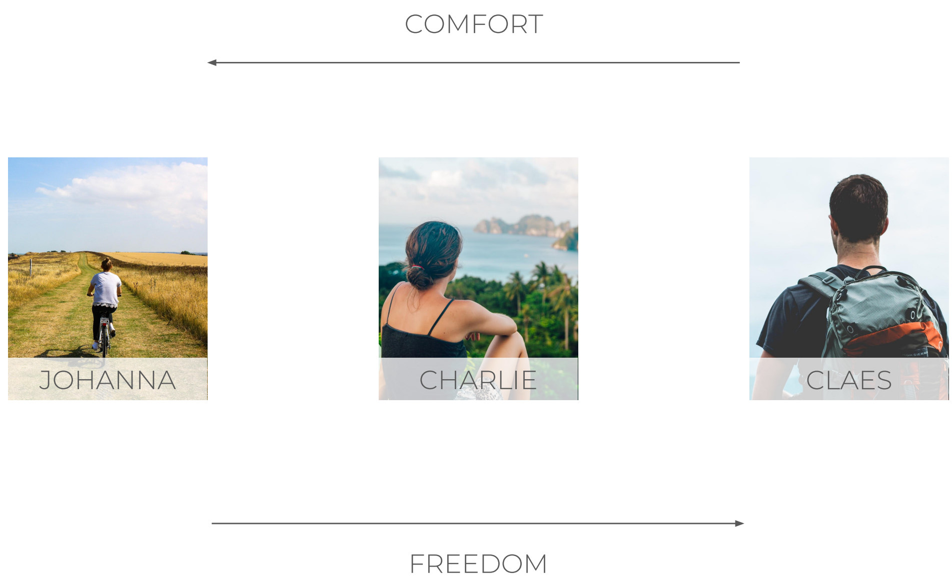

Figure 4.6 Comparison of the three personas. Pictures from Unsplash.com.

As seen in Figure 4.6, Johanna is a person who values comfort and Claes is a person who values freedom. The final product should appeal to Charlie, who is a person who values something in between the needs of Johanna and Claes. She wants something that allows her freedom, but not at the expense of her comfort.

4.4 Benchmarking

In order to develop creative ideas, without reinventing the wheel, benchmarking was made to explore what was already out on the market. The purpose was to gain inspiration to possible solutions and be able to position the holiday camper on the market. This is empathized in *Produktutveckling* written by Ulrich and Eppinger (Ulrich & Eppinger, 2014, 49).

4.4.1 Bicycle campers

There are very few competitors when it comes to an actual bicycle camper made for overnight stays. However, a Danish company called Wide Path Camper was found that had developed a bicycle camper. This camper had the looks of a normal car camper, but in a smaller size. It was foldable to reduce size while cycling and weighed approximately 45 kg (Williams, 2015). This was the only commercial bicycle camper that was found on the market.

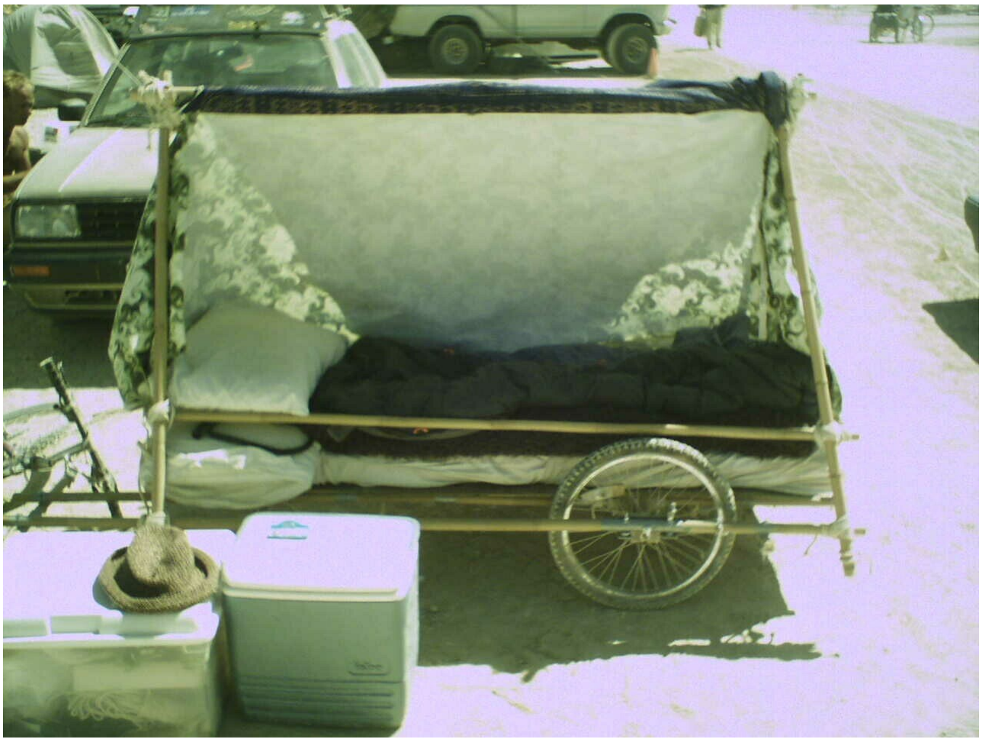

Figure 4.7 Bamboo bicycle trailer (Veen, 2006).

Even though it was hard to find existing products on the market there were many homemade solutions where a great deal of inspiration could be found. An example of this can be seen in Figure 4.7. It seemed like it had been attempted many times to create this kind of product but only a few concepts were continued with in a larger scale.

4.4.2 Car campers

Figure 4.8 Jayco 1006 Pop-up Camper Trailer (Korey99, 2009).

Car campers were also a good source of inspiration since the market is more explored. There are two concepts called *pop-up camper* and *rooftop tent* which are especially creative solutions on how to transport a mobile bed in a relatively small box. The pop-up camper is pulled behind a car and then extended in different directions to create a bigger volume inside. This is shown in Figure 4.8.

Figure 4.9 Isuzu Rodeo roof top tent (Blizzard, 2010).

The rooftop tent is a box mounted on the roof of a car which could be expanded into a tent allowing the user to sleep high above the ground. This is shown in Figure 4.9. Both of these concepts provided clever solutions on how to make a home foldable and transportable.

4.4.3 Bicycle trailers

Figure 4.10 Thule bicycle trailer (EHRENBERG Kommunikation, 2014).

Because the holiday camper should be towed behind a bike, bicycle trailers of different price ranges, sizes and designs were studied. This is shown in Table 4.1. A picture of a bicycle trailer can be seen in Figure 4.10.

Table 4.1 Benchmarking of bicycle trailers.

Product name	*Price (SEK)*	*Weight (kg)*	*Size (cm)*	*Capacity (kg)*	*Wheel size (‘’)*
Thule Chariot Sport1	10 000	14	85.5 x 62 x 37.5 (folded)	34	20
Journey Trailer	4200	4.85	157 x 44.7 x 42	32	16
Croozer Cargo	2500	13.5	84 x 69 x 36	40	16
Burley Flatbed Bicycle Trailer	2100	6.6	83.8 x 78.5 x 40.9	45	16
Red Cycling Products Cargo Trailer	1900	11	50 x 60 x 40	25 (+ 3 on the roof rack)	20

4.4.4 Bicycle trip packages

Some companies were found online that offered bike trip packages which included rental bikes, hotel nights and meals. Sweden By Bike is a company that describes itself as the leading company when it comes to informing about, and inspiring to bicycle vacations in Sweden. In addition to bikes and full board hotel stays they also offer bike maps and insurance for customers who books bike trip packages through their service. The bicycle trips they offered ranged between day trips to week long vacations and covered many parts of Sweden. The cost of a bike trip package with an overnight stay started at around 700 SEK per person with an average price of more than 1000 SEK per person and night.

4.4.5 Key insights

The benchmarking gave inspiration to different kinds of designs and possible folding solutions. It also gave the project a span of key parameters for the analysed bicycle trailers. These are shown in Table 4.2.

Table 4.2 Table of insights from benchmarking.

Price (SEK):	1900 - 10 000
Weight (kg):	4,85 - 14
Width (cm):	44 - 78
Length (cm):	60 - 157
Capacity (kg):	25 - 45
Wheel size (“):	16 - 20

The insights gained from looking into the bicycle packages were that there was a market for bicycle vacations, because they let customers experience nature and a physical activity in a comfortable way. It was also interesting to see the price range of the offered packages and the variety of options available. This was since these offered packages could be potential competitors to a bicycle camper and in order to compete with these the price is of interest.

4.5 Inspiration

To design a product and also form the relatively unexplored market niche that was identified, inspiration was taken from sources outside of the bicycle world.

4.5.1 Interior design

Figure 4.11 Bright room. Photo by Hutomo Abrianto on Unsplash.com.

Figure 4.12 Wooden decoration with white flowers. Photo by Palon Youth on Unsplash.com.

Figure 4.13 Books on floor. Photo by Pavel Nekoranec on Unsplash.com.

Figure 4.14 Kitchenware. Photo by Ryan Christodoulou on Unsplash.com.

After the field trips in the Discover phase it was concluded that a softer image was desired compared to the high-performance gear of elite cyclists. As a starting point when it came to formulate how the final product should be experienced inspiration was taken from bright, light and simple interior decoration seen in Figures 4.11 – 4.14.

4.5.2 Chuckwagons

Figure 4.15 Covered wagon at Pipe Spring National Monument, about 20 miles west of Fredonia, Arizona (Fowler, 2012).

To relate the product to the environmentally friendly aspect of the project, and attach the trend soft adventure from the start of the ideation, inspiration was found at the covered wagons, also called chuckwagons, from the American prairies. A chuchwagon is shown in Figure 4.15. The chuckwagons were mainly used as a cowboy's home on wheels that they used while moving herds of cattle through Texas after the end of the American civil war in the late 1800s (Thompson, 2018). The use of white fabric as the roof of the wagon was appreciated as a nice-looking contrast to the wooden chassis and it connected well with the bright interior design photos that had been used as inspiration earlier in the process. The creased canvas also gave the wagon a lightweight look and an air of freedom, which was taken as important inspiration for the project.

4.5.3 Sailboats

Figure 4.16 Sailboat. Photo by Taduuda on Unsplash.com.

Figure 4.17 Sailboat. Photo by Ian Keefe on Unsplash.com.

Figure 4.18 Sailboat. Photo by Dogan Gulcan on Unsplash.com.

Figure 4.19 Boat. Photo by Evren Aydin on Unsplash.com.

Building upon the idea of canvas and wood from the chuckwagons, sailboats were another area of inspiration. The connotations of freedom from wagons on the prairies were also applicable on boats on the open seas. In the photos of chuckwagons found online, the canvas roof seemed to be fastened to the wooden chassis with ropes through loops in the fabric. This was also something that was found in photos of sailboats, seen in Figure 4.16 – 4.19. Especially interesting was the fastening of boat covers used over the boat deck to protect the inside of the boat from rain. In that case a waterproof canvas was tightly fastened over the boat so that no water could get inside. It was concluded that if the project was to continue in the direction of using a canvas covered wooden construction, water would be a big problem if not handled correctly. Therefore, inspiration was taken from boat covers and the way of fastening them with ropes and loops, just like the canvas over the chuckwagons were fastened.

4.5.4 Tents

Figure 4.20 White tent. Photo by Dmitry Bayer on Unsplash.com.

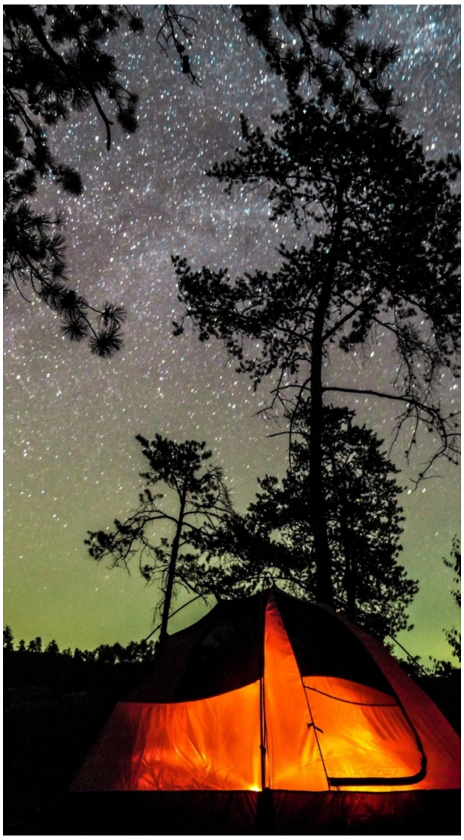

Figure 4.21 Red tent. Photo by Rohan Makhecha on Unsplash.com.

The idea of white canvas in contrast to wood derived from inspiration from both chuckwagons and sailboats. To understand how canvas made for outdoor use behaved, different types of tent structures were analysed. White fabric is often used for more robust tents for outdoor events or at restaurants and cafés that have them raised for a longer time period, like the whole summer or during a festival. This is seen in Figure 4.20. Smaller more lightweight tents used for overnight stays are often brightly coloured in orange, green or red, shown in Figure 4.21. It was hard to understand why this type of outdoor product that helped people experience nature did not blend in to the environment at all, but on the other hand looked really out of place in the wild. One explanation that was discussed was that a brightly coloured canvas could catch the eyes of by passers so that they didn't stumble upon the tent and that it could help the user to find the campsite if he or she was lost in the surrounding woods. These two examples of how colour connected to different usage scenarios of tents were considered as something that could be used in the ideation process.

4.5.5 Teardrop car trailer

Figure 4.22 T@G Tailgate (Legraen, 2018).

When benchmarking car campers, teardrop shaped trailers were found. This type of car camper offered the user a bedroom area inside of the trailer and a kitchen area in end of the trailer, found beneath a hatch opened upwards. An example is shown in Figure 4.22. The campers were sold by several different companies and being built by private persons as hobby projects. It was smaller than most other campers because the kitchen could take up a smaller space in the trailer when the user did not have to stand up inside of the trailer while cooking. The teardrop trailer also did not have a toilet which allowed it to be smaller at the expense of comfort. When it came to form, the teardrop shape was considered as attractive because it took a step away from the otherwise, often, box shaped mobile homes and gave an eager expression that was used in the ideation process for the project.

4.6 Functional analysis

The gathered information and insights resulted in a functional analysis which is presented in Appendix A. A functional analysis is a matrix consisting of different sets of verbs and nouns describing a function. The different functions are categorized in three different categories: main function, necessary functions and desirable functions. The functional analysis is about expressing the needs in functions - not solutions. More specifically, to think before acting out. (Landqvist, 1994, 34-37).

The main function for the project was chosen to be: Simplify vacation (on a bicycle).

4.7 Design brief

4.7.1 Summary

In order to summarize the Define phase, a design brief was written with the aim of answering the following questions:

- What does the product want to be?
- What is the main function of the product?
- How is the product perceived?
- Who is the user?
- What is the personality of the product?
- How is the experience of the product?
- Is the product part of a bigger system?
- How is the technical quality level of the product?
- How does the product affect the environment?

These questions were taught in the course *Design Methodology* lectured by Per Liljeqvist, lecturer at the Department of Design Sciences at Lund University.

4.7.2 The design brief

- The product wants to be a comfortable and affordable way of providing social freedom on a bike without compromising on safety
- The main function of the product is to encourage and simplify bike vacations
- The product is perceived as simple and straightforward. It is also perceived as cool and interesting.
- The user is someone who enjoys the thought of spending the night in nature without actually wanting to go through the effort of tenting.
- The personality of the product encourages spontaneous usage. The product provides the possibility of social interactions.
- The experience of using the product is that it is safe and stable enough to handle any kind of weather and nocturnal animals. The product is lightweight and aerodynamic which makes the experience of using it enjoyable.
- The product is part of a bigger system including bicycles, bike trails, outdoor equipment and camp sites.
- The technical quality level is on the same level as a bike. The product has standardized components allowing the user to easily replace broken parts.
- The product has a low impact on the environment using only muscle power and electricity to transport itself.

5 Develop

5.1 Sketches

The ideation started early in the project with sketches and discussions. Collapsible concepts were investigated to reduce the size of the holiday camper while on the road. Some sketches are shown in Figure 5.1.

Figure 5.1 Quick sketches of collapsible concepts.

5.2 Modelling

Figure 5.2 Cardboard models in scale 1:5.

Continuing from the sketched ideas, models to show form and function were created. Something that was researched and discussed a lot was how big a bicycle trailer could be. Based on the benchmarking done in the Define phase, physical models were created which were a good way of understanding size. Some quick cardboard models are shown in Figure 5.2. During the development process different kinds of decision making processes were then used to proceed forward. Prototype building and testing, discussing advantages and disadvantages and using intuition were all important ways to do this. These are all different methods used in product development (Ulrich & Eppinger, 2014, 199).

5.2.1 Iteration 1 - Quick ideas

Collapsible concepts were made in cardboard, paper and plastic with the goal to fit on a bike trailer with set dimensions.

Figure 5.3 Folded concept in folded position in scale 1:5.

Figure 5.4 Folded concept in unfolded position in scale 1:5.

Folded was a concept where a wall was risen and the bed extended, which allowed for two persons to sleep and dine together. This concept is shown in Figure 5.3 – 5.4.

Figure 5.5 Bellow concept in folded position in scale 1:5.

Figure 5.6 Bellow concept in unfolded position in scale 1:5.

Bellow was a similar concept as Folded, but with a plastic bag representing the ceiling and walls of the bed area. This concept is shown in Figure 5.5 – 5.6.

Figure 5.7 Accordion concept in folded position scale 1:5.

Figure 5.8 Accordion concept in unfolded position scale 1:5.

Accordion was an alternative to the plastic bag in the concept Bellow. This concept uses paper with many folds to collapse the ceiling. This concept is shown in Figure 5.7 – 5.8.

Figure 5.9 Drawer concept in folded position in scale 1:5.

Figure 5.10 Drawer concept in unfolded position in scale 1:5.

Drawer was a different concept than the earlier ones in iteration 1, which placed the bed on top of the wheels allowing the trailer to have the wheels closer together. It unfolded perpendicular to the direction of the bike. This concept is shown in Figure 5.9 – 5.10. The Drawer concept was chosen as the most interesting because it allowed for the trailer to make a smaller footprint behind the bike at the cost of the trailer being higher from the ground. It was modelled in scale 1:1 to see how big it felt compared to a real bike. This is shown in Figure 5.11 – 5.12.

Figure 5.11 Drawer concept in folded position in scale 1:1.

Figure 5.12 Drawer concept in unfolded position in scale 1:1.

A conclusion to be made was that the other concepts in scale 1:5 in iteration 1, where the width of the bed fitted between the two wheels, made the trailer very wide. The Drawer concept was therefore interesting, where the bed area was extended above the wheels. Another interesting thing was the possibility, shown in the concept Folded, to integrate a kitchen area into the trailer to make it something more than just a bedroom on wheels. A search for a better housing for the bed and kitchen area started of iteration 2.

5.2.2 Iteration 2 - More than a bedroom

The *Barrel* concept was created, which divided the camper in half with a kitchen part and a bedroom part fitted under the same roof. This roof consisted of many boards of cardboard, which was rolled of the gables rather than folding it upwards. In the same motion, the tent was unfolded, which covered the bedroom. This concept is shown in Figure 5.13 – 5-14.

Figure 5.13 Barrel concept in folded position scale 1:5.

Figure 5.14 Barrel concept in unfolded position scale 1:5.

The concept had an innovative feeling, fulfilling both the bedroom and kitchen needs in one housing. To understand the dimensions, this concept was made in scale 1:1. This is shown in Figure 5.15 – 5.18.

Figure 5.15 Barrel concept in scale 1:1.

Figure 5.16 Barrel concept in scale 1:1 with open kitchen area.

Figure 5.17 Barrel concept in scale 1:1 with open luggage area.

Figure 5.18 Barrel concept in scale 1:1 with unfolded tent.

The Barrel concept extended into a bed big enough for two persons and offered a big kitchen area with collapsible boxes for luggage storage. It was concluded that it was an interesting concept to continue with, but different problems appeared. Firstly, the mechanism that would allow a bed to be collapsible, was an important part to investigate because the bed would need to carry heavy weight at the same time as it should be made of lightweight components and fold up nicely into the housing. Another point of interest was that if the whole Barrel should be fitted on top of the trailer and not interfere with the wheels of the trailer, the whole trailer would have its centre of gravity high above the ground. This could make the trailer unstable in tight turns and take a lot of force from wind. As a conclusion it was decided to further investigate bed mechanisms to see what was possible to develop.

5.2.3 Iteration 3 - Mechanisms

Two different bed mechanisms had previously been discussed: Drawer and Folded. When evaluating these two concepts further it became prominent that the Drawer concept posed a big problem with the bed being on different levels. However, the ability to be divided in three instead of two was interesting. This was applied to the Folded concept, making it fold on two places and making the width of the bed being the length of the camper.

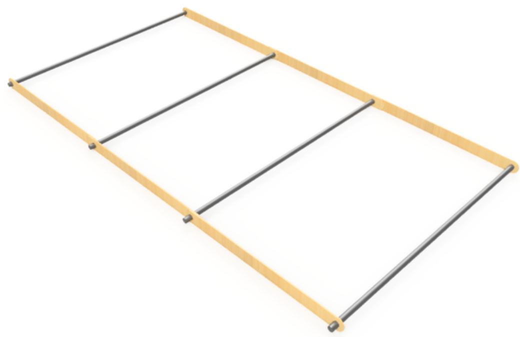

Figure 5.19 Rendering of the Trilogy concept in unfolded position.

Figure 5.20 Rendering of the Trilogy concept in folded position.

To evaluate the concept *Trilogy* an assembly was made in a CAD program called Autodesk Fusion 360 to demonstrate the folding of the bed. This is shown in Figure 5.19 – 5.20. Upon folding the bed in CAD, an important discovery was made: it was not possible to fold the bed as predicted due to the collision of the different floor parts. Hence, the concept had to be further developed in order to avoid this collision.

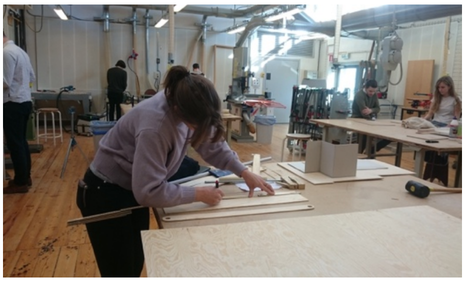

Figure 5.21 Making of model for the Second floor concept.

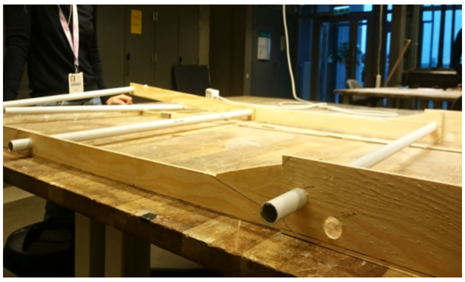

Figure 5.22 Model of the Second floor concept.

To avoid the collision of the two floors, a concept called *Second floor* was developed and built in plywood and plastic pipes, seen in Figure 5.21 – 5.22. This concept created a distance between the two colliding floors when folded, but unfortunately it also meant that there would be two different floor levels on the bed, which was not ideal. Hence, the ideation continued.

Figure 5.23 Model of the Appendicitis concept.

To gain inspiration from folding mechanisms, regular collapsible beds were studied. These beds usually have a smaller part in between the folding parts to avoid collision of the mattresses. A model made of plywood and plastic pipes was made to illustrate the concept *Appendicitis*, shown in Figure 5.23. This concept worked well considering both collision and bed level. However, it appeared unstable with this many parts of the folding mechanism. It would stabilize the construction if the small middle part could be integrated with one of the longer parts. A new concept called *Hockey stick* was created.

Figure 5.24 Model of the Hockey stick concept.

Figure 5.25 Model of the Hockey stick concept while folded.

A three-part mechanism, folding up in the shape of a Z, was chosen as the most promising mechanism and made out of plywood and plastic pipes, seen in Figure 5.24 – 5.25. This mechanism ensured that the mattress floor had the same level when unfolded, but still avoided collision of the two floors when folded. However, this mechanism, together with previous mechanisms demanded a large volume of the housing, and hence other solutions were considered.

Figure 5.26 Model of the Triangle concept.

Another alternative that was discussed was to fold the bed as a triangle. In this way the mattress would not cause any problems when folded. This concept was called the *Triangle* and is shown in Figure 5.26. The folded size would be bigger, but could be made with similar and fewer components which would make it more lightweight. The bed floor could also act as walls for the housing and therefore reduce the overall volume of the camper.

After the investigation of a collapsible bed, the conclusion was drawn that the project was going into a direction with too many details which could result in a heavyweight and complex construction. Therefore, a decision was made to take a step back and generate concepts with an easy to use - and easy to understand - design.

5.2.4 Iteration 4 - CAD models

Figure 5.27 Rendering of the Lowrider Barrel.

The Barrel concept was created in CAD, seen in Figure 5.27. A CAD model of a bicycle was downloaded from the webpage GrabCAD (created by Krishna Kanth Vutukuru, https://grabcad.com/library/bicycle-in-fusion-360-1) and imported into the assembly to give a better understanding of size. The trailer wheels were positioned behind the sleeping module to lower the whole trailer and its centre of gravity. This allowed the bottom of the trailer to be placed lower than the wheel axis and a luggage compartment was created between the wheels. In this concept the housing was created as a solid body and did not take into account the size of the folded bed.

Figure 5.28 Rendering of the Box.

Inspired by the bed mechanism, the Triangle, where the bed was not fully folded to give a lot of space for the mattress in a triangular shape, the Box folds the bed even less, this time in the shape of a rectangle. This concept is shown in Figure 5.28.

Figure 5.29 Rendering of the Horse trailer.

Continuing on the idea of the Box, the Horse trailer had a lower profile and a smoother ending to the trailer where luggage could be stored as in the concept, Lowrider barrel. This concept is shown in Figure 5.29.

Figure 5.30 Rendering of the Small hatch.

With a lower, flat roof the Small hatch combines the earlier concepts with a rectangular bed mechanism but lowers the profile of the trailer below the axis of the wheels. The luggage compartment is opened by a small hatch that opens upwards from the back of the trailer. This concept is shown in Figure 5.30.

Figure 5.31 Rendering of the Symmetrical opening.

The three-part rectangular shaped bed mechanisms of the earlier CAD models still posed problems with how to fold and how get the legs extended. In this concept another idea was tested, where the two walls on either side of the trailer unfolds outwards and extends to a double bed. This symmetrical way of collapsing the trailer would be easier for the user and require less parts, which could make it more lightweight. This concept is shown in Figure 5.31.

Figure 5.32 Rendering of the Teardrop chuck trailer.

Building on the concept of the Symmetrical opening, a smoother shape was designed taking inspiration from chuckwagons and retro looking teardrop trailers, found in the Define phase. By putting the legs in a groove in the side of the trailer they catch the eye of the user and encourage the user to pull the legs towards them. The legs could also work as a lock for the trailer so that it unlocks and opens the bed module in the same motion. This concept is shown in Figure 5.32. The combination of usability and design made the Teardrop chuck trailer a promising concept and it was modelled in cardboard in scale 1:5 to be studied further. This is shown in Figure 5.33 – 5.34.

Figure 5.33 Cardboard model of the concept Teardrop chuck trailer in folded position in scale 1:5.

Figure 5.34 Cardboard model of the concept Teardrop chuck trailer in unfolded position in scale 1:5.

The cardboard model of the Teardrop chuck trailer was overall satisfying but it gave a larger impression next to the bike than expected. Hence, the question whether it was possible to bike with a trailer this big arose. The next step was therefore to assemble a scale 1:1 model on an existing bike trailer and try to cycle with it.

An existing bike trailer was borrowed from a bicycle library called Cykelbiblioteket in Malmö. The arm connected to the bike was lengthened with wooden planks and the existing scale 1:1 cardboard model of the Barrel concept was mounted on top of the trailer, seen in Figure 5.35 – 5.36. This concept had a different appearance than the Teardrop chuck trailer, that was the chosen concept to continue with, but had approximately the same dimensions.

Figure 5.35 Test of the scale 1:1 model.

Figure 5.36 Test of the scale 1:1 model.

The trailer was tested in an outside environment by biking uphill, downhill and doing U-turns. It worked better than expected and the size of the trailer was not a problem except in sharp right way turns. This was due to the hitch-arm of the trailer that was connected to the bike on the left side of the back wheel of the bike.

Because the outer dimensions of the concept were not considered to be a problem, it was decided to continue with the development of the Teardrop chuck trailer.

5.2.5 Iteration 5 - Detailed CAD model

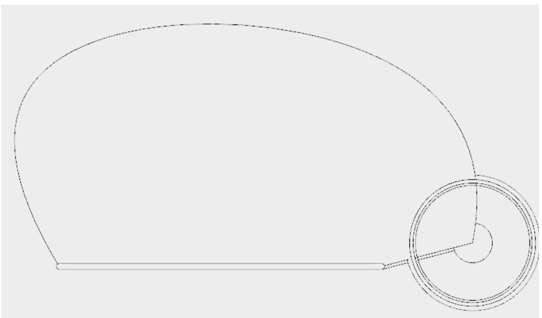

Figure 5.37 Outlines of the CAD model.

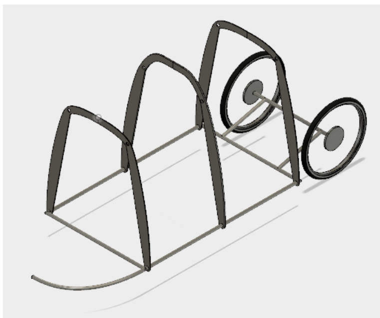

Figure 5.38 Skeleton CAD model.

A new CAD model was designed with a higher level of detail. At first a silhouette was sketched on top of a trailer frame, seen in Figure 5.37. This had the right outer dimensions that was needed for the bed area as well as the kitchen and luggage area of the trailer. In order to keep the weight down, inspiration was taken from wooden airplane skeletons, seen in Figure 5.38. Many experimental airplanes are made out of wood thanks to its physical characteristics. It is strong, twice the tensile strength of aluminium if you compare it by weight (DiFrisco, 2000). Since the camper needed to be low-weight, this was a major advantage. Wood is also easy to handle and can be cut with common tools, which was within the scope of the project.

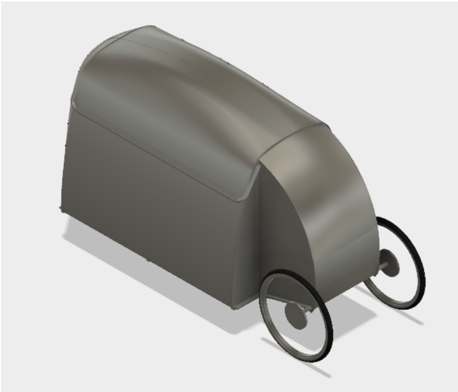

Figure 5.39 The CAD model in folded position.

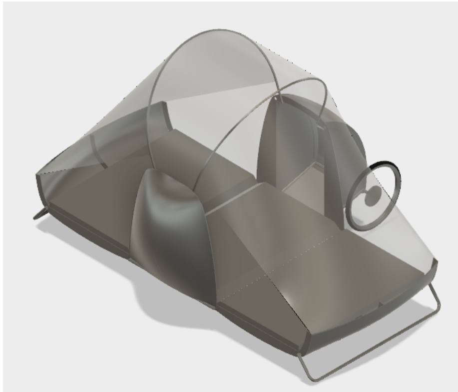

Figure 5.40 The CAD model in unfolded position.

During the modelling in CAD a new way to suspend the tent ceiling above the camper was designed, seen in Figure 5.39 – 5.40. The thought was to raise two arcs automatically while unfolding the sides of the camper to minimize the effort required from the user. In this way the tent ceiling would not need any extra tent pegs, which was considered to be positive, and something that had been picked up during the field trips in the Discover phase. If the arcs were big enough, it would lead to a high indoor ceiling while unfolded, which was also considered as comfortable, something that also had been emphasized during the earlier field trips. To experiment with how this type of arc-mechanism could work, more investigation was done by cardboard modelling.

5.2.6 Iteration 6 - Further development of cardboard model

Figure 5.41 Making of pulley mechanism.

Figure 5.42 Making of pulley mechanism.

As seen in the previous section, a mechanism for the arcs lifting up the tent to a higher ceiling level was needed. A pulley mechanism was considered as a good solution for this in theory, but had to be tested in practice. Hence, the pulley mechanism was built from cardboard and was mounted on the existing cardboard model, seen in Figure 5.41 – 5.42. The pulley had a thread connected to it that was also connected to the end of the bedside. When the bedside was unfolded, the thread became tightened and hence, started to rotate the pulley. Since the arc was connected to the pulley, it also rotated, making the tent rise. This concept is shown in Figure 5.43 – 5.44.

Figure 5.43 Cardboard model of Teardrop chuck trailer with pulley mechanism in scale 1:5 in folded position.

Figure 5.44 Cardboard model of Teardrop chuck trailer with pulley mechanism in scale 1:5 in unfolded position.

The pulley mechanism was functioning, but it was hard to make the arcs stop in the right position. Therefore, the idea of attaching the arcs to the tent arose. It was also considered unnecessary to have two arcs, so it was decided to create another model with only one arc with the tent attached to the arc, seen in Figure 5.45 – 5.46.

Figure 5.45 Detailed cardboard model in folded position in scale 1:5.

Figure 5.46 Detailed cardboard model in folded position in scale 1:5.

This model was made using digital prototyping to get a higher level of detail. Finer cardboard was used and laser cut prior to assembly to test the idea of having a skeleton similar to the ones found in experimental airplanes. The chassis of the trailer was also designed in CAD and then 3D-printed with the plastic material Polylactic acid (PLA). Cloth was used to cover the outside of the laser cut cardboard frame and wooden sticks were attached as handles. The cardboard frame was glued together and the joints for the sides that opened the sides were created with small screws and nuts.

Figure 5.47 Building of cardboard model in scale 1:1.

Figure 5.48 Finalizing of cardboard model in scale 1:1.

To test if the size and weight was working, a scale 1:1 cardboard model was once again mounted onto a normal bike trailer and a kettlebell weight was fastened onto it. It was also of interest to find out if the handles and hatches of the trailer were comfortable to reach for the user, and if the general user scenario worked as hoped. The creation of the model can be seen in Figure 5.47 – 5.48.

Figure 5.49 Test of cardboard model in scale 1:1.

Figure 5.50 Test of cardboard model in scale 1:1.

The cardboard model was made to resemble the final shape of the camper, but the tent had not been mounted since the cardboard would not have been able to carry the weight. The model was taken for a test ride in order to find out how the weight and size of the camper would feel while connected to a bike. The model was only tested by the two team members of the project. Pictures from the ride are shown in Figure 5.49 – 5.50. The result of the test was satisfying since the camper was easy to handle while turning. It was also easy to unfold the sides of the camper and the handles were in good positions for reaching, although the user had to bend forward a bit to grasp them. The kettlebell mounted onto the trailer had a weight of 10 kg. This gave the trailer a total weight of 20 kg, which was the goal weight of the trailer. Biking with this weight on flat ground and small slopes worked well, but it was hard to pedal up steeper slopes.

5.3 Summary

The Develop phase resulted in many different concepts that were evaluated and then decisions were made on how to continue. The choice of concept was a natural and smooth process taking the functional analysis and the design brief into consideration.

The Teardrop chuck trailer had the advantage of being easy and understandable to unfold. It was also stable as the centre of gravity was placed in the middle of the bed when unfolded and the pulley mechanism made the tent rise automatically when the trailer was opened. Additionally, it had an aesthetically appealing design which led the thoughts to retro car campers and cowboy chuckwagons.

The concept is an overnight camper where a bed can be unfolded perpendicular to the direction of travel. When unfolded there is also a tent rising above the bed to protect from rain and wind. The concept includes luggage areas in the front and the back of the trailer. The one in the back is intended for storing kitchen utensils such as a portable stove. This compartment will hereby be referred to as the kitchen area.

The advantages of being user friendly, stable and simple made the Teardrop chuck trailer the final choice of concept. The test of the concept with a smaller, highly detailed, cardboard model in scale 1:5 and a big one in scale 1:1 to test drive it made the concept convincing enough to move on to the next phase.

6 Deliver

The Deliver phase included making a detailed CAD-model of the final concept, approaching companies and asking if they could sponsor the final prototype and manufacturing the needed components in the workshops in IKDC and the A-building at LTH. The development of the details of the prototype was an ongoing process where a CAD design was turned into a drawing, discussions were held with the employees of the workshops and the supervisor of the project. Then the components were manufactured or redesigned to optimize for factors like weight, stability and affordability.

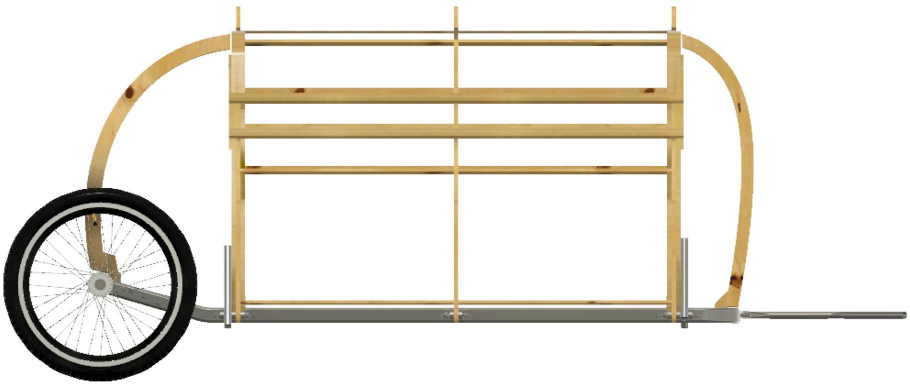

Figure 6.1 Screenshot of the sideview of the final concept modeled in CAD.

The bottom part of the camper was designed to be made out of a metal pipe, creating a chassis. In the back of the chassis, two 20” wheels were connected and in the front, a hitch arm was fastened. The upper part of the camper was designed to be made out of wooden components that acted as a housing when closed and partly acted as a bed when unfolded. Metal legs were supposed to unfold while using the camper as a bed to handle the load of two persons sleeping on it.

6.1 Company visit - EcoRide

Figure 6.2 Beautiful Gothenburg in the sunshine.

The electric bicycle company EcoRide was contacted and a meeting was held at their office in Gothenburg, seen in Figure 6.1, were the idea of the project was pitched. The response was quite positive, but they did not have the time to sponsor or partner up with the project due to a high workload.

6.2 Chassis

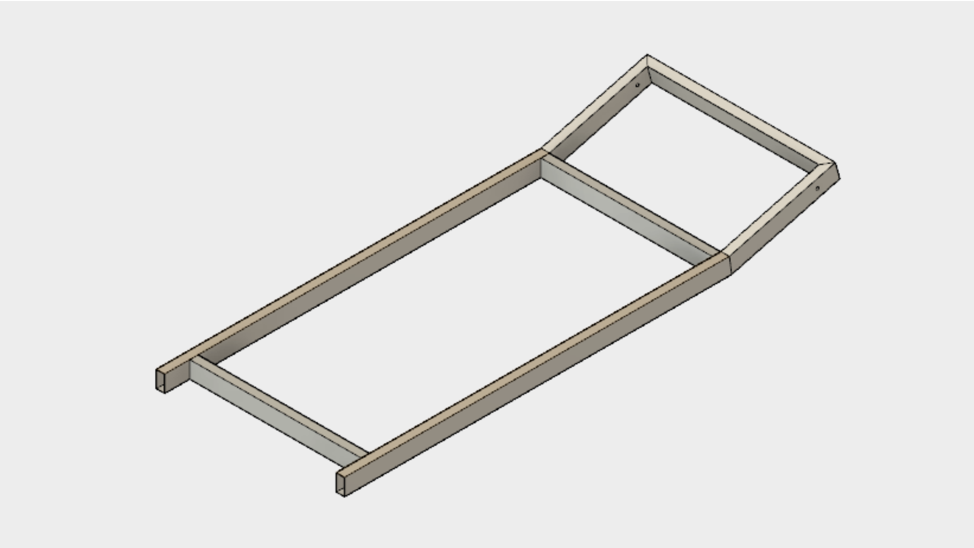

Figure 6.3 Screenshots of the aluminium chassis.

The metal chassis of the trailer was one of the most important components when it came to strength. At the front of the chassis the hitch arm that connected the trailer to the bike was to be fastened and at the back, two wheels were to be located. While sleeping in the trailer, the load of two persons should be handled by the chassis and transmitted to the legs and wheels, fastened in ears bolted to the chassis. The shape of the chassis is shown in Figure 6.2 – 6.3.

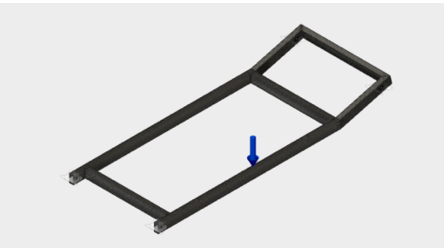

Figure 6.4 The mesh of the aluminium chassis.

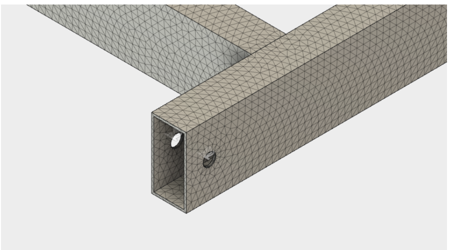

Figure 6.5 The mesh of the aluminium chassis.

To keep the chassis lightweight, aluminium was chosen as a starting point when it came to the choice of material because it has a lower density than steel and if designed correctly was estimated to be able to handle the expected loads (Alfredsson, 2014, 386 and 390). To decide which kind of pipes to use for the chassis, an online catalogue of aluminium pipes from Alumeco was searched.

Several pipes were created in CAD and simulated to find one that was strong enough to work as a chassis and also be lightweight. Using the finite element method-simulation (hereafter referred to as simulation) workspace in the CAD software Autodesk Fusion 360, the parametric CAD model was turned into a mesh. The mesh was refined until a smaller mesh size did no longer affect the result. This mesh size had an average size of 1% of the model size. The mesh is shown in Figure 6.4 – 6.5.

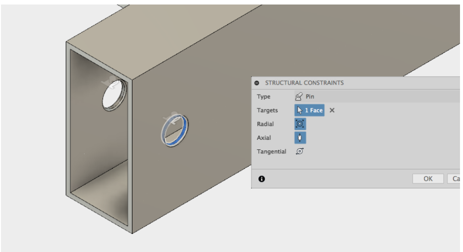

Figure 6.6 Constraints applied to the aluminium chassis.

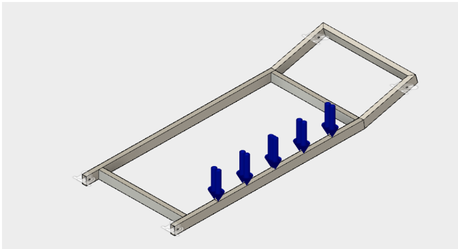

Figure 6.7 Loads applied to the aluminium chassis.

Holes with 10 mm in diameter were made in the end and front of the chassis to simulate places where the wheels and legs of the chassis were to be fastened. Pin constraints were created in the insides of the holes to simulate that only the press and not the pull of the axis affected the chassis. Fillets were made on the edges of the holes to smoothen the contact between the mesh elements in the edges where simulations otherwise might show too high tensions in the material due to problems with the mesh in perpendicular corners. The constraints are shown in Figure 6.6.

A load of 1570 N, shown in Figure 6.7, was applied over a central area of one of the side pipes of the chassis. 1570 N was chosen as a load because it is the approximate force applied by the weight of two persons with an average weight of 80kg sitting on one side of the trailer. The dynamic load of two persons sitting down at the same time would be bigger but it was chosen to simulate for this scenario because while in use the dynamic load would mainly be put onto the unfolded wooden sides of the camper. It was decided to not simulate the wooden parts because of the difficulty in simulating non-metal materials.

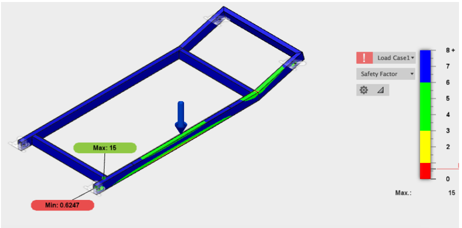

Figure 6.8 Simulation of the aluminium chassis.

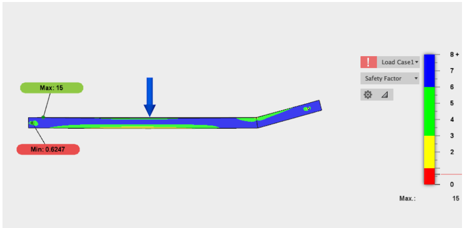

Figure 6.9 Simulation of the aluminium chassis.

It was determined that the chassis could handle the expected load with a safety factor of 2 times the yield point of the material with a chassis made of rectangular pipes of aluminium EN AW-6060 T6 with the dimensions 60x30x2mm (height x width x wall thickness). However, this was only in the straight parts of the chassis, and not in the holes with the pin constrains where the safety factor was simulated to be below 1. The simulations are shown in Figure 6.8 – 6.9.

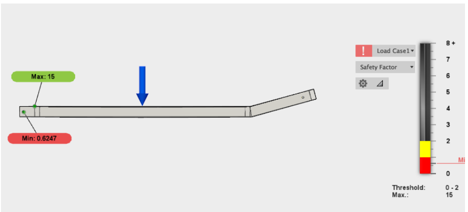

Figure 6.10 Dangerous areas in the simulation of the aluminium chassis.

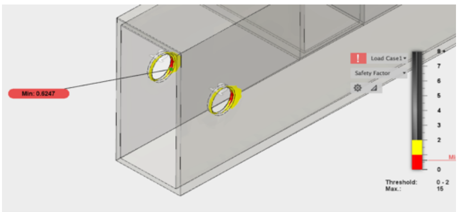

Figure 6.11 Dangerous areas in the simulation of the aluminium chassis.

The simulations returned areas of the chassis which would break by the load applied. These areas were the holes with the pin constraints, and are shown in Figure 6.10 - 6.11. After discussions with colleagues with more experience of simulations, it was decided to still continue developing the chassis with this type of pipe because it was possible to weld circular pipes as reinforcements inside of the holes to increase the strength in these places if needed. A chassis like this would weigh a total of 4841 g.

Figure 6.12 Cutting aluminium pipe.

Figure 6.13 Testing aluminium pipe.

The company Alumeco working with aluminium was contacted and sponsored the project with 6 meters of rectangular pipe, which was picked up at a shipping company in Malmö, seen in Figure 6.12. The pipe was quickly tested by applying a load of a person to observe the deformation, seen in Figure 6.13.

The chassis was calculated to handle the load and fulfil the function of being the foundation of the other parts of the trailer to be fastened on. Although it handled the necessary load, the feeling was that it had gone too fast deciding the design of the chassis. It was an important constructional component of the trailer, but at the same time it was an important aesthetic component. With the chosen rectangular aluminium pipe, it would also need several welding operations to manufacture the chassis. A step back was taken and the chassis was redesigned to make it more simple and smooth. After discussing with the supervisor of the project, Karl-Axel Andersson, it was decided to use a flat oval profile instead of a rectangular one. This would give the prototype a more finished feeling and allow for it to be displayed in more types of professional situations. It was also decided to use a longer pipe and bend it into shape instead of several smaller pipes welded together.

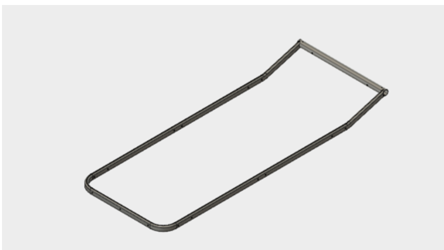

Figure 6.14 Screenshots of steel chassis.

Figure 6.15 Screenshots of steel chassis.

The bent shape is shown in Figure 6.14 – 6.15. However, after further investigation it became prominent that is was not possible to buy a flat oval shaped aluminium pipe in small quantities with the existing budget. These kinds of pipes needed to be imported from abroad which made them very expensive if only purchased for one prototype. An alternative was to use steel pipes with a flat oval profile, because it was easier to find in Sweden and therefore cheaper to buy. However, if the product was to be produced in larger scales it would be preferred to use flat oval aluminium pipes instead due to the material's lower density (Alfredsson, 2014, 386 and 390).

Steel has a higher density than aluminium and is also stronger which meant that the dimensions of the pipe needed to be analysed again. Companies working with selling and bending flat oval steel pipes were contacted and different standard profiles that they sold were simulated in CAD to optimize for strength and lightweight. At the same time discussions were held with companies working with bending metal pipes to understand which bending operations were possible for different dimensions of profiles. As became apparent it was harder to bend a flat oval pipe than a circular pipe.

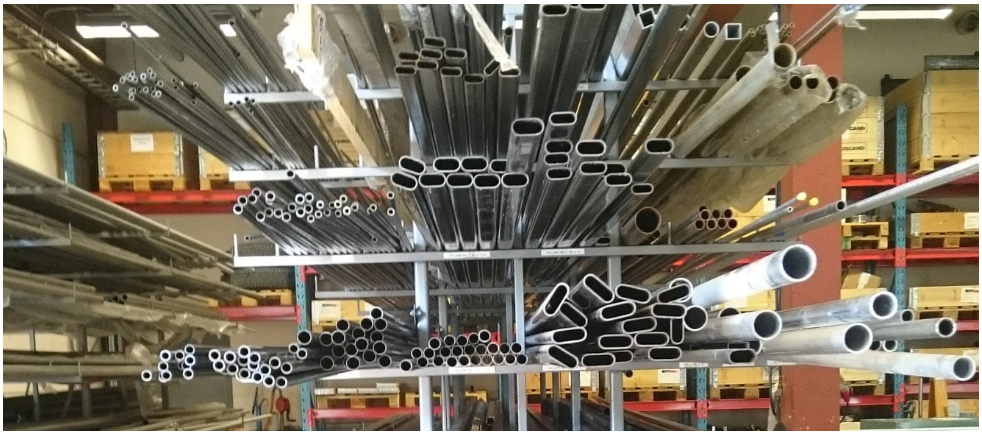

Figure 6.16 Cross sections of different kinds of pipes at BS Rörbockning AB.

Different profiles are shown in Figure 6.16. Finally, the company BS Rörbockning AB in Värnamo offered a flat oval pipe with the dimensions of 40x20x2mm. The pipes also worked with the bending operations that were needed to get the result desired. This meant that the frame could be made of only one long pipe, bent to the desired shape and welded together with a circular pipe with the dimensions of 40x2mm to create a closed cross section when seen from above.

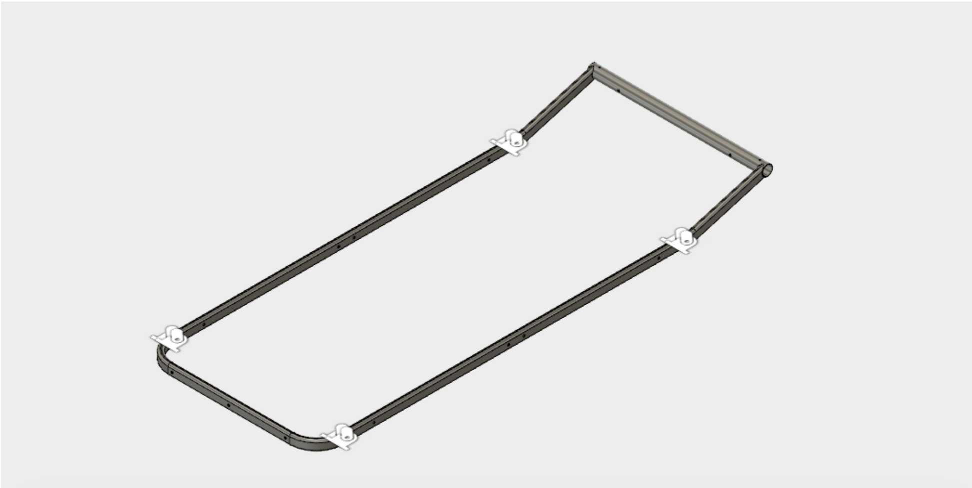

Figure 6.17 Constraints applied to the steel chassis.

For the new chassis to be able to handle the applied load of 1570 N, a second pair of legs was introduced right before the bend leading up to the end of the trailer, where the circular pipe was to be welded. Instead of the wheels taking the load while unfolded this new pair of legs would handle it. This meant that it was closer between the two points of constraints that supported the chassis, seen in Figure 6.17. This led to a smaller deformation in the middle of the pipe on the side of the trailer. This led to less stress in the material and enabled the chassis to be made out of a smaller, more lightweight pipe. It would also save the wheels from breaking if the load would be too big for them while sleeping in the trailer.

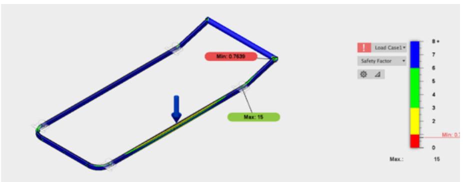

Figure 6.18 Simulation of the steel chassis.

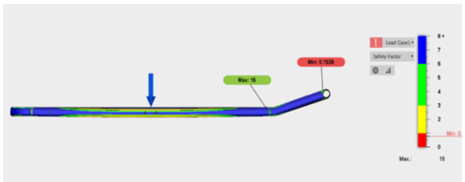

Figure 6.19 Simulation of the steel chassis.

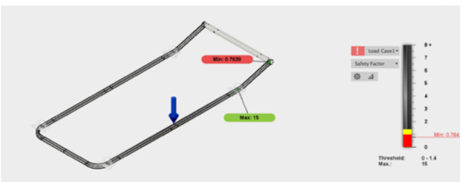

Figure 6.20 Simulation of the steel chassis.

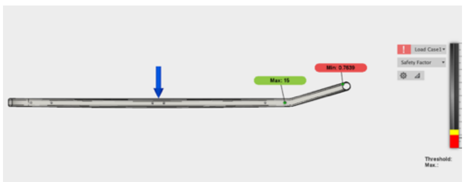

Figure 6.21 Simulation of the steel chassis.

The new chassis was simulated with the same sized mesh, load and constraints settings as the aluminium chassis. It handled the applied load with a safety factor of 1.4 everywhere except in the areas where parts were welded together, which was considered to be good enough even if it was a lower safety factor than for the previous aluminium chassis. The simulations can be seen in Figure 6.18 – 6.21.

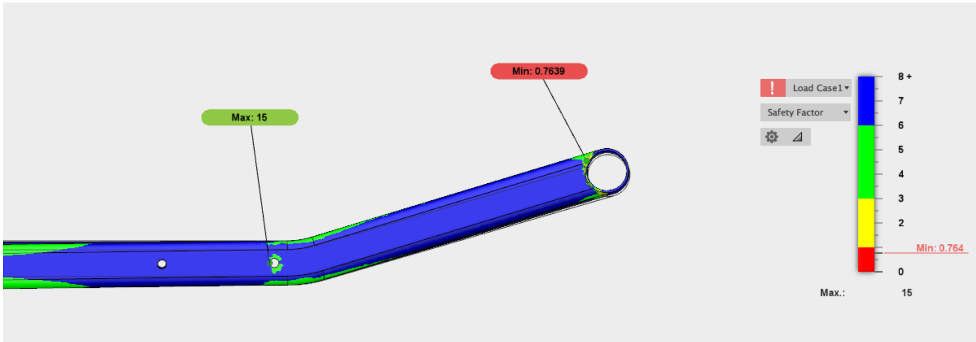

Figure 6.22 Simulation of the steel chassis.

In some parts of the area, where the flat oval pipe was welded onto the circular pipe, high stresses appeared in the simulations that led to the safety factor of these areas to be below 1, seen in Figure 6.22. This was considered to be an error in the simulations due to mesh problems, because no load was applied to the circular pipe and the constraints for the legs at the back of the trailer were located far away from the place of stress. In earlier courses about construction and simulation cases like these had been brought up as situations where the simulation software cannot handle areas of contact between components that overlap, and therefore flag these as problematic parts of the design, even if they in the real world would not have the stresses indicated. Therefore, it was considered to be an error in the simulation and not a real problem in the design.

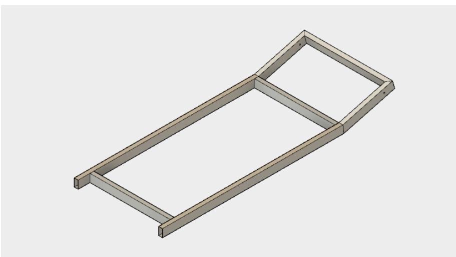

Figure 6.23 The aluminium chassis.

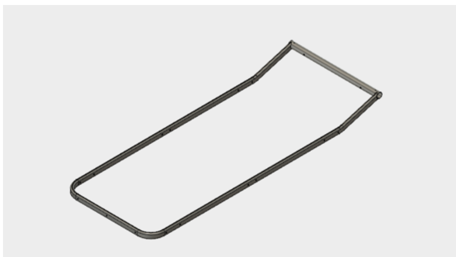

Figure 6.24 The steel chassis.

The total weight of the steel chassis would be 7266 g, which was 2425 g heavier than the aluminium chassis but had a better design when it came to aesthetics and required less welding operations. The steel chassis was also much cheaper, with a cost of 1400 SEK, including the cost of the bending operations, than the cost of a flat oval pipe of aluminium, with a cost of 3600 SEK, excluding the cost of bending operations. The new design of the chassis was therefore considered to be the best alternative available and drawings for the bending operation and a purchase order were sent to BS Rörbockning. The aluminium chassis and steel chassis are shown in Figure 6.23 and 6.24.

Figure 6.25 Visit to BS Rörbockning in Värnamo to pick up the bent steel chassis.

Figure 6.26 The tool used for bending the steel chassis.

Soon thereafter the flat oval steel chassis was picked up in Värnamo where an employee from BS Rörbockning gave a tour of the workshop and explained the bending process. Pictures from the workshop are shown in Figure 6.25 – 6.26.

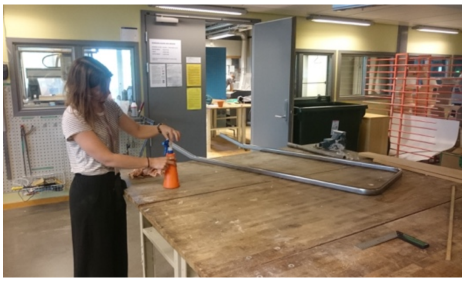

Figure 6.27 Cleaning of chassis.

Figure 6.28 Drilling in chassis.

After cleaning the chassis from lubricants from the bending procedure holes were drilled to fit components screwed to it, shown in Figure 6.27 – 6-28.

Figure 6.29 Welding done by Bert in the IKDC workshop.

Figure 6.30 Welded steel chassis.

A technician in the IKDC workshop helped with welding the bent flat oval steel pipe together with a circular steel pipe, which would act as fastener for the wheels. In the middle of the chassis it was also decided to weld a reinforcement pipe of the same pipe type as the bent pipe. Firstly, metal inert gas (MIG) welding was used to fasten the reinforcement pipe and then tungsten inert gas (TIG) welding was used to get a finer weld. The MIG weld was then grinded down with an angle grinder so that it was levelled with the rest of the chassis. The welding process is shown in Figure 6.29 and the welded steel chassis is shown in Figure 6.30.

It was decided to add a reinforcement in the middle of the chassis because it helped the bent steel pipe to hold its shape better and also to support the floor that was supposed to be fastened on top of it, so that two persons could sit inside the camper while it was set up for camping. It was also concluded that the reinforcement pipe would increase the torsional rigidity while riding the bicycle. A pair of diagonal reinforcements would increase the torsional rigidity even more but it was decided that this would lead to a heavy construction and also be unnecessary. This was because the loads of the chassis would not be that big when the camper is on the move that it needed that kind of extra stability.

6.3 Wheels, wheel axis and axle hub

6.3.1 Company visit - Cargobike

Figure 6.31 Wheels donated by Cargobike in beautiful Malmö.

In the analysis phase of the project it was benchmarked that bicycle trailers used 16" or 20" wheels. In the chosen concept 20" wheels were used to minimize vibrations due to uneven terrain. This was something that had been picked up in the interviews in the Discover phase. The company Cargobike, that had been visited during the early field trips in the project used the same size of wheels on some of their products and their bikes were also built to handle a lot of loaded weight. Therefore, they were contacted with a request to sponsor the project with two wheels, which they gladly did. A picture with one of the wheels outside the Cargobike store is shown in Figure 6.31. The employee at Cargobike that was contacted said that each wheel could handle at least 100 kg.

Figure 6.32 Rendering of wheel.

The wheel was then modelled in CAD so that it could be used when modelling the final concept for prototyping. This is shown in Figure 6.32.

6.3.2 Wheel axis

On cargo bikes, the wheels are fastened with a special kind of fork which increases the width of the bike. To minimize the width of the trailer, a new wheel fastening mechanism was designed. First, the wheel axis from the cargo bike wheels needed to be adjusted to allow for a stub axle fastening.

Figure 6.33 Screenshot of stub axle.

The wheel axis needed a smaller diameter on one side with a slot for a pin that should hold the axis in place, shown in Figure 6.33.

Figure 6.34 The stub axle mounted in the wheel.

The axes were turned to the desired result and mounted into the wheel, seen in Figure 6.34.

6.3.3 Wheel hub

Figure 6.35 Screenshot of axle hub.

To hold the stub axle in place an axle hub was designed in CAD, seen in Figure 6.35. It would act as a bridge between the end pipe of the chassis to the wheel axle, and be fastened in the end pipe with a screw. Inside the axle hub, a spring-loaded metal pin would snap into the slot in the wheel axis when mounting the wheel.

Figure 6.36 One axle hub with handle and screw.

Using manual turning and drilling, two copies of the axle hub were manufactured in aluminium, seen in Figure 6.36.

6.3.4 Wheel pipe

Figure 6.37 Assembly of wheel related components.

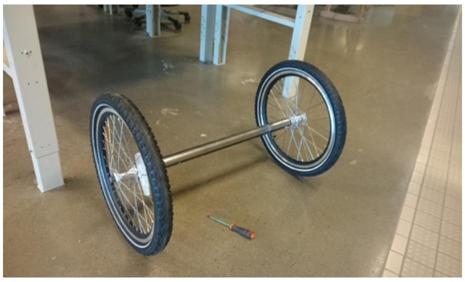

Figure 6.38 Assembly of wheel related components.

A circular pipe was cut and drilled to fit the two axle hubs. The wheel axes were mounted in the wheel hubs and fastened in the axle hubs to see that they fit before welding the wheel pipe to the rest of the steel chassis. The assembly is shown in Figure 6.37 – 6.38.

6.4 Ears, angle brackets, inner legs and hitch arm

6.4.1 Ears

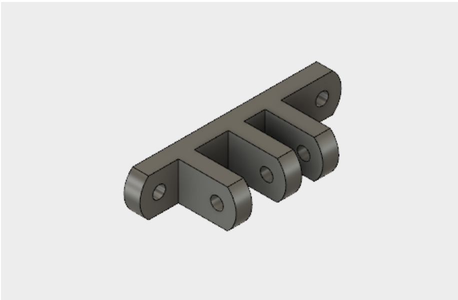

Figure 6.39 Screenshots of side ears.

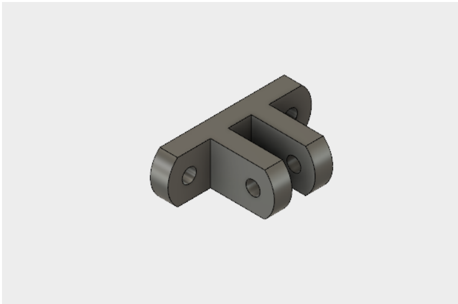

Figure 6.40 Screenshots of middle ears.

To fasten the legs and sides of the trailer to the chassis, ears were designed in CAD, seen in Figure 6.39 – 6.40.

Figure 6.41 Ola milling the ears.

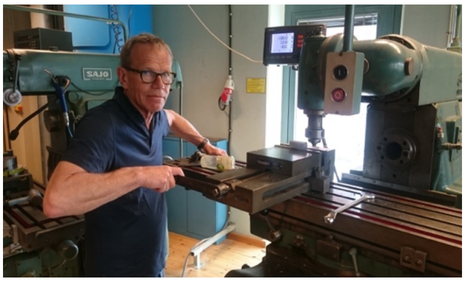

Figure 6.42 Karl-Axel helping out in the making of the ears.

One copy of the bigger ear was created using manual milling and drilling in aluminium, seen in Figure 6.41. Karl-Axel Andersson, helped with setting up a special cutter in the mill to create a big radius on the edges of the ears so that they would not be too sharp and cut the end user, seen in Figure 6.42. At the same time the radius gave the ears a smoother and more finished look. The design was considered to be working and the remaining copies needed were water cut instead of manually milled to save time, seen in Figure 6.43.

Figure 6.43 Water cut ears.

Figure 6.44 Water cut ears assembled to the steel chassis.

After water cutting the ears were manually drilled and milled to get a finer surface. Then they were fastened to the steel chassis to see if the drilled holes fitted, seen in Figure 6.44.

Figure 6.45 The final result of the outer and inner ears.

As a final touch the holes that allowed for screws to connect the ears to the steel chassis were countersunk to hide the screw heads, seen in Figure 6.45.

6.4.2 Angle brackets

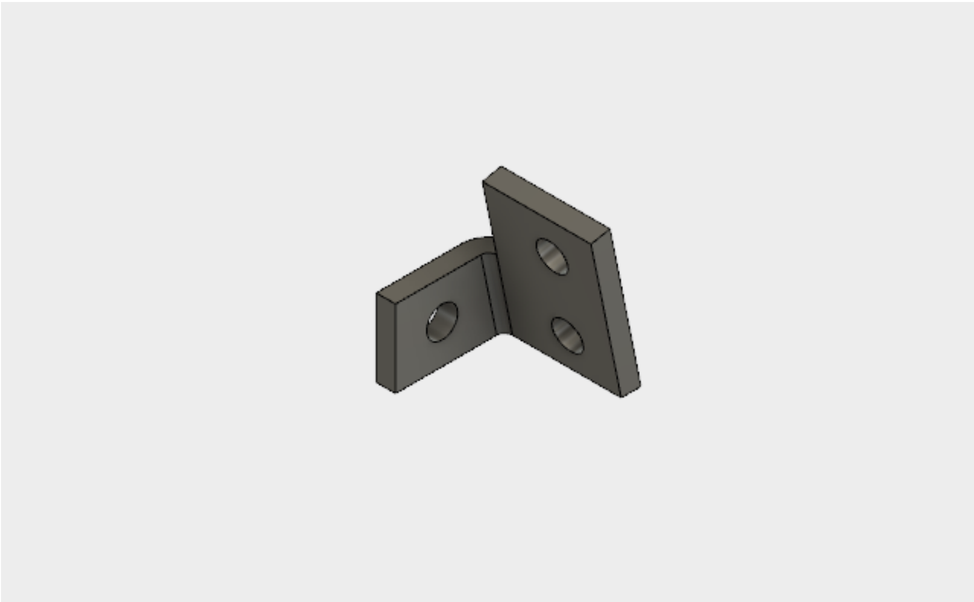

Figure 6.46 Screenshot of angle bracket.

To fasten the wooden planks for the kitchen module to the steel chassis, two angle brackets were needed and made in CAD, seen in Figure 6.46.

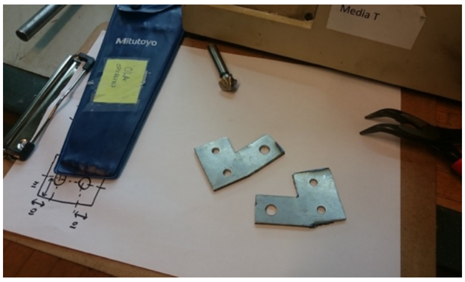

Figure 6.47 Unbent angle brackets.

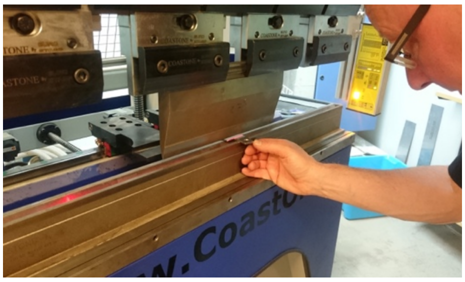

Figure 6.48 Bending angle brackets with Bert at the IKDC workshop.

Using an angle grinder, the angle brackets were cut out of a sheet of steel with a thickness of 3 mm. The brackets where drilled, grinded and bent to the desired shapes, seen in Figure 6.47 – 6.48.

Figure 6.49 Three types of angle brackets after water cutting and bending.

It was concluded that the first type of angle bracket was working when it came to material thickness and size. Therefore, ten more brackets were designed in CAD for the gables and front module of the camper and water cut to save time. Then they were bent to desired shape with the help of a technician in the IKDC workshop. The final result is shown in Figure 6.49.

6.4.3 Legs

Figure 6.50 Sawing the pipe into legs.

Figure 6.51 Assembly of legs.

Metal legs were cut from the same type of pipe as the chassis was made of. This was done to keep the design uniform and also to keep the different types of pipes used to a minimum, which would allow for bigger quantities to be bought of the same kind of components if produced in bigger series, and in that way lower the purchasing cost. The legs were then drilled and milled to get a track which was used to assemble the legs onto the chassis, shown in Figure 6.50 – 6.51.

Figure 6.52 A finished metal leg,

The track allowed for the leg to be pulled out and then folded. When unfolded the leg is locked against the screw through the track and the aluminium ear fastened to the chassis. This makes the leg stay in place even if a heavy load is put onto the steel chassis. This type of built-in safety was important to ensure the safety of the user. The final result of the leg is shown in Figure 6.52.

6.4.4 Hitch arm & Company visit - Thule

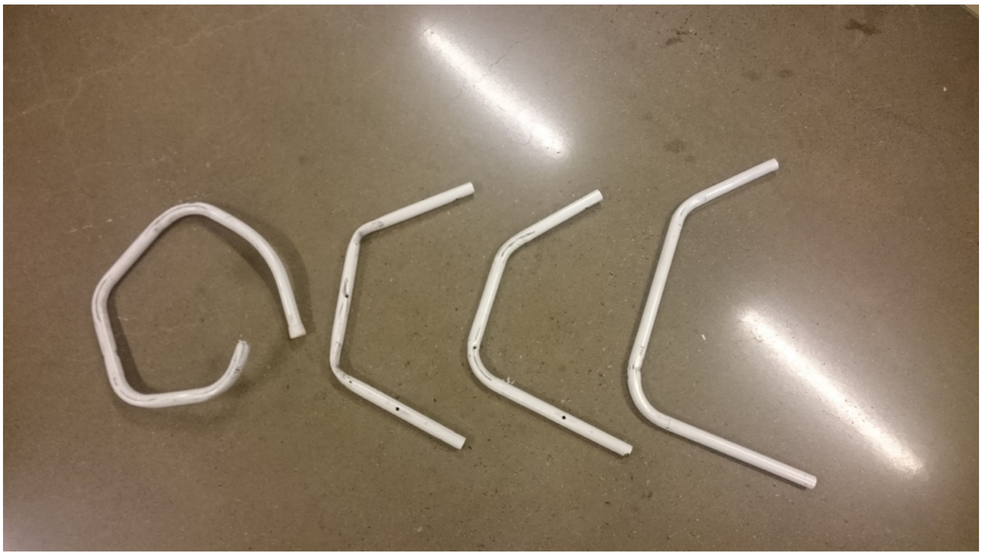

Figure 6.53 Trial and error in bending pipes to use as a hitch arm.

To connect the holiday camper to the bicycle a hitch arm was needed. Inspiration was taken from different bicycle trailers examined in the benchmarking of the Define phase. Most of the trailers had a hitch arm that connected to the left side of the back wheel of the trailer. A sleeve was fastened between the wheel nut and the wheel hub on which the hitch arm connected. Then different kinds of ropes and bands made of plastic or though fabric acted as extra safety and was fastened around the bike’s rear metal pipes if the hitch arm or sleeve would fail during cycling.

Figure 6.54 Components sponsored by Thule mounted in the projects custom made hitch arm.

In the final weeks of the project a meeting was held with Thule in Malmö. Feedback for the project was received and they also sponsored the project with one of their hitch arms that they used for their bicycle trailers. The sleeve and joint that was fastened to their hitch arm was removed and a new pipe was designed to fit their components and the holiday camper, the process seen in Figure 6.53. After several attempts with a pipe bending machine in the workshop at IKDC a geometry that worked well was created and the Thule components were installed, seen in Figure 6.54.

6.5 Sides and outer legs

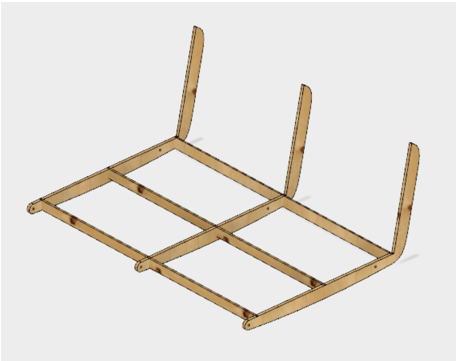

Figure 6.55 Screenshot of sides without floor.

Figure 6.56 Screenshot of sides with floor.

It was decided to use plywood for the wooden parts used in the prototype, seen in Figure 6.55 – 6.56. This was thanks to its physical characteristics and looks. Plywood is a sheet material with characteristics that resembles the solid wood it is made from, but with the fibre directions positioned in perpendicular directions for each sheet, increasing the strength compared to the corresponding solid material (Ceos, 2018). In this project three different types of plywood were considered; birch, pine and poplar. According to a technician in the A-building workshop at LTH, birch is the strongest and heaviest, pine is in the middle, and poplar is the weakest and lightest.

The sides and outer legs of the trailer needed to be lightweight but still stable and able to withstand the forces put upon them. Since wood cannot be simulated in CAD-programs as easily as metals due to its anisotropic structure, the thickness of wood needed for the construction to hold was discussed with the technicians in the A-workshop. It was decided to use pine plywood with a thickness of 12 mm for the skeleton to test and apply a load of a person onto it. The plywood part managed this weight without problems. Pine was chosen for the parts of the sides carrying the heaviest loads, being the parts connected to the ears and legs.

However, pine is quite heavy and therefore a lighter wood was used for the horizontal stabilizing parts. These lighter parts were made of 9 mm poplar plywood. These parts were strong when a force was applied upended, but they could easily bend in the other direction. In order to keep them stable in their unstable direction they needed to be fixated somehow. This could be solved with a thin wooden floor glued to the skeleton side since this would keep the poplar plywood parts in place, and also act as a floor for the user.

Figure 6.57 Screenshots of vertical side part.

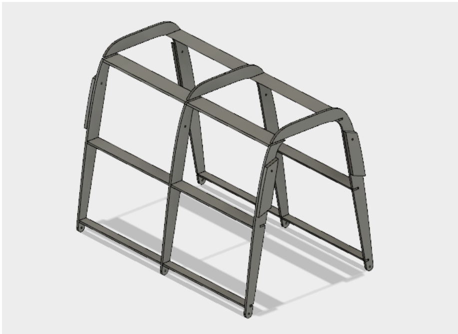

Figure 6.58 Screenshots of sides and legs.

After finding a smooth shape by experimenting in CAD, seen in Figure 6.57 – 6.58, the real pieces were cut out with a band saw and sanded into the desired result. Holes were drilled for the ears and legs.

Figure 6.59 Making of the wooden sides.

Figure 6.60 DOMINO joining method.

The indentions were cut out on the middle vertical part and the horizontal parts. A method called DOMINO joining by the company Festool, seen in Figure 6.60, was used to mount the outer vertical parts to avoid making the attachment visible from the outside. A skeleton for one of the wooden sides can be seen in Figure 6.59.

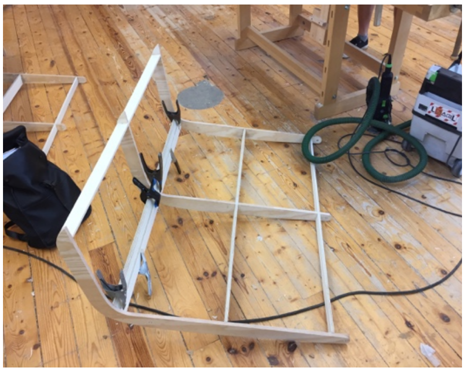

Figure 6.61 Wooden strip glued to the top of the side.

Figure 6.62 Floor glued to the sides.

When both sides were assembled, wooden strips were glued to the top of the sides to be able to glue a 4 mm wooden floor onto the two sides, seen in Figure 6.61-6.62.

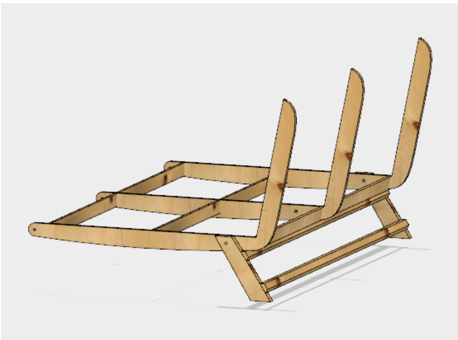

Figure 6.63 Screenshot of wooden sides with outer legs.

Figure 6.64 Outer legs with connecting strips.

When designing the legs, inspiration was taken from wooden sun chairs, where a wooden strip connects two legs and stops the legs from rotating too far when unfolded. Two of these strips were attached; one for stopping the rotation and one to use as a handle when opening the sides, seen in Figure 6.63. The legs were made in 20 mm thick pine plywood to ensure stability. Since the connecting strips were thin and still had to be stable, birch plywood, which is even stronger than pine, was used. The connecting strips were attached to the legs with glue and dowels, and aluminium bushings were placed in the holes to increase the strength and avoid splintering, seen in Figure 6.64.

6.6 Gables, front and kitchen

6.6.1 Gables

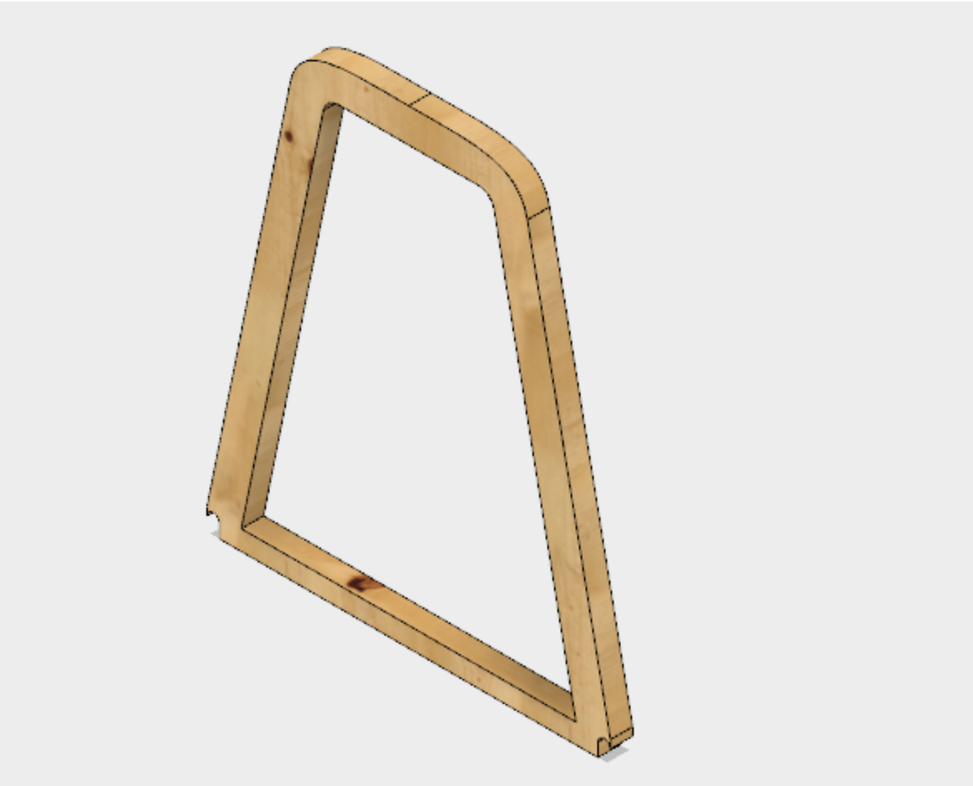

Figure 6.65 Screenshot of gable.

The gables situated in the front and back of the steel chassis were made in the same shape as the inside of the sides while in closed position. A small play to fit a band of rubber along the edges of the gable was left to avoid wood against wood contact and make the closing of the sides as smooth as possible. The initial design did not include the horizontal bottom part, but after realizing that the gables could be a good place to attach the floor of the middle part of the camper the horizontal section was added, seen in Figure 6.65. This also increased the stability of the gables by making them a closed cross section. When choosing the material of the gables two things were taken into consideration; weight and stability. The gables do not need to withstand large amounts of weight, but they have to manage the arc holding up the tent and the vibrations caused by towing the camper over uneven terrain.

Figure 6.66 The gluing of gables.

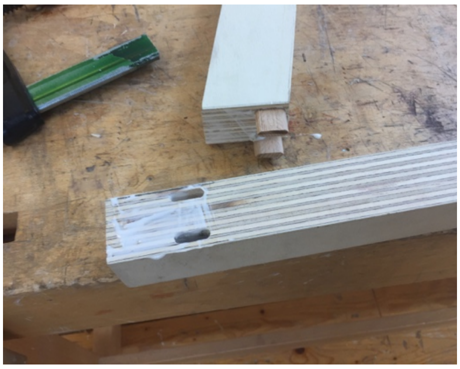

Figure 6.67 DOMINO joining of the bottom parts of the gables.

The gables were only connected to the chassis in their bottom parts, and therefore they needed to be quite thick to avoid bending while raising the arm to hold the tent. To minimize the weight poplar plywood was once again used. When discussing with the employees in the wooden workshop, the thickness needed was concluded to be 40 mm. Plywood with this thickness was both expensive and hard to find so instead four sheets of 9 mm plywood, amounting to a thickness of 36 mm, was glued together after sawing the shape of the gables, seen in Figure 6.66. The bottom parts of the gables were sawed separately and attached with DOMINO joining, seen in Figure 6.67. The final result of the gables are shown in Figure 6.68.

Figure 6.68 Final result of the gables.

In order to enable the gables to rest on the steel chassis the corners of the gables were sawn out when the glue had dried and finally the holes for the brackets were drilled.

6.6.2 Front and kitchen

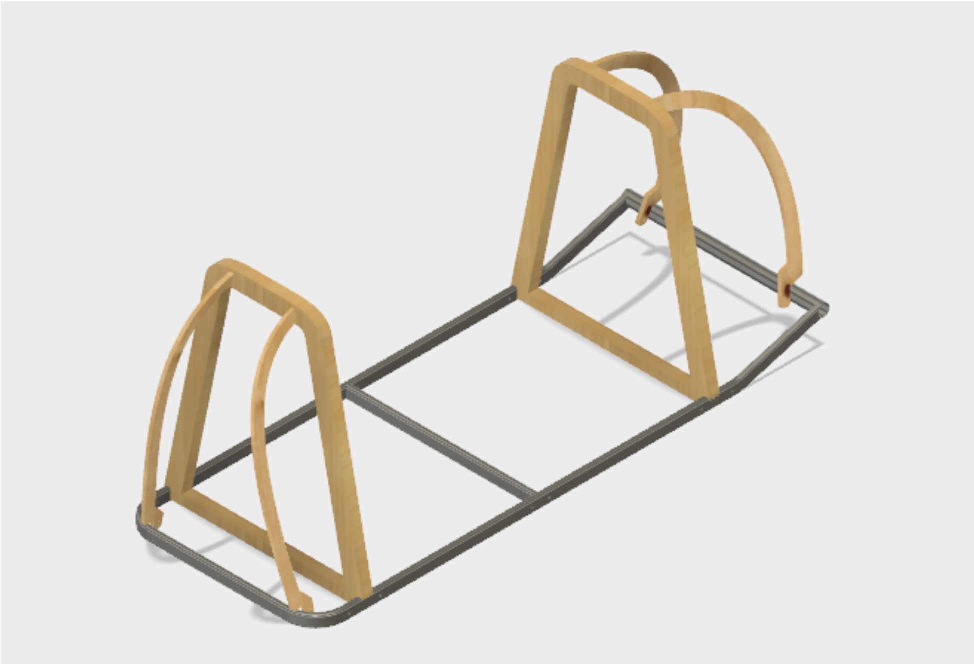

Figure 6.69 Screenshot of front and kitchen mounted on steel chassis with the gables.

The front and kitchen of the camper were designed to give a smooth transition from the sides to the steel chassis, seen in Figure 6.69. They were decided to be attached with brackets on the steel chassis and the gables. The small crutches on the bottom of both the front and the kitchen enabled them to rest on the steel chassis and prevented them from sliding down whilst in movement.

Figure 6.70 9 mm poplar plywood to use as the front and the kitchen.

The front and kitchen were made in 9 mm poplar plywood to minimize the weight. They were sawn in the same manner as the gables and afterwards they were sanded to the desired shape. Holes for the brackets were drilled after assembling the gables onto the chassis in order to match the angle of the gables. The result is shown in Figure 6.70.

6.7 Exterior

The exterior of the camper was chosen to be in fabric since it was sought after to have a natural and relatable look, and because fabric complements wood and steel in a good way. When looking back at the construction of wooden airplanes it was discovered that they are using fabric as an exterior in many cases (Federal Aviation Administration, 2012, 2-24). Inspiration was also taken from boat covers and sails, both with connotations to nature and freedom.

Figure 6.71 Choice of fabric.

When it came to choosing fabric the most important function was water resistance. Fabric used for outside blinds and for outdoor furniture were investigated, but both of these were considered to be too stiff. To enhance the shape of the wooden skeleton something thinner and more stretchable was needed. When talking with a employee at Ohlssons tyger in Helsingborg a fabric used for raincoats was recommended, seen in Figure 6.71. This fabric was thin, stretchy and water proof. The only downside was that it did not breath. However, since no person will be inside the camper when it was closed it was not a major issue. When choosing the colour of the fabric, inspiration was again taken from cowboy chuckwagons. Their main components were steel, wood and a white canvas, which had been inspirations throughout the whole final prototyping. The downside with white is that it easily gets dirty, but since the chosen fabric was raincoat fabric, it would be easy to wash by simply cleaning it with water.

Figure 6.72 Elastic bands and wooden balls laced through eyelets in the fabric.

Figure 6.73 Attachment of fabric onto the wooden skeleton.

After cutting the purchased fabric to the right shapes a welt had to be made to get a fine edge and avoid ripping. This was made by folding the edges and attaching them with textile glue instead of sewing. This was done to avoid sewing holes in the fabric which could allow leakage. The next step was to attach the fabric onto the wooden skeleton. To be able to see the wood and steel of the structure, elastic band loops with small wooden balls were used, seen in Figure 6.72. The loops were laced through eyelets in the fabric and holes in the wood attaching the fabric by letting the loop hug the wooden ball. The attachment of the fabric is shown in Figure 6.73.

6.8 Tent and arc

Figure 6.74 The tent canvas sponsored by Tältcentralen.

The tent and arc of the camper could not be finalized within the time frame of the project. It was chosen to focus on the outer shell of the camper instead to be able to test the weight, size, and the ability to lie in the camper when it was unfolded. However, Tältcentralen, in Stockholm, sponsored the project with 6 m red tent canvas that could be used to finalize the prototype outside the scope of the project, seen in Figure 6.74. The colour red fit well with the inspiration found in the Define phase. When set up for camping, the holiday camper would have a bright coloured red tent unfolded just like many tents for hiking are brightly coloured.

6.9 Name and logo

Figure 6.78 The logo of the holiday camper Kamrat.

During the project the five key words; Freedom, Safety, Comfort, Affordability and Social, was considered a lot and it was concluded that this should be kept in mind while deciding the name for the final product. The final result was also supposed to connect to the trend soft adventure as it was decided as a starting point for the project.

It became apparent during the development of the final concept that the product kept coming back to being a perfect product for a pair of users. The bed area was big enough for two persons and the storage compartments could fit luggage for two. When unfolding the camper, it was also easier to do so if two users could help each other. While on the road with an electric bicycle it could become a problem with a connected trailer if the bicycle battery died. Then the heavier weight of the electric bicycle compared to a normal one, summarized with the weight of the trailer, would lead to a hard time cycling uphill. If being a duo on the trip, when one battery died the other person could hitch the holiday camper to his or her e-bike instead and continue the journey. In that way the group could travel further each day.

A Swedish word for friend, kompis, was considered as a name as it felt right with the desired connotations and as the product would work best when used with a friend. The holiday camper could also be seen as friend itself that you could bring along on your holiday. A synonym to kompis, kamrat, felt even better as it was a word that was considered to be more bold and hard and therefore more serious and safe than the word kompis that was considered to be a little childish. Therefore, the final product was named Kamrat.

To attach the name to the desired feeling of the product inspired from the Define phase and give it a soft and adventurous vibe, a font called *Brännboll* (created by Måns Grebäck, https://www.mansgreback.com/) was used to create a logo with a smooth handwriting-style to it.

7 Result

Figure 7.1 The final result of the prototype and the team.

7.1 Cycling

Figure 7.2 The holiday camper being tested.

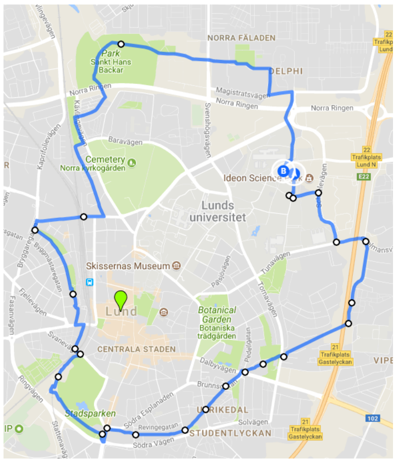

Figure 7.3 Screenshot of map from Google Maps showing the tested route around Lund.

The holiday camper was taken on an 11 km route around Lund to see how it behaved on the road, a picture of the camper on the road and a map of the route can be seen in Figure 7.2 – 7.3. Even if the camper was supposed to be towed by an electric bicycle it was tested with a normal bike to test how it worked without the electric assist. Safety was considered by keeping to bicycle roads and cycling with reduced speed. An extra cyclist was brought along to monitor the traffic around the camper. Many stops were made to inspect if any components had deformed. Along the route it was tested to cycle on different kinds of terrain such as asphalt, gravel and cobblestone. It was also tested how the camper behaved when cycling uphill and downhill.

7.2 Opening

A stop was made at Stadsparken in Lund where the user scenario of opening the camper was carried out and documented. This is shown in Figure 7.3 – 7.10.

Figure 7.3 Camper parked.

Figure 7.4 Steel legs unfolded.

Figure 7.5 Hitch arm released from the bicycle.

Figure 7.6 Side buckles opened.

Figure 7.7 Outer legs grabbed as handles.

Figure 7.8 Sides unfolded into a resting position.

Figure 7.9 Shoes taken off.

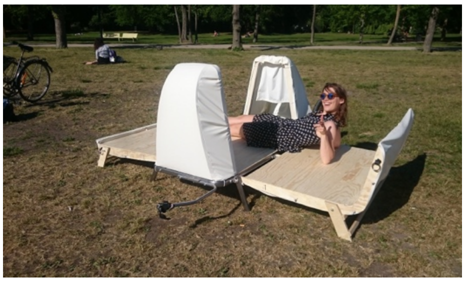

Figure 7.10 Beata chilled out in the camper.

7.3 Details

Details of the final prototype are shown in Figure 7.11 – 7.15.

Figure 7.11 The holiday camper seen in perspective.

Figure 7.12 The outer legs also acting as handles to open the camper.

Figure 7.13 Two rings locking the sides together during cycling.

Figure 7.14 Front right corner of the camper.

Figure 7.15 Right wheel of the camper.

7.4 Tent

In the final stages of the project, time was found to add a tent to the camper. The unfolding procedure was repeated, but with the tent to illustrate the sleeping area.

Figure 7.16 Side buckles opened.

Figure 7.17 Outer legs grabbed as handles.

Figure 7.18 First side unfolded.

Figure 7.19 Arc is rotated.

Figure 7.20 Arc rests in upright position.

Figure 7.21 Second side unfolded.

Figure 7.22 Camper with tent unfolded seen in perspective.

Figure 7.23 Camper with tent unfolded seen in from behind.

Figure 7.24 Camper with tent unfolded seen in from the inside.

Figure 7.25 Ola trying out the bed.

Figure 7.26 Outside fabric overlapping the tent canvas.

Figure 7.27 Unfolded camper seen from behind.

7.5 Evaluation

While cycling, the camper handled both asphalt and gravel roads well but did not manage the hard and uneven surface of cobblestone so good. That surface led to vibrations leading to shaking of the sides against the gables which in turn led to an annoying rattling sound. This problem could be helped in the future by fastening soft materials like rubber or fabric between wooden components that are in contact with each other while on the road, like the sides and the gables. Another alternative could be to add a spring system suspension mechanism to the wheels that would allow for the vibrations to not affect the wooden structure as much.

The width of the holiday camper led to the test user needing to adapt its cycling pattern to not cycle too far to the right of the bicycle lane. If the user would forget about towing the camper and go too far to the right, it could be dangerous for pedestrians walking on the same side and also for the user if the camper was to hit a lamp post or something else standing close to the bicycle lane. It was concluded that the importance of adapting cycling pattern when towing the camper was something that should be stressed for new users.

Another thing affecting the cycling was turning. The user towing the holiday camper could make full turns to the left but not to the right because of the hitch arm connecting the camper to the left side of the back wheel of the bike. Therefore, sharp right turns were hard to make and this was something that the user needed to have in mind especially when cycling in the city where the bicycle lanes in some places were pretty small.

When entering the unfolded camper to rest, the user had to be careful due to the fragile wooden floor in the middle of the camper. The floor could not handle too much force on a small area so the user had to crawl inside the camper to minimize the pressure. However, when lying down the floor did not pose a problem. This problem could be solved in the future by adding a supporting structure of underneath the middle floor.

The cycling test was all in all considered satisfying, especially as that it was tested with a normal bicycle and not an electric bike and that it still was possible to cycle uphill without too much effort. The usage scenario of unfolding the camper for sleeping was also considered to be working well. During the test ride a person who had not seen the holiday camper before was asked to try to park and open the camper. Except of a little help from the team the person handled to unfold the camper easily himself.

8 Discussion and conclusion

8.1 Design process

During the project, the Double Diamond design process was used to divide the project into broad phases. This was rewarding by giving freedom to experiment within each phase without focusing too much on quickly arriving at the final result. By doing so, time was given to dig into each phase without rushing to the next one. Time was taken to explore many different concepts before heading to a decision.

The Development phase included many models and iterations. This was a very hands-on way of working that gave quick results. With each new concept, the models were used to evaluate if the current idea was user friendly and if the user would understand and feel comfortable with using the product. By building physical models, shape and function were easier and quicker to understand and discuss than if it would have been modelled entirely in CAD. It was also rewarding to work in two different scales. The scale 1:5 was good for modelling quick concepts without taking too much time and the scale 1:1 models were a good way of understanding the real size.

When it came to details CAD was a helpful tool to discover problems in the design before manufacturing. There were many details in the final concept and without CAD it would have been hard to organize joints and components into a final design, with everything working the way it should. It was also realized during the project that the smallest detail can take a long time to manufacture by hand and hence, the importance of simple solutions and accurate CAD design became even more prominent. However, if a product is to be manufactured in a larger scale a more complicated design could also be more efficient.

Another insight during the project was that it is not always as easy as one might think to get hold of desired components. If it is not a standard component it could be hard to buy small quantities and the delivery times can be long. It was valuable to get experience from reality by contacting real businesses to order components and operations. This was also one of the goals of the project; to initiate contact with companies in the industry.

One thing that could have been done differently during the design process is to include more end-users during the testing of the models and prototype. This would have given a more accurate evaluation and things that the designers did not see as problems might have come to light. Unfortunately, this was not done due to time limitations. If further developed, the prototype should be tested by real users in a real user scenario.

8.2 Time management

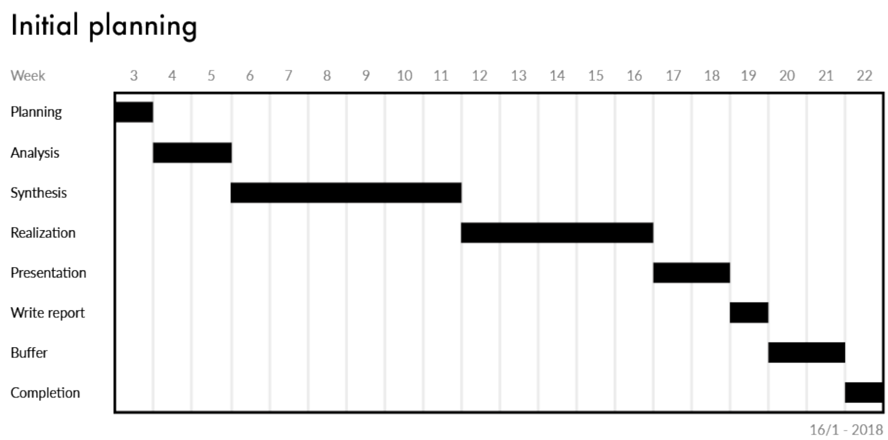

Figure 8.1 Early schedule for the whole master thesis.

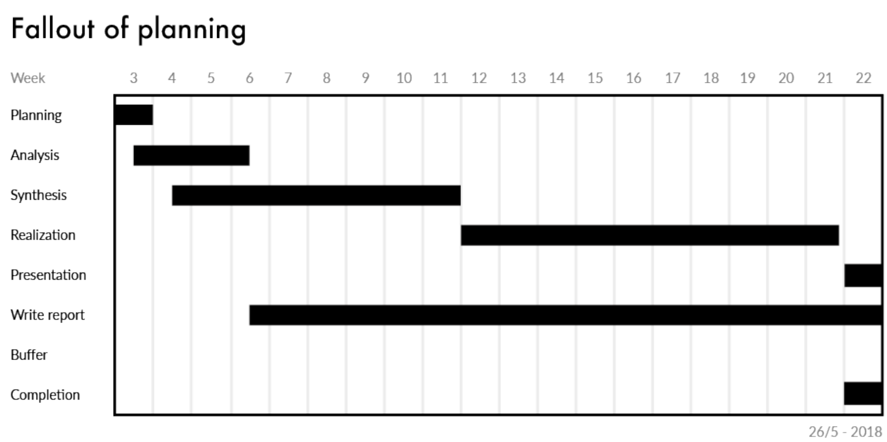

Figure 8.2 Fallout of planning.

The initial time plan made in the beginning of the project matched the reality quite well up until the Deliver phase. The initial plan is shown in Figure 8.1. This phase took longer than expected, but luckily some buffer weeks had been planned for. This was mainly because the final prototype became more detailed than first expected and because it was harder than expected to find the right pipes for the chassis and someone who could bend them to desired shape. This made it hard to include all the different parts in the final prototype, so it was chosen to focus on the most important ones to be able to test them. The internal deadlines could have been stricter, but then the final result would have been different since some phases took longer than expected.

Something that could have been made differently was to start designing details in CAD later in the process. Some details were designed in CAD before the final shape and concept was decided, which resulted in a lot of redesigning being needed for many components, which was time consuming. On the other hand, CAD helped to kill some ideas that would not have worked in reality due to weight and function, which also was time saving. That was something that would have been hard to realize by only doing cardboard models and sketches.

8.3 Product

The chosen concept is an exciting product that encourage people to holiday with their bicycles. It is a product appealing to a rather unexplored market which is inspiring, but also poses a big challenge. It could be hard to successfully launch a product on an unexplored market since the customers might not yet be ready to try this concept. However, after interviews with potential users and different field trips, it has been identified that there is a desire on the market for more opportunities to have soft adventures, which this product is offering.

The product was tested by cycling, opening and laying on the product. These actions are the basic actions that the product should handle. However, due to time limitations the camper was not tested in a real camping situation. The prototype was only tested by the project members and future tests would be carried out on potential customers and users.

The product fulfils a majority of the functions in the functional analysis and has the possibility to fulfil the functions missing if further developed. To make the camper lighter, some materials could be changed when produced in a larger scale. For example, the steel chassis could be changed to an aluminium chassis and the wooden parts could be changed to a lighter and stronger composite. Another thing to develop further is to make the trailer modular, enabling the user to use the camper as a cargo trailer when not on vacation.

After the project the product will hopefully be displayed on fairs to gain attention and create an interest in the product to get funding to develop it further. This will be possible because a lot of attention has been put on the details of making the final prototype look good.

8.4 Further work.

Even though the prototype is working, there are many things that need to be further developed before put into production. Below is a list of things that need to be done.

- Investigate the regulations and rules for CE marking to ensure that the final product follows the directives and laws for products sold in the European Union.
- Ensure that it the unfolded tent is water proof by adding weather strips to the gables.
- Add burdocks or zippers to the tent to enable closing.
- Add floors and nets as walls to the luggage areas to prevent the luggage to fall out of the camper or into the sleeping area.
- Add a mattress to the bed.
- Add mudguards to the wheels.
- Add lights and glares to the camper according to laws and regulations.
- User tests with real end-users to ensure that the product is user friendly and understandable.
- Further FEM simulations to ensure that the construction will not break. This would include looking further into dynamic loads, since the simulations done in this project only has taken static loads into consideration.
- A further material study. As mentioned earlier, many materials in the final prototype could be changed to more lightweight and strong materials. For example, the steel chassis could be changed to a aluminium chassis, and the wooden floor on the sides of the camper could be changed to a honeycomb composite to ensure stability.
- A spring suspension system could be added to the camper to enable it to work on bumpy roads.
- Different braking systems should be investigated. Since the final product is heavy, it could ensure the security of the user to have an inertia braking system.

8.5 Alternative usage

During the project it was discussed if parts of the final design could have alternative areas of use as well.

Figure 8.3 Rendering of stripped down chassis.

The chassis shown in Figure 8.3 is stripped of the wooden and metal components used to fulfill the functions for camping. What was left could be seen as the backbone of the design and it was concluded that this frame could be used in more ways.

Figure 8.4 Rendering of a cargo version of the trailer.

One area of use could be to transport cargo that does not fit onto the luggage rack or in baskets fastened on the bicycle. As shown in Figure 8.4 a floor and a railing is fastened to the stripped down chassis creating a bed for luggage to be strapped down. The transport of bulky cargo was considered to be one important reason to why people use cars instead of bicycles, even for shorter trips. If loaded with too much weight the trailer could pose a danger to the cyclists while breaking or in sharp turns. To address that danger it would be needed to further investigate how to attach a brake system to the trailer so that it breaks itself when the cyclist tries to stop his bicycle. It would also be interesting to investigate if it would be possible to make the trailer modular so that it could be used as a camper in summer and for cargo transportation during the rest of the year.

8.6 Conclusion

The final product was considered to fulfil the goal of connecting the trend of soft adventure with the concurrent bike boom of electric bicycles. In that way it could encourage more people to take their bicycle on vacation and hopefully act as an environmentally friendly holiday alternative.

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Appendix A Functional Analysis

Functional Analysis - 180207

(MF / N / D = Main function / Necessary / Desirable)

Verb	Noun	Comment	MF / N / D
Simplify	Vacation	On a bicycle	MF
Offer	Berth	For two people, above ground	N
Minimize	Volume	While cycling	D
Offer	Seating area	Table/chairs/sofa	D
Offer	Comfortability	While unfolded	D
Enable	Attachment	To bike	N
Breath	Simplicity		D
Simplify	Experience	Of nature	D
Minimize	Impact	On the environment	D
Maximize	Safety	In traffic	N
Maximize	Aerodynamics	While biking	D
Resist	Wind	While unfolded	N
Prevent	Leakage	Of water	N
Minimize	Weight	Maximum of 20kg	N
Offer	Adaptability	Foldable roof if it is sunny	D
Protect	Kitchen		D
Offer	Trunk	For luggage	N
Avoid	Puncture	Of tires	N
Minimize	Strain	On user while cycling	D
Simplify	Packing	Of luggage	N
Prevent	Imbalance	While cycling	N
Offer	Softness	In sleeping pad	D

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Shorten	Takeoff	When it comes to folding the product	D
Prevent	Intrusion	Off animals while unfolded	D
Handle	Terrain	While cycling and unfolding	D
Offer	Insulation	Against cold	N
Store	Water		D
Avoid	Pool	Of water under the sleeping pad	N
Prevent	Burglary		D
Encourage	Usage	Simplify spontaneous usage	D
Adapt	Inclination	To keep the head high during sleep	N
Minimize	Shaking	Regarding wheels, tires, construction	N
Enable	Lifting	Over rough parts of road	D
Maximize	Headroom	Inside of unfolded product	D
Prevent	Accident	Avoid loose parts getting into wheels	N
Simplify	Transport	Through post or as luggage	D
Prevent	Theft	Of the product	D
Lower	Cost	For the end consumer	D

Appendix B Work Distribution

The work distribution among the team members has overall been equally distributed with exception for when building the final prototype where Ola had the main responsibility for the metal parts and Beata had the main responsibility for the wooden parts.