Degree thesis

Innovation Engineering Program 180 hp

E-Scooter car carrier concept

-Bring your E-scooter

Product development and Innovation management 22,5 hp

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Calle Clenow

HÖGSKOLAN
I HALMSTAD

Abstract

In the urban adventure the electric scooter is often the most available and convenient transportation in the cities, while also supporting city environmentally friendly transportation. Electric scooters are a big part of the so-called micromobility in big cities. This is showcased in many American and European cities but also in Stockholm were there are 5 operating companies like Voi, Lime and Tier to name a few. Voi has around 25 000 electric scooters in Scandinavia and 4 million daily users in Europe (2020). In the American market there was over 85 million trips made in 2019.

This trend has made many people realize the benefits of owning their own electric scooter as a fast short-distance transportation without breaking a sweat. Making companies like Mercedes, Seat and Segway to name a few, create their own electric scooter.

There is today no good way to transport electric scooters, even though most of them are collapsible. This is due to their unusual shape that makes them hard to properly pack.

The goal of this project is to create a solution for carrying electric scooters that fits onto Thule´s bike carrier. This to enable easy transportation of multiple electric scooters while also freeing-up space inside the car.

The project has resulted in a product with a strong market that the company Thule will have the opportunity to continue working with.

Sammanfattning

I dagens stadsäventyr är den elektriska skoter ofta den mest tillgängliga och bekväma transporten i städerna, samtidigt som den stöder stadens miljövänliga transporter. Elektriska skotrar är en stor del av den så kallade mikromobiliteten i städerna. Detta visas i många amerikanska och europeiska städer men också i Stockholm där det finns fem operativa företag som Voi, Lime och Tier för att nämna några. Voi har cirka 25 000 elektriska skotrar i Skandinavien och 4 miljoner dagliga användare i Europa (2020). På den amerikanska marknaden gjordes över 85 miljoner resor 2019.

Denna trend har gjort att många människor inser fördelarna med att äga sin egen elektriska skoter som en snabb transport på korta sträckor utan att svettas. Detta får företag som Mercedes, Seat och Segway för att nämna några att skapa sina egna elektriska skotrar.

Det finns idag inget bra sätt att transportera elektriska skotrar, även om de flesta är hopfällbara. Detta beror på deras ovanliga form som gör dem svåra att packa säkert.

Målet med detta projekt är att skapa en lösning för att bära de elektriska skotrar som passar på Thules cykelhållare. Detta för att möjliggöra enkel och säker transport av flera elektriska skotrar samtidigt som det frigöra utrymme inne i bilen.

Projektet har resulterat i en produkt med en stark möjlighet som företaget Thule kommer att fortsätta arbeta med.

Preface

This examination project was completed during the autumn of 2020 to spring of 2021 as the final part on the Innovation Engineering program at Halmstad University. It has been within product development and innovation management.

The project have been accomplished by Calle Clenow who has a great interest in development and innovation. During this process I gained new technical knowledge and gained a deeper understanding of the development process.

The project result is something I am very proud of, mainly because of the great opportunity it has as a product and the future of it.

I want to direct great thanks to:

- Magnus Ferman, Senior Technical Advisor at Thule
- Jeanette Gullbrand, Supervisor at Halmstad University
- Leif Nordin, Examniator at Halmstad University
- My classmates at Innovation engineering 2018-2021, looking forward to see you in the future.

And lastly to my family, without them this would had been a lot harder.

Table of content

Abstract 1

Sammanfattning 2

Preface 3

1. Introduction 7

1.1 Background 7

1.2 Complications 7

1.3 Problem formulation 8

1.4 Goal and Purpose 8

1.5 Restrictions 8

2. Frame of reference 9

2.1 Theory 9

2.1.1 Motorized Scooter 9

2.1.2 Trending 9

2.1.3 Forecast 10

2.2 Project model 10

2.2.1 Stanford Design Thinking 10

2.2.2 Agile workflow 12

2.3 Creative methods 12

2.3.1 Data Collection 12

2.3.2 Requirement specification 12

2.3.3 Brainstorming 12

2.3.4 SWOT analysis 12

2.3.5 Breakdown Structure 13

2.3.6 Prototype construction 13

2.3.8 Business Canvas Model 14

3. Method 14

3.1 Data collection 14

3.2 Requirement specification 14

3.3 Planning 14

3.4 Brainstorming 14

3.5 Sketch 15

3.6 WBS 15

3.7 SWOT-analysis 15

3.8 Prototype construction 15

3.9 Business canvas model 15
4. Development process 16
4.1 Empathize 16
4.2 Define 16
4.3 Ideate 1.0 17
4.4 Prototype V.1 17
4.5 Test 1.0 18
4.6 Ideate 2.0 18
4.7 Prototype V2 18
4.8 Test 2.0 19
4.9 Ideate 3.0 19
4.10 Prototype V3 19
4.11 Test 3.0 19
5. Product 20
5.1 Product description 20
6. Process of product 21
6.1 Material order and production 21
6.2 Competence analysis 21
7. Business system 21
7.1 Business Canvas model 21
7.2 Intended market 22
7.3 Economy plan 22
7.4 Market plan 22
7.4.1 Value offer 22
7.4.2 Distribution 23
8. Discussion 23
8.1 Product discussion 23
8.2 Project discussion 23
9. Sustainable development 25
9.1 Sustainable development 25
9.2 Work environment 25
9.3 Ethics and morals 25
References and appendices 26
Appendix 1, Preliminary research 29
Appendix 2, Work breakdown structure 30

Appendix 3, Swot-analysis Product 31
Appendix 4, Swot-analysis Project 32
Appendix 5, Picture on PV3 33
Appendix 6, Product breakdown structure 34
Appendix 7, PV3 35
Appendix 8, C-Claw 36
Appendix 9, Connector 37
Appendix 10, pipe attachment 38
Appendix 11, Lower attachment 39
Appendix 12, puck 40
Appendix 13, Pipe 41
Appendix 14, Screw 42
Appendix 15, Upper attachment 43
Appendix 16, Lower attachment 44
Appendix 17, Avtal Företag 45
Appendix 18, Project description 46

1. Introduction

1.1 Background

In the urban adventure the electric scooter is often the most available and convenient transportation in the cities, while also supporting city environmentally friendly transportation. Electric scooters are a big part of the so-called micromobility in big cities. This is showcased in many American and European cities but also in Stockholm were there are 5 operating companies[1] like Voi, Lime and Tier to name a few. Voi has around 25 000 electric scooters in Scandinavia and 4 million daily users in Europe (2020)[2] [3]. In the American market there was over 85 million trips made in 2019[4].

This trend has made many people realize the benefits of owning their own electric scooter as a fast short-distance transportation without breaking a sweat[5]. Making companies like Mercedes, Seat and Segway to name a few, create their own electric scooter[6] [7] [8].

Some companies like Mercedes promote the electric scooter to be the last mile transport to your urban destination, by bringing your own electric scooter. Not only for entertainment but as a sustainable solution on car-free city transport[9].

1.2 Complications

There is today no good way to transport electric scooters, even though most of them are collapsible. This is due to their unusual shape that makes them hard to properly pack.

In the preliminary study, it was noticed that most models are built of the same type of frame, i.e. they have equivalent dimensions. This facilitates the mapping as it does not require a

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[1] That´s up, *Getting around stockholm -How to rent a electric scooter*, 26 juni 2020, https://thatsup.co/stockholm/guide/getting-around-stockholm-how-to-rent-an-electric-scooter/ Retrieved 30/1 2021.

[2] Björn Wallenberg, *Voi erbjuder samhället 25 000 elscootrar: "Hellre än att de står på ett lager".* Digital DI, Retrieved 26/3 2020 https://digital.di.se/artikel/voi-erbjuder-samhallet-25-000-elscootrar-hellre-an-att-de-star-pa-ett-lager Retrieved 30/1 2021.

[3] Voi, *Voi Technologies* (2021), https://www.voiscooters.com/voi-technology/, Retrieved 30/1 2021.

[4] Nacto, 136 Million Trips Taken on Shared Bikes and Scooters Across the U.S. in 2019 (2020), https://nacto.org/2020/08/27/136-million-trips-taken-on-shared-bikes-and-scooters-across-the-u-s-in-2019/ ,Retrieved 4/5 2021.

[5] THE NEW YORKER, (2021), *The E-Scooters Loved by Silicon Valley Roll Into New York*, https://www.newyorker.com/magazine/2021/04/26/the-e-scooters-loved-by-silicon-valley-roll-into-new-york , Retrieved 4/5 2021.

[6] Seat, *Seat Mó eKickScooter (2021), https://www.seat.se/mobilitet/mo/e-kickscooter-65.html* , Retrieved 30/1 2021.

[7] Mercedes-Benz, *The New Mercedes-Benz eScooter -Last Zero-Emission Mile*, Retrieved 4/10 2020 https://www.youtube.com/watch?v=ZEDXwY7_1X0&t=11s&ab_channel=Mercedes-Benz, Retrieved 30/1 2021.

[8] Segway-Ninebot, *KickScooters* (2021), https://se-en.segway.com/kickscooters, Retrieved 30/1 2021.

[9] Mercedes-Benz, *The New Mercedes-Benz eScooter -Last Zero-Emission Mile*, Retrieved 4/10 2020.

large amount of collected data to be able to get an overview and a general basis of information to get a basic structure of the concept of electric scooters.

The scooters were divided into 3 classes, Light/Middle/Heavy class. The main factor was weight.

In terms of weight, each class is equal to each other except for the larger scooters. For example, the middle class scooters vary between 12-25 kg. The larger class scooters can vary enormously as some models should actually be classified as electric mopeds. The weight of the large class for electric scooters varies between 40-60 kg, while the "electric mopeds" weigh significantly more than that. See the preliminary study in the appendix 1.

It quickly becomes a problem to transport scooters safely inside the vehicles. With a crash test that Folksam has made, showcases the danger of transporting loose objects in the car. For example, a car crash at 50 km/h makes the object around 30-40 times heavier. With an average scooter weighing in at 16 kg, it becomes 550 kg heavier at a car crash at 50 km/h[10].

1.3 Problem formulation

With today's use of electric scooters worldwide there are hardly any products that simplify the transportation of an electric scooter on a car or motorhome. Storing a single e-scooter inside the car is manageable, but if there´s more than one it's a safety issue.

The problem is that there is no product that can easily transport electric scooters today.

1.4 Goal and Purpose

The goal of this project is to create a solution for carrying electric scooters that fits onto Thule´s bike carrier. This to enable easy transportation of multiple electric scooters while also freeing-up space inside the car.

1.5 Restrictions

The delimitations for this project are discussed in the preliminary study. This project will exclude Light and Heavy class of electric scooter due to the weight. This due to the light class being too light to be practical using the solution. The same applies to the Heavy class but the other way around, it's too bulky and heavy.

[10] iKörkort, *Inre säkerhet -Lasta rätt* (2021), https://www.ikorkort.nu/teori.php, Hämtad 30/1 2021.

2. Frame of reference

2.1 Theory

The project is based on relevant and up to date articles, webpages and experts with broad knowledge relevant to the product development, both theoretically and practically. It allows for a foundation of information to start building from.

2.1.1 Motorized Scooter

A motorized scooter is a stand-up scooter with a motor i.e. combustion or electric. The design for a stand-up scooter is with a wide platform to stand on. It has 2 or more wheels and are often collapsible. The design makes the scooter a fast transportation in the cities and is a part of the micromobility[11].

The scooters are manufactured in different sizes and in engine power. For the sake of simplicity the scooters are divided into classes based on weight. A lightweight scooter is a foldable scooter below 12 kg and is very compact. A middle class or the standard scooter is still foldable but weighs more 12-25 kg, they are often more robustly built then the lightweight. The heavy class scooter is heavier than 25 kg and isn't foldable. They usually have a seat and higher engine output. These classes are a simplification when the laws of different countries are excluded due to them often being dissimilar, see appendix 1.

2.1.2 Trending

The electric scooters are right now a trend due to companies like Voi, Lime and Tier who rent out electric scooters in the cities. Voi has over 4 million daily users in Europe (2020)[12] [13]. In the American market there was over 85 million scooter trips made in 2019[14]. When people get to rent and test an electric scooter they quickly realize the simplicity of having an electric scooter. The trend of owning your own electric scooter has made many companies like Mercedes, Seat and Ducati to produce their own electric scooter. The most popular electric scooter in the world Xiaomi M365 has sold over 560 000 units[15].

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[11] Deloitte, *Small is beutiful* (2019), https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/micro-mobility-is-the-future-of-urban-transportation.html, Retrieved 25/5 2021.
[12] Björn Wallenberg, *Voi erbjuder samhället 25 000 elscootrar: "Hellre än att de står på ett lager".* Digital DI, 26/3 2020 https://digital.di.se/artikel/voi-erbjuder-samhallet-25-000-elscootrar-hellre-an-att-de-star-pa-ett-lager Hämtad 30/1 2021.
[13] Voi, *Voi Technologies* (2021), https://www.voiscooters.com/voi-technology/, 30/1 2021.
[14] Nacto, 136 Million Trips Taken on Shared Bikes and Scooters Across the U.S. in 2019 (2020), https://nacto.org/2020/08/27/136-million-trips-taken-on-shared-bikes-and-scooters-across-the-u-s-in-2019/ , 4/5 2021.
[15] Mi Store, *Elskotrar (2021)*, https://www.mistore.se/sv/elscootrar/elscootrar/, Retrived 25/5 2021.

2.1.3 Forecast

The electric scooter trend is growing and is showcased by both how many major cities investing into micromobility[16], but also by how many manufacturers like Mercedes, Seat, Segway have joined the market[17] [18] [19]. A market analyst report in the US shows that the global electric scooter market was estimated to be around 18.6$ Billion[20].

Over the forecast period the market of electric scooters is expected to increase, this is due to many things like the goal to decrease the amount of cars inside the cities. It is also about reducing noise- and CO2- pollution[21] [22].

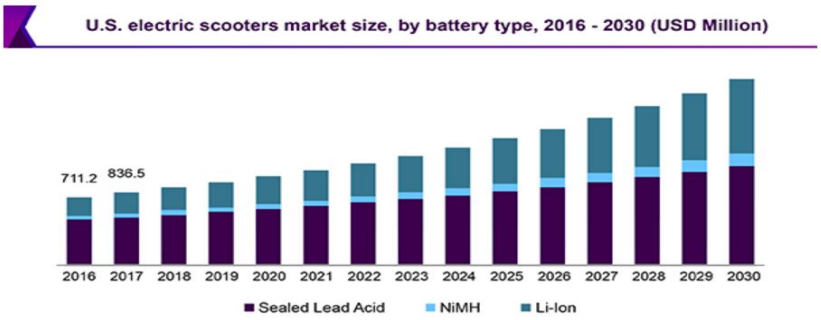

Figure 1: Grand View Research forecast

2.2 Project model

2.2.1 Stanford Design Thinking

Using the Stanford Design thinking process with influence from agile workflow, made this problem easier to grasp and made a clear way of development. The Stanford Design thinking process is a five stages concept; Empathize, Define, Ideate, Prototype and Test. Each stage is a part of a process that helps to solve a hard defined problem[23]. Every stage has a definition

[16] Nacto, *Shared Micromobility in the US 2019* (2020), https://nacto.org/shared-micromobility-2019/, Retrieved 4/5 2021.
[17] Mercedes-Benz, *The New Mercedes-Benz eScooter -Last Zero-Emission Mile*, Retrieved 4/10 2020 https://www.youtube.com/watch?v=ZEDXwY7_1X0&t=11s&ab_channel=Mercedes-Benz, Retrieved 30/1 2021.
[18] Seat, *Seat Mó eKickScooter (2021)*, *https://www.seat.se/mobilitet/mo/e-kickscooter-65.html* , Retrieved *30/1 2021*.
[19] Mercedes-Benz, *The New Mercedes-Benz eScooter -Last Zero-Emission Mile*, 4/10 2020 https://www.youtube.com/watch?v=ZEDXwY7_1X0&t=11s&ab_channel=Mercedes-Benz, Retrieved 30/1 2021.
[20] Grand View Research, *Electric Scooter Market Size.*. (Feb 2020), https://www.grandviewresearch.com/industry-analysis/electric-scooters-market, Retrieved 30/1 2021.
[21] Voi, *Kära stad* (2021), https://www.voiscooters.com/sv/for-stader/, Retrieved 30/1 2021.
[22] Lime, *About us* (2021), https://www.li.me/sv/about-us, Retrieved 30/1 2021.
[23] Interaction Design Foundation, *5 stages in design thinking process* (15/1 2021) https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process, Retrieved 30/1 2021.

which gives a good representation of where the development was, while also allowing for iteration which improves the product development, see figure 2.

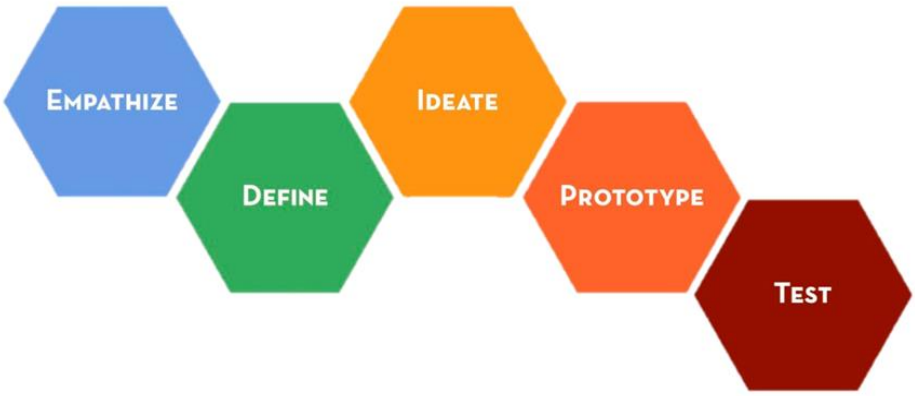

Figure 2: Stanford Design Thinking stages.

First stage is Empathize, empathizing is about understanding the problem you´re trying to solve. This by talking to an expert, talking and/or observing the users, trying the product in mind and reading relevant information.

The purpose of the Define stage is to combine the knowledge learned from before and define the problem. This is to aid the designers to find out what features and functions should be on the requirement list to ease the development of the product.

Ideate stage is where ideas for solving the problem are generated, for example with brainstorming. This stage usually brings a lot of different solutions that either don't work, aren't good enough or succeed and proceed to the next stage. This can be referred to as the “drawing board” due to this stage developing the idea and improving upon it.

The prototype stage is where the product is built often on a smaller scale with cheaper material. This stage is where the prototype is studied to either accept, improve or reject the features. In other words, evaluate the solution for iteration.

Last stage is the testing stage to try the complete product/prototype to see if it holds up to the requirements and to the world. This process often leads to redefining to create a better product.

2.2.2 Agile workflow

The agile workflow makes the development smoother with weekly based meetings, fast prototyping and creative solutions. The meetings consisted of discussions, exchange of knowledge and improvements to the product. This assured that the project moved forward[24].

The reason why the project used Stanford Design Thinking combined with agile workflow is because it helps grasping a hard defined problem, while also giving a clear development path with iterations. The other models were either too complex or not flexible for suiting this type of product development.

2.3 Creative methods

The creative methods are used to ease the development process and create a structure to carry the development forward. The methods used were selected due to them being the best for the development process due to them being most optimal.

2.3.1 Data Collection

To get an understanding of the problem in mind a collection of information surrounding the problem area is needed. Doing a preliminary study makes the problem easier to grasp and will allow for better brainstorming and in the end a better solution.

2.3.2 Requirement specification

A requirement specification is a set list of product needs and desirable needs. It's used to give a clear picture of the design and function of said product. A proper requirement list is essential for a project to succeed in the development[25].

2.3.3 Brainstorming

Brainstorming is a method of creative thinking, so to generate ideas for a solution. To brainstorm, a group with mixed experience and knowledge gathers to bounce different ideas with each other which will eventually lead to ideas worth trying[26].

2.3.4 SWOT analysis

SWOT analysis is an evaluation tool which is designed to review Strength, Weakness, Opportunities and Threats for a product or project. Strength is about finding the strong points in a product or project. Weakness is the opposite of strength. Opportunities is about finding the possibilities with the product or project, to be able to use the potential. Threats are the

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[24] PMI, *Design thinking to improve your agile process (2020)*, https://www.pmi.org/learning/library/design-thinking-improve-agile-process-11909, Retrieved 15/5 2021.
[25] Projektledning, *Kravspecifikation* (2018) https://projektledning.se/kravspecifikation/. Retrieved 19/5 2021.
[26] *Nationalencyklopedin,* brainstorming. http://www.ne.se/uppslagsverk/encyklopedi/lång/brainstorming, Retrieved 30/1 2021.

challenges that can arise and possibly harm the product or project. Each part is used to describe the up- and downsides of the product or project which allows for better planning and shows the possibilities[27].

2.3.5 Breakdown Structure

Work Breakdown Structure

Work Breakdown Structure is a common tool to break down a project to core elements in a hierarchical order[28]. This allows an easier organization and simplifies the workflow by presenting each step in hierarchical order.

Product Breakdown Structure

Product Breakdown Structure is the same as a WBS but with focus on the product. By breaking down the product to pieces it shows what the product consists of and what to work on.

2.3.6 Prototype construction

Prototyping is an important step in any product development and has many benefits by creating prototypes and are often made in a smaller scale. It allows for further investigation of the product and gives an impression of reality. With many prototypes it allows for easier comparison and decision making.

3D-Printing

3D-printing is a manufacturing method which transforms a digital 3-dimensional model from CAD to reality by additive manufacturing. Additive manufacturing is a layer by layer method which adds upon layers. This allows for complex models to be created for cheap low-production[29] [30]. 3D-Printing supports a plethora of different materials like plastic, metal, ceramics and carbon fiber[31] which makes it great for prototyping and advanced construction.

CAD

Computer aided design is a software based design tool used for both constructing and drawing designs on a computer. CAD works with both 2D and 3D workspace which allows for quick design and drawing[32].

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[27] Nationalencyklopedin, SWOT-analys. http://www.ne.se/uppslagsverk/encyklopedi/lång/swot-analys, Retrieved 30/1 2021.
[28] Projektledning, *Work Breakdown Structures (2018)*, *https://projektledning.se/wbs/*, Retrived 7/5 2021.
[29] 3D Guide, *3D skrivare Material (2021)* ,https://www.3dguide.se/nyheter/om_3d_skrivare, Retrived 17/5 2021
[30] Nationalencyklopedin, 3D-skrivare. http://www.ne.se/uppslagsverk/encyklopedi/lång/3d-skrivare, Retrieved 30/1 2021.
[31] 3D Guide, *3D skrivare Material (2021)*, https://www.3dguide.se/3d_skrivare_material, Retrived 17/5 2021.
[32]*Nationalencyklopedin*, datorstödd konstruktion. http://www.ne.se/uppslagsverk/encyklopedi/lång/datorstödd-konstruktion, Retrieved 30/1 2021.

Sketching

Sketching is a fast and simple drawing style to showcase how something looks or will look like. A sketch is often used to display an idea or design which can then be translated into CAD[33].

2.3.8 Business Canvas Model

A business Canvas Model is a creative method which clarifies the business plan in a simple manner. It focuses on the key elements of a company in a matrix. The key elements consist of Key partners, Key activities, Key resources, Value propositions, Customer relation, Distribution channels, Customer segment, Cost structure and Revenue stream. This is good for presenting a business plan for investors or colleagues[34].

3. Method

3.1 Data collection

To get an understanding of the circumstances of the problem a preliminary research needed to be done. This by collecting dimensions of electric scooters, relevant information and talking to experts. The project also used multiple electric scooters and the Thule carrier to empathize with the user.

3.2 Requirement specification

With the summarized preliminary research a product requirement specification was decided. The product has 4 requirements and 2 desirable requirements. It has to be easy to use, be adaptable, lightweight and be able to carry up to 4 scooters. It also has desirable requirements of the design being modular and being lockable.

3.3 Planning

Throughout the span of the project, there has been a rough development schedule to ensure progress. With the agile aspect there was no need for long term detail planning and the project had multiple deadlines. This proved to be helpful as a guide and improved flow of the development process.

3.4 Brainstorming

With a requirement specification a brainstorming session could begin. The use of the brainstorm is to generate multiple ideas for the solution without hindering creativity. Then presented the ideas for discussion. The brainstorming session gave some ideas that evolved into possible solutions to the problem.

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[33] *Nationalencyklopedin, skiss.* http://www.ne.se/uppslagsverk/encyklopedi/lång/skiss, Retrieved 19/5 2021.
[34] Nystartad, *Om Business Model Canvas (2021), https://www.nystartad.se/om-business-model-canvas/*, Retrieved *8/5 2021*.

3.5 Sketch

To get a better overall picture of the ideas generated through brainstorming, sketches were made. With the sketches an idea could easily be discussed for evaluation and could be denied or improved.

3.6 WBS

A work breakdown structure was created to form a structure of what the project will consist of. This made it easier to organize and follow where the project where, see appendix figure 3.

3.7 SWOT-analysis

A SWOT-analysis is used to identify four aspects; Strength, Weakness, Opportunities and Threats of a product or project. Each part describe the up- and downsides which is important to evaluate and consider the product/project. This is a quick and easy risk assessment which allow for better planning according to the conditions.

3.8 Prototype construction

The construction of the prototype consists of 4 steps. First step is to verify the CAD construction, with a verified CAD-file a choice of production was done. 3D-printing was the fastest, cheapest and the most available method to construct the prototypes and therefore it was selected. The material used for printing the prototype was PLA, a plastic type with good material properties for prototypes while also being cheap. With the parts printed it all was assembled accordingly and ready for testing.

3.9 Business canvas model

With this model a business plan could be developed for the product. With a business plan all the key activities are showcased which makes it easy to present and also show the value of the product for the customer.

4. Development process

The project structure was defined by Stanford design thinking 5 stage process. To allow for easy overwatch on the development.

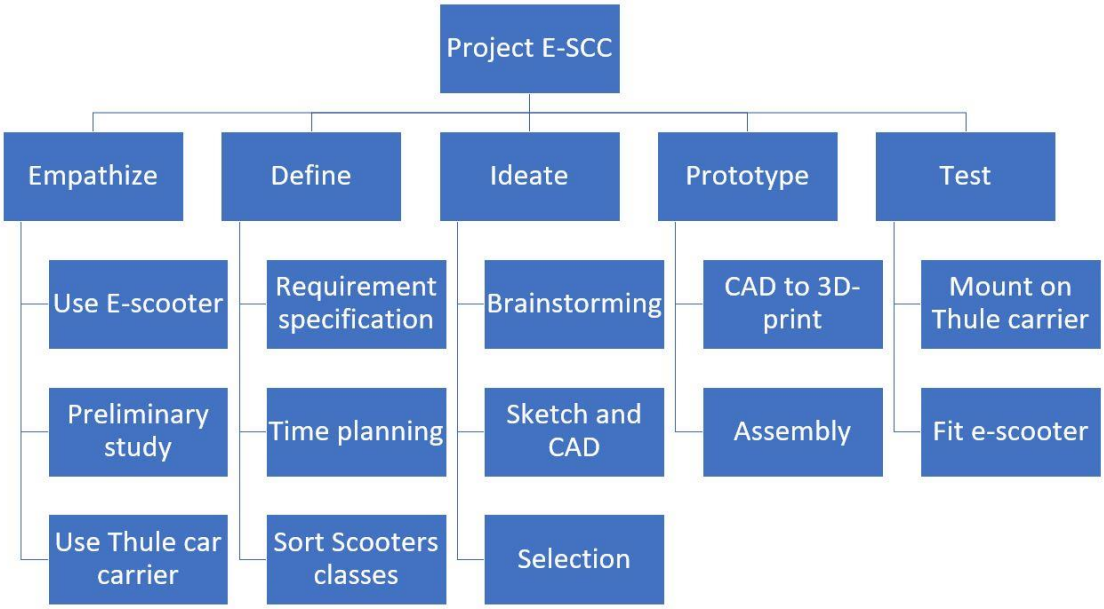

Figure 3: Work breakdown structure Appendix 2

4.1 Empathize

The project started with an assignment from Thule, to create a working concept to bring your electric scooter. The very first challenge was to broaden the knowledge about electric scooters, Thule's bike carrier and both of the users. This was done with empathizing so as to learn how a scooter works, how Thule's bike carrier work so to get the big picture of the problem. This combined with a preliminary research of the dimensions of electric scooters and associated companies which gave information how the project would continue.

4.2 Define

With the information collected like the dimension, see appendix 1, the project divided the electric scooters into 3 classes; Light/middle/heavy. This to ease the development but also to limitate the problem.

A requirement specification was made consisting of 4 requirements and 2 desirable needs.

1. Easy to use
2. Handle wide selections of scooters
3. Lightweight
4. Up to 4 electric scooters
5. Modular design (desirable)

6. Lockable (desirable)

In this stage, a timeline was made to give structure and set deadlines. It was decided with Thule to have an open dialogue to maintain the pace and progression.

4.3 Ideate 1.0

With the problem defined and a requirement specification the project could continue with brainstorming and several sketches. From these sketches discussions took place to evaluate the idea. It emerged that the product would consist of multiple parts and the most suitable solution of the ideas was designed in CAD for further discussions and improvements. An evaluation of if the scooters should be mounted horizontally or vertically was made and a decision to mount them vertically was made as it allowed for easier handling of the scooters.

Figure 4: Scooter orientation

Figure 5: Scooter orientation

4.4 Prototype V.1

PV1 was the first prototype to realize the concept, Bring your electric scooter. With 2 base supports (per pipe) it was mounted to the Thule's bike carrier allowing for a foundation for the rest of the product. The pipes had different designs to allow for similar scooters to be mounted without interfering with each other. The electric scooter would be secured by the claw who worked by screwing it tight. As the first version, PV1 was a start for further improvements. It fulfilled the

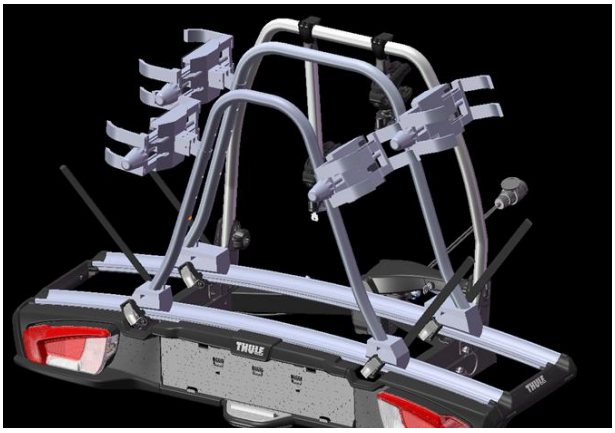

Figure 6: Prototype version 1, PV1

requirements to carry four scooters but also the requirement to be modular. It was a great first prototype that showcases the opportunities for improvements as a beginning of the concept. With this knowledge iteration could begin.

4.5 Test 1.0

Testing was carried out continuously during the development process when finished parts were produced which then were discussed in the open dialogue with Thule for evaluation and improvements.

4.6 Ideate 2.0

To start the iteration, another brainstorming session took place to generate new ideas for improvements of PV1. Every part was evaluated from the ground up for iteration to create a better product. The base support needed some changes so it would better fit and be mounted onto the Thule's carrier. The pipes needed to change to allow for a more modular design. The claw was redesigned to make it more compact and therefore lightweight. A lower attachment was designed to decrease a directional force that the claw needed to handle.

4.7 Prototype V2

With the above changes, PV2 was developed. The base support was improved upon to improve the stability of the product. The pipe design was changed to be identical to allow for a more modular design. A lower attachment was added to improve the grip of the scooter and lower the outward force for the claw. The claw got more compact and got more lightweight.

Figure 7: Prototype version 2, PV2

4.8 Test 2.0

PV2 was test fitted on Thule's carrier with an electric scooter. The PV2 worked in a similar manner as PV1 but with a lower attachment. The lower attachment improved the stability of the scooter. The pipe design with two identical pipes worked and allowed for 4 scooters and retained the modular design.

The product worked but could be improved and therefore it needed to be evaluated. The lower attachment needed a redesign to make it stronger. As with the claw it also needed a redesign to remove the screw, the screw could be untightened during travel.

Figure 8: Prototype version 2, PV2

4.9 Ideate 3.0

With knowledge learned from the testing an improvement was needed for the lower and for the upper attachment a redesign was needed. To improve the lower attachment more support walls were added and it was printed for testing. The upper attachment was redesigned to remove the screw. The new design needed to handle a wide selection of scooters and therefore a C-claw seemed optimal. The C-claw has a Thule pump-buckle which uses a strap to tighten the scooter to the C-claw. With this ideating, material choice was considered and was concluded to adhere with Thule's standard material choices PA6 with 30% glass fiber and aluminum. This is because of the great material properties these materials already have and due to Thule's expertise in them.

4.10 Prototype V3

PV3 works similar to PV2 but replaces the claw design with a C-claw. What the C-claw does is that it doesn't need to be retightened. This makes PV3 more reliable but also more lightweight. The design continues to allow up to 4 scooters or 2 scooters and a bike.

Figure 9: Prototype version 3, PV3

4.11 Test 3.0

The test of PV3 shows great possibilities in this product. It can support similar and different electrical scooters without interfering with each other. The user interface is the same throughout the product with Thule´s pump-buckle which makes it easier for a customer to use it. One consideration is to change the pipe to a square tube so as to secure the upper and lower attachment from spinning.

5. Product

5.1 Product description

The product consists of 38 parts (excluding Thule's original parts) that attach to Thule's bike carrier as an adapter. The product consists of these parts, See appendix 7-16.

1. Base support (4 pcs.)
2. Pipe (2 pcs.)
3. Pipe attachment (8 pcs.)
4. Connector (8 pcs.)
5. Lower attachment (4 pcs.)
6. Upper attachment (4 pcs.)
7. Screw handle (8 pcs.)
8. Thule pump-buckle (8 pcs.)
9. Thule straps (8 pcs.)

Figure 9: Prototype version 3, PV3

The base supports are the foundation of the product and attaches to the rails on the bike carrier with the existing straps. Then attach the existing arms to the pipes and the product is secure for mounting electric scooters. The C-claw accepts a wide selection of scooters due to its design and the lower attachment helps to stabilize and secure the scooter. It's also designed for being easy to use and allow for up to 4 electric scooters or 2 scooters and one bike.

The product works by attaching the folded scooter to the upper and lower attachment by tightening the straps around the body of the scooter. This secures the scooter and allows for easy and safe transportation.

But it's still a prototype that needs a few more improvements before it launches on the market. For example, the pipe could be changed to square tubes to stop the attachments from spinning. A prototype with the selected materials should be made and fully tested to ensure strength and stiffness.

Figure 10: Prototype version 3, PV3

6. Process of product

6.1 Material order and production

To produce the product materials and parts are needed. The materials used are PA6 (30% glass fiber) and aluminum. All the materials are ordered and parts are produced by Thule. Producing the product needs machines for bending the pipes and plastic molding machine to produce the parts needed. Assembling all the parts and packaging is easy but needs manpower.

6.2 Competence analysis

When developing and producing the product, it's important that the staff are competent and know how to handle the process. Thule has great competence and experience with both developing and producing products.

7. Business system

7.1 Business Canvas model

To develop a business plan, the project used the business canvas model. This structured the key elements and led to an understanding of the unique value the product would create to meet the need, but also the great opportunities it has on the market.

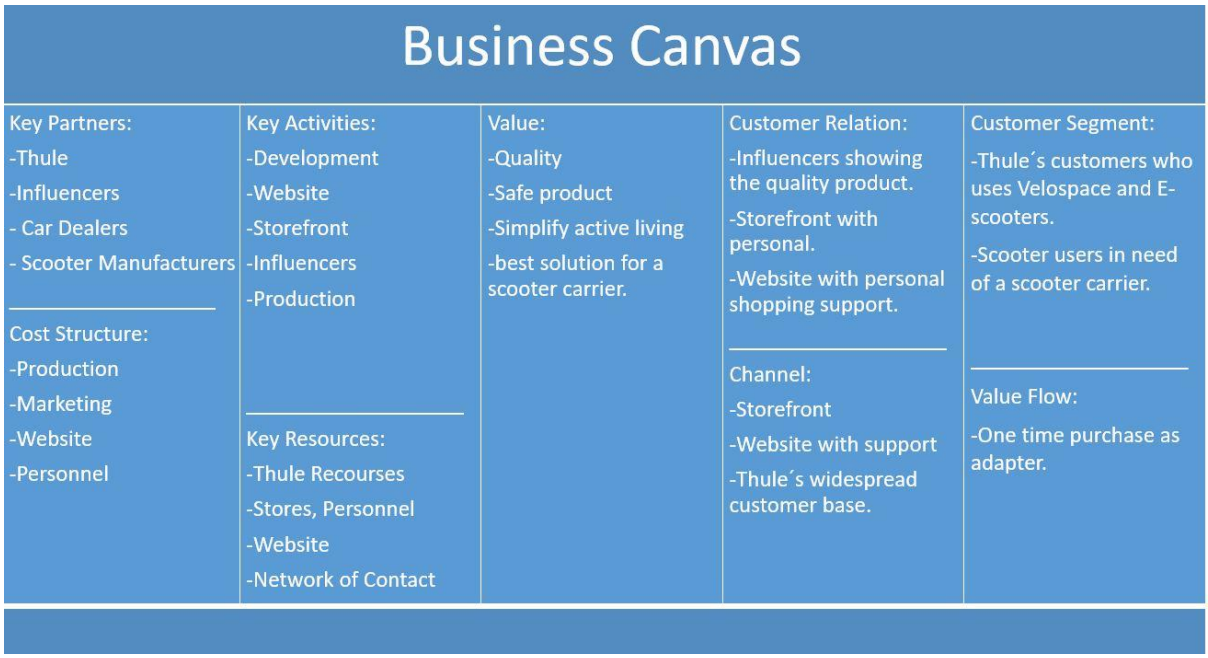

Figure 11: Business Canvas Model

7.2 Intended market

Today's market doesn't have an electric scooter carrier even though electric scooters are on an increasing trend, with the most sold electric scooter (Xiaomi M365) selling over 560 000. Therefore there is a possible need for a solution. The intended customer is:
1. a family that uses electric scooters as a means of transport on holiday i.e. camping trips or visiting a city where the trunk is filled with baggage. The modularity makes it possible to bring 2 electric scooters and a bike which further improves the flexibility of exploration.
2. a fully loaded car with 4 people visiting a big foreign city with electric scooters, where the car might not be the most suitable transportation, cities like New York, Stockholm or London.
The product will enhance the microbility for these people and will simplify the travel and the possibilities to explore.

7.3 Economy plan

A final calculation has been compiled based on the components that Thule has contributed to the project and estimation on material cost. Components like the U-frame, Pump buckle and straps and Thule's material cost.
The calculation is made to showcase a rough estimation of producing the product, keep in mind that the full product is a pair of U-frames i.e. the real price is double and would cost about 400 SEK.
The actual cost of the product if defined further to become and actual Thule product would be more expensive. Thule will add on cost margin for research and development, machine cost producing the parts and profit margin, the margin depends on Thule.

1pcs	ALU U-frame	50 sek/pcs	50 sek
2pcs	Adapter pucks	10 sek/pcs	20 sek
2pcs	Lower holder	25 sek/pcs	50 sek
2pcs	Upper holder	35 sek/pcs	70 sek
Packaging + misc.			10 sek
			200 sek

Figure 12: Cost estimation

7.4 Market plan

7.4.1 Value offer

The value this product offers for the customer is simplifying the transportation of the electric scooter while also freeing up space inside the car. This allows the customer to focus on what

matters, the big city adventure. Electric scooters mobility in the big cities makes exploring the city easy.

7.4.2 Distribution

Marketing and selling of the end product will be handled by Thule, this by selling on Thule´s website, storefront and at car dealers. The product will be built to stock and be sold as an adapter to Thule bike carrier VeloSpace.

8. Discussion

8.1 Product discussion

The product shows a great opportunity to become a real product and have come far in the development. If the product is launched it would simplify, free up space and make the transportation safe with multiple electric scooters. It will also be first to market as there is currently no product specifically made for transporting electric scooters. With this product, exploring cities will be easier with electric scooters and will give the freedom to explore on your own.
There will be a future need for this product because there is no similar existing product but also because of the growth of electric scooter users.

From the SWOT-analysis (appendix 3) it emerged that the product is strong because of its customer value and it will be first to market on an increasing trend. It's also supported by the Thule brand as it will be an adapter to one of their own products.
The weakness of the product is that it's not yet ready for market and it also needs to fulfill regulation demands as the car industry is strictly regulated.
The opportunities are many, it’s first to market, and it is an increasing trend to own an electric scooter which makes it a good timing. Because of that the product can be implemented.
The threats of this product are the ongoing pandemic covid-19 and time constraints. This is because of delays that might happen due to covid-19.

8.2 Project discussion

The SWOT-analysis (appendix 4) of this project showcases success regardless of weakness. This is because of the good cooperation with Thule and also because of the right resources being available. The project is developing a good product with a lot of opportunities.
The weakness and the threats of this project is the ongoing pandemic Covid-19 and time constraints. It has also been a struggle due to it being a one person project which means the workload is not divided.

The opportunities given by this project is insight on a quality company with great brand. The project can also be implemented easily due to the great possibility of the product on the trending market.

The project used Stanford design thinking which worked well together with the creative methods. This has led to the development of the product being in focus instead of the process. I am really happy with the results and with the cooperation with Thule. This project wouldn't be possible without the resources provided by Thule as SolidWork license and expertise provided by Magnus Ferman.
The cooperation with Magnus Ferman at Thule has worked great and have been of great help with both developing the product but also sharing knowledge. The communication with Thule has been good even through the pandemic Covid-19 and it hasn't hindered the development process as bad as predicted.

What could have been better is the consistency in the development timeline as this led to out of focus and stress that may have affected the development. Being a solo person project has affected the development too, mainly because of not being able to share the workload.

This project has been both tough and instructive, it's for sure a learning experience that will help with my future work.

9. Sustainable development

9.1 Sustainable development

The project has during the development taken into account a sustainable development. The use of PLA to create the prototype is due to PLA being biodegradable and can easily be recycled, while also requiring less energy to print.
Since the product is yet a prototype the materials are to be decided by Thule, this in accordance with their existing sustainability plan. Thule is a part of many environmental organizations like “UN Global Compact” and “Leave No Trace” to mention a few. More information regarding sustainable development at Thule is available at their website.

9.2 Work environment

Because of the project working with Thule, the fair work environment has been at a high standard and which is reflected in Thule’s code of conduct. This also reflects the moral and ethical obligations you as an “employee” has towards Thule.

“We will only engage business partners who provide their workers and employees with a safe and healthy work environment. This also applies to business partners who provide residential facilities for their employees. We are convinced that it is essential to provide a safe, healthy and inspiring work environment for all Thule Group employees. All our employees are responsible for maintaining this objective. We do not tolerate use of alcohol, narcotics or misuse of medicines during work. It is strictly forbidden to use, sell, buy, produce, and possess alcohol or narcotics within and around Thule Group premises. This includes also driving under the influence of alcohol or narcotics during or in connection to any work related occasion. We do not tolerate any violence or threat of violence against employees, visitors, customers, suppliers or any others at the workplace. Disciplinary action, which can lead to dismissal and termination of employment, will be taken against those who violate this rule. We are convinced that companies which support a healthy lifestyle and strive to motivate and empower their staff have better performing employees. Therefore we encourage our employees to live a balanced and active life.”[35]

9.3 Ethics and morals

The product is develop to be easy to use and allow a convenient transportation of electric scooters. This can reduce the carbon footprint of the user going into a city, allowing for a greener alternative as a last mile transport. The product is also meant to cause no harm to its user, the environment or others but also make transportation of the scooter safer.
Combine these with Thule’s code of conduct as mention above the product and project will adherer to many goals of united nation global goals for sustainable development.
With change of time and the customers increased awareness connected to the climate change and equal right, this will stand the test of time.

[35] Thule, *Code of conduct (2021)*, https://www.thulegroup.com/en/our-code-of-conduct, Retrieved 30/5 2021.

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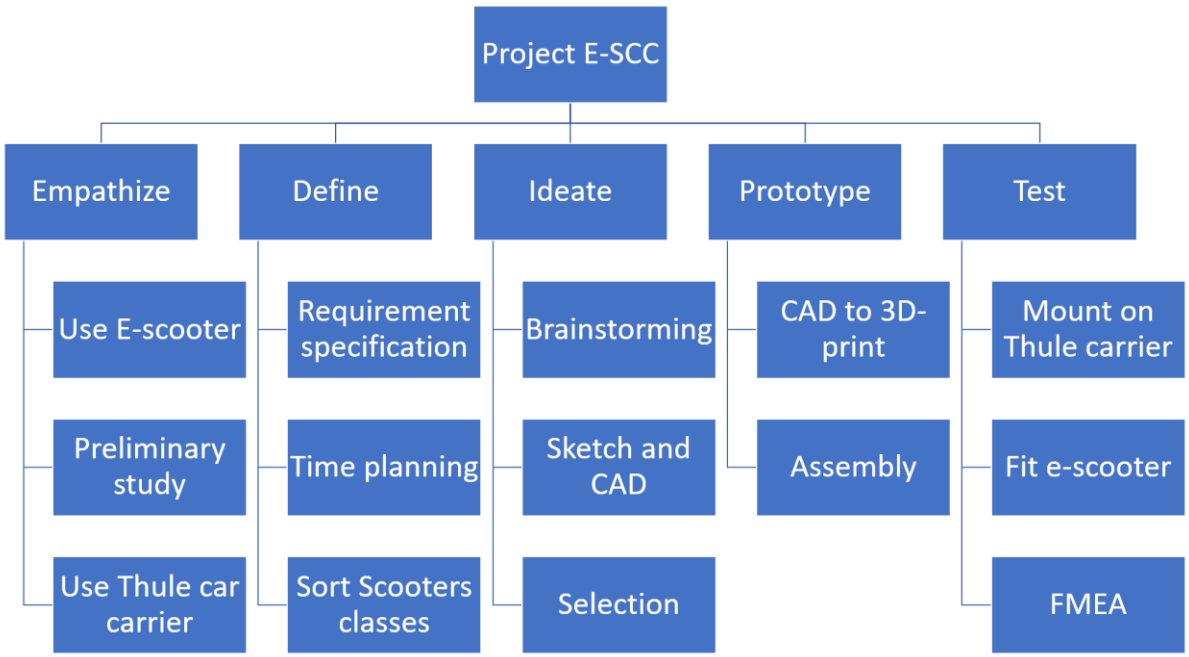
Appendix

Appendix 1, Preliminary research

Elscootrar

	Märke	Land & Klass	Dimension (L/B/H)	Dimension ihopvikt	Däck (F/B)	Vikt	Pris
1.	Nitrox alu-8 flex	SE, M o ihopF	106, 42 , 120	N/A	8,5 tum	19 kg	4495
2.	fco Elscooter Premiu	SE, M o ihopF	130, - , 110	N/A	12/14 tum ???	48 kg	11 699
3.	Egret 8 V2/V3	SE, L o ihopF	111, 55, 92	N/A	8 tum	14 kg	13105
4.	OBG rides Scooter v2	SE, S	175, 75, 70	N/A	18x 9,5 tum	52 kg	19995
5.	Nitrox 350W Li	SE, L o ihopF	116, 55 ,120	118, 55, 43.5	8 tum	11 kg	4195
6.	Nitrox Alu-5	SE, L o ihopF	92, 40.5, 100	100, 40.5, 23.5	5 tum	8,5 kg	2995
7.	Segway ES1/ES2	Int, L o ihopF	102, 43, 113	113, 43, 40	F 20, B 19,2 cm	11.3/12.5 kg	4290
8.	Segway Max G30D	Int, S o ihopF	117, 47, 120	117, 47, 53	10 Inch	19,5 kg	8990
9.	Mi E-Scooter 1S	Int, M o ihopF	108, 43, 114	108, 43, 49	8,5"	12,5 kg	4990
10.	Mi E-Scooter Essentia	Int, M o ihopF	108, 43, 114	108, 43, 49	8,5"	12 kg	3990
11.	Egret 10 V4	Int, M o ihopF	115, 55, 115	N/A	10"	17 kg	17599
12.	Nitrox 1600W 48V Dirt	Se, S	123, 65, 117	N/A	27,5 cm	46 kg	7495

Appendix 2, Work breakdown structure



Appendix 3, Swot-analysis Product

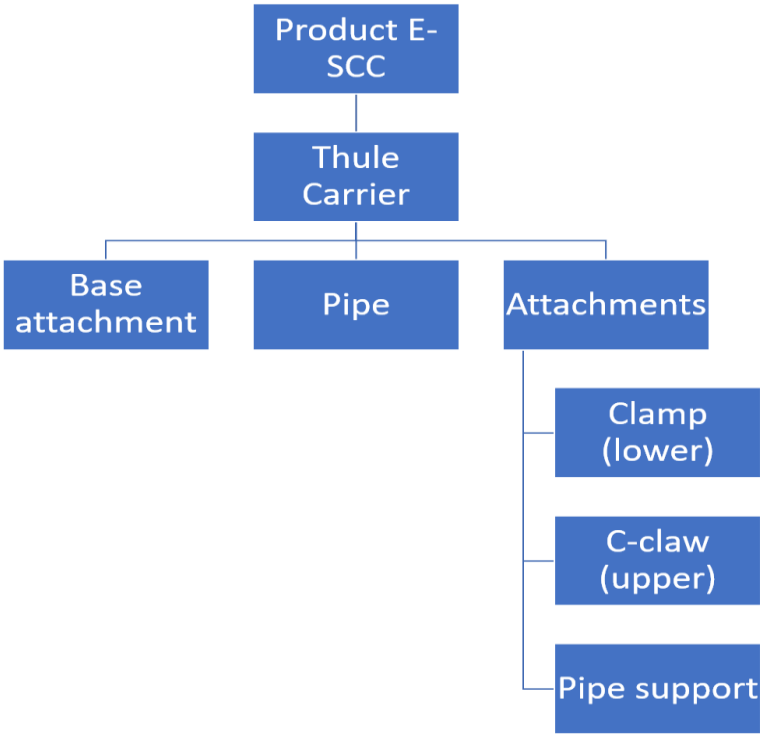
SWOT-analysis Product	
Strength: -First to market -Trending need -Great brand support -Adapter	Weakness: -Regulation -Not yet ready for market
Opportunities: -First to market -increasing e-scooter trend -Good timing -Might be implemented	Threat: -Covid-19 -Time limit -Regulation

Appendix 4, Swot-analysis Project

SWOT-analysis Project	
Strength: -Good cooperation with Thule -Good product -Right resources available	Weakness: -Work alone -Timeline -Regulation
Opportunities: -Insights on a quality company -Project can be implemented	Threat: -Covid-19 -Time limit

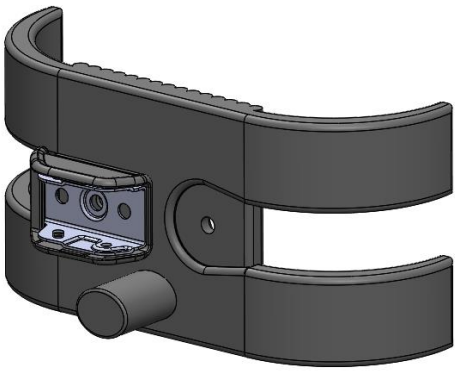
Appendix 5, Picture on PV3

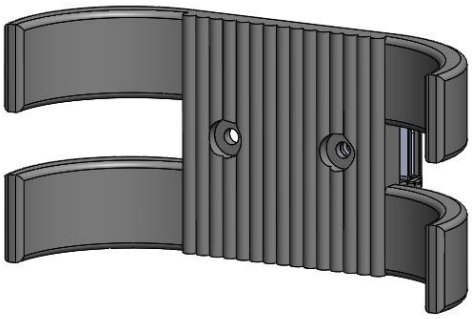
Appendix 6, Product breakdown structure

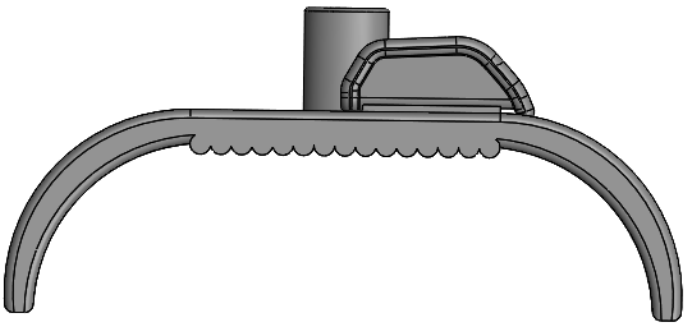


Appendix 7, PV3

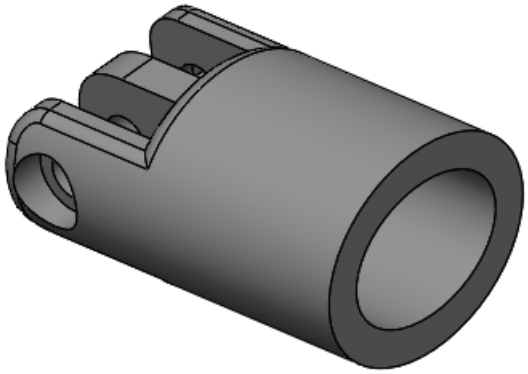
Appendix 8, C-Claw



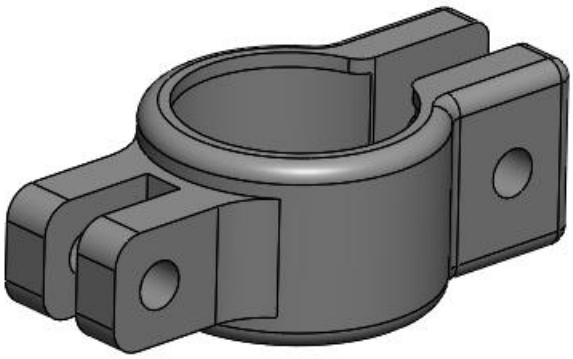




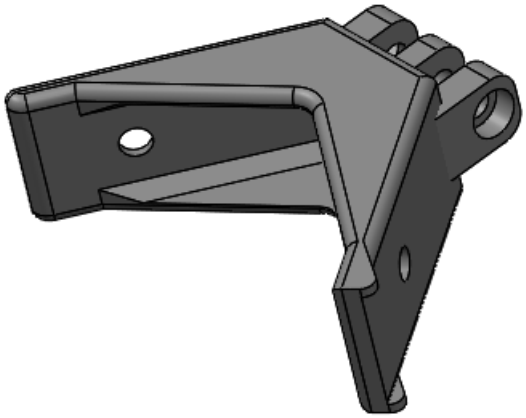
Appendix 9, Connector



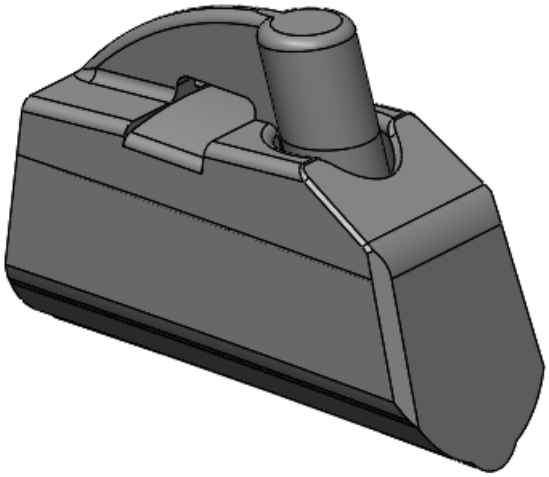
Appendix 10, pipe attachment



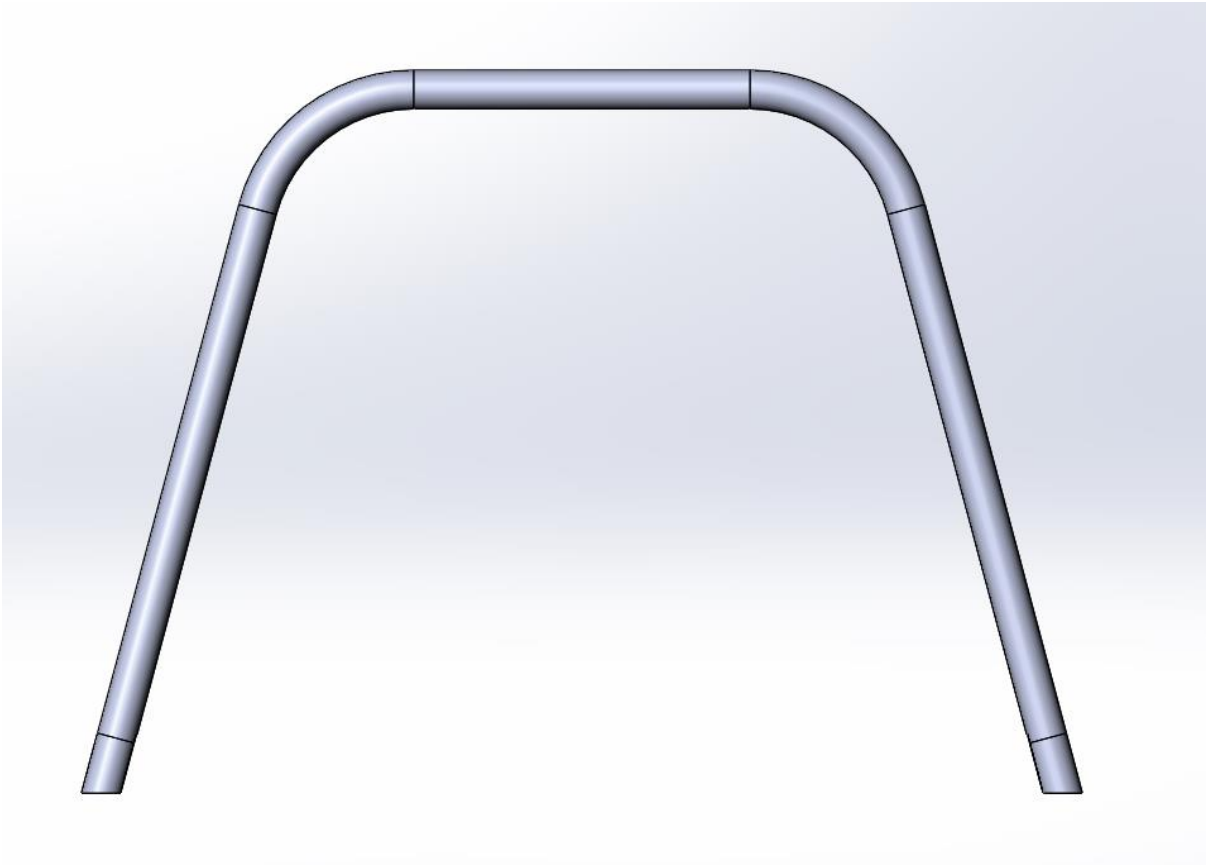
Appendix 11, Lower attachment



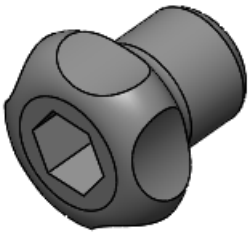
Appendix 12, puck



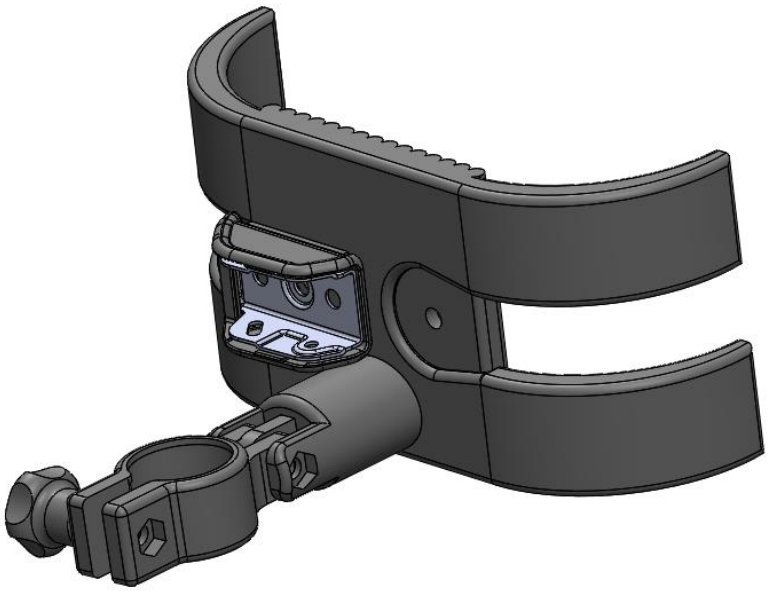
Appendix 13, Pipe



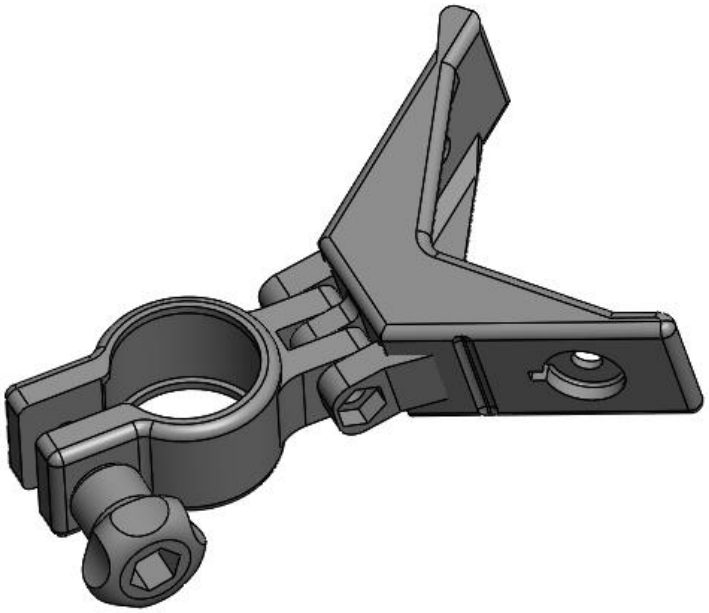
Appendix 14, Screw



Appendix 15, Upper attachment



Appendix 16, Lower attachment



Appendix 17, Avtal Företag

AVTAL

§ 1 Parter

Följande avtal gäller å ena sidan studenterna NN1, PNR1 och NN2, PNR2, nedan gemensamt kallade studenterna, samt å andra sidan Företaget AB, orgnr, nedan kallat företaget.

§ 2 Sekretess

Studenterna förbinder sig att hantera information konfidentiellt, som inte är offentlig eller på annat sätt är att anse som allmän eller allmänt känd, som fås i samband med projektet. Studenterna har dock rätt att diskutera med lärare och andra studenter vid Högskolan samt redovisa projektet muntligt inför lärare och elever vid Högskolan och i en skriftlig rapport.

Företaget förbinder sig å andra sidan att behandla information som fås från studenterna konfidentiellt. Speciellt gäller detta information som kan göra att nyhetshinder uppstår vad gäller immaterialrättsligt skydd.

§ 3 Immaterialrätt

Alla av studenterna framtagna nya uppfinningar, patenterbara eller ej, produkter, processer, tekniker förbättringar eller annat som uppstår ur arbetet och som kan vara föremål för immaterialrättsligt skydd skall tillfalla studenterna. Företaget äger rätt att, mot utgivande av skälig ersättning till studenterna, helt eller delvis förvärva rätten till eventuell uppfinning. Förvärv ska meddelas studenterna inom tre månader efter det att uppfinningen blev känd för företaget. Vid fastställande av ersättning ska hänsyn tas till graden av rättighetsförvärv samt till företagets bidrag till uppfinningen. Utnyttjar inte företaget denna rättighet äger studenterna själva rätt att söka immaterialrättsligt skydd för samt att exploatera eventuell uppfinning.

Analogt ska gälla för andra immaterialrättsliga former än patent.

§ 4 Ansvar

Studenterna ska bedriva arbetet självständigt och får således inte detaljstyras av företaget. Studenterna bär inget ansvar vare sig tids-, miljö-, resultatmässigt eller ekonomiskt för projektet.

Företaget åtar sig att bekosta med studenterna avtalade kostnader i projektet. Företaget ska avsätta rimliga resurser, vari ingår en kontaktperson, för att projektet ska kunna bedrivas meningsfullt. Vid inköp ska företaget faktureras direkt.

§ 5 Resultat och rapportering

Studenterna ska göra en muntlig presentation och lämna en skriftlig rapport av projektarbetet jämte en kostnadsredovisning med originalverifikat till företaget.

§ 6 Ändringar

Samtliga ändringar av och tillägg till detta avtal ska vara skriftliga.

§ 7 Tvist

Tvister angående detta avtals tolkning ska avgöras av allmän svensk domstol.

Av detta avtal har studenterna tagit varsitt och företaget ett exemplar.

Halmstad 202__ - ____ - ___

Appendix 18, Project description

Background

In the urban adventure the electric scooter is often the most available and convenient transportation in the cities, while also supporting city environmentally friendly transportation. Electric scooters are a big part of the so-called micromobility in big cities. This is showcased in many American and European cities but also in Stockholm were there are 5 operating companies like Voi, Lime and Tier to name a few. Voi has around 25 000 electric scooters in Scandinavia and 4 million daily users in Europe (2020). In the American market there was over 85 million trips made in 2019.

This trend has made many people realise the benefits of owning their own electric scooter as a fast short-distance transportation without breaking a sweat. Making companies like Mercedes, Seat and Segway to name a few, create their own electric scooter.

Some companies like Mercedes promote the electric scooter to be the last mile transport to your urban destination, by bringing your own electric scooter. Not only for entertainment but as a sustainable solution on car-free city transport.

Problem

With today's use of electric scooters worldwide there are hardly any products that simplify the transportation of an electric scooter on a car or motorhome. Storing a single e-scooter inside the car is manageable, but if there´s more than one it's a safety issue.

The problem is that there is no product that can easily transport electric scooters today.

Goal and purpose

The goal of this project is to create a solution for carrying electric scooters that fits onto Thule´s bike carrier. This to enable easy transportation of multiple electric scooters while also freeing-up space inside the car.

Preliminary method

Using the Stanford Design thinking process with influence from agile workflow, made this problem easier to grasp and made a clear way of development. The Stanford Design thinking process is a five stages concept; Empathize, Define, Ideate, Prototype and Test. Each stage is a part of a process that helps to solve a hard defined problem. Each stage has creative methods associated with design thinking which will ease the development.

Requirement specification

A requirement specification was made consisting of 4 requirements and 2 desirable needs.

1. Easy to use
2. Handle wide selections of scooters
3. Lightweight
4. Up to 4 electric scooters
5. Modular design (desirable)
6. Lockable (desirable)

Timeline

The project has worked with deadlines set by Halmstad University and Thule.

- 7/9 2020, Project start
- 1/10 2020, Present preliminary study at Thule
- 14/12 2020, Concept presentation
- 31/1 2021, Concept report
- 22/3 Prototype 2
- 28/4, Prototype 3
- 25/5, Final presentation
- 30/5, Final report

Risk

See appendix 3 and 4.

Secrecy

Between the student and Thule a secrecy policy was signed based on confidentiality agreement "Avtal Företag", See appendix 17.

About the cooperation company

Thule is a company established in Hillerstorp 1942 and has since then expanded worldwide with over 2400 employees at 9 facilities and 35 sales offices. They have innovated products like the Thule ski box, towbar-mounted bike carrier and rooftop tent to name a few in their portfolio.

Their focus is to create quality solutions to ease the adventure. So the customer can spend more time on what matters, the adventure.

Thule has over 200 engineers supporting innovation and development with a strong focus on quality. This is to maintain a global market leading position with their products. Their motto is: “ACTIVE LIVE, SIMPLIFIED.”