WANDERLUST

Product Report • Aalborg University • June 2022 • MSc04 ID09

Frederik Kiersgaard Lund • Mette Clausen Nielsen • Mie Charlotte Lundborg

TITEL PAGE

PROJECT TITLE	WANDERLUST
REPORT TYPE	PRODUCT REPORT
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MAIN SUPERVISOR	CHRISTIAN TOLLESTRUP
CO SUPERVISOR	LARS ROSGAARD JENSEN
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MIE CHARLOTTE LUNDBORG ______________________

ABSTRACT

Dette kandidatprojekt er udviklet af tre industriel design studerende fra Aalborg Universitet og omhandler problematikken i at vandre med våde vandrestøvler. Projektet resulterede i løsningsforslaget Wanderlust. Dette projekt belyser udviklingsprocessen for løsningen, samt en detaljering af det endelige løsningsforslag. Wanderlust er udviklet som et sæt af transportabelt støvletørre, som kan bringes med på vandreture. Løsningen blev udviklet på baggrund af et identificeret behov for at tørre støvle på vandreture, da våde støvler leder til ukomfortabelhed og fodkomplikationer. Årsagen til våde støvler kommer af interne og eksterne forhold, såsom sved, vand, regn eller sne. Løsningen er designet og udviklet på baggrund af en brugergruppe af midaldrende mænd, som går op i at undersøge og købe nye vandreprodukter, og defineres som grej fanatikeren. Det nuværende konkurrenter på markedet for støvletørrer, bliver anset af vandre for ikke at præsterer at tørre på kort nok tid eller opfylde deres behov. Derfor blev der analyseret frem til et potentiale for at udfordre det nuværende marked og skabe en løsning, som løser vandrerens problemer Desuden med potentialet for at skabe en virksomhed som inkorporere flere segmenter, så som jægere eller andre udendørs aktivitet hvor fodtøj kan blive vådt.

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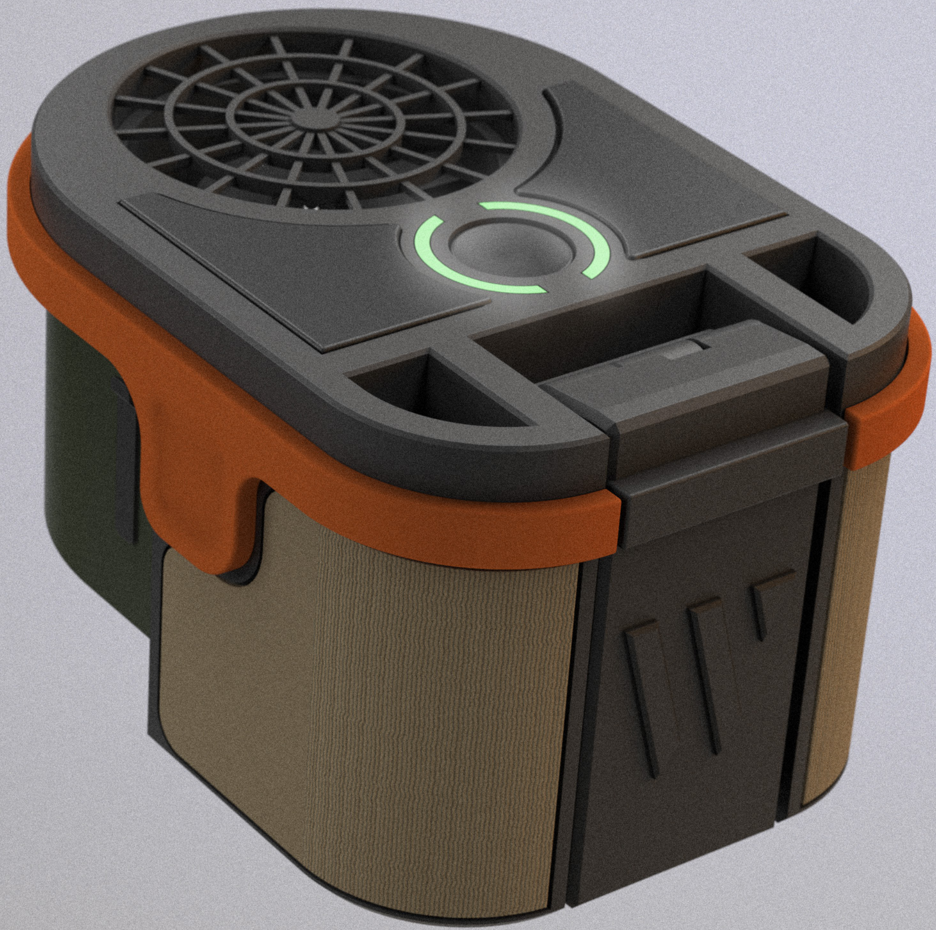
INTRODUCTION TO HIKING

Hiking is hard to define, it all depends on how far and for how long you want to walk. Hiking is usually defined as between 5 - 30 km and can range from a single day, an overnight stay in shelter to a multiple day trip. Trekking in rough terrain and hiking is all about getting out in nature and exploring. However, when hiking, both weather, river crossings and sweaty feet can cause your boots to get wet. Having wet boots can cause blisters, soars and in the worse case infections. Having dry and comfortable boots means having a comfortable hike.

WANDERLUST

Whether you get wet boots because of the weather, crossing rivers or from sweating, Wanderlust is your new hiking buddy that makes sure you can dry your boots and keep your feet healthy.

WANDERLUST



THE ULTIMATE BOOT DRYER

With its 8400mAh battery Wanderlust can last to three full cycles without draining completely.

Faster than any portable boot dryer on the market, it can dry a pair of boots in just 3 hours.

Wanderlust only weights 290g per unit giving a total of 580g. This is Less than an extra pair of boots.

FEATURED DETAILS

Wanderlust is designed with compactability and function at the forefront. Wanderlust fits perfectly in your boot, and the rubber band for gives a correct grip and easy placement in the boot.

Wanderlust's collapsible heating element is stored compact and safe within the main unit when it is not in use. The interactive button on the top of the device secure easy accessibility when in use.

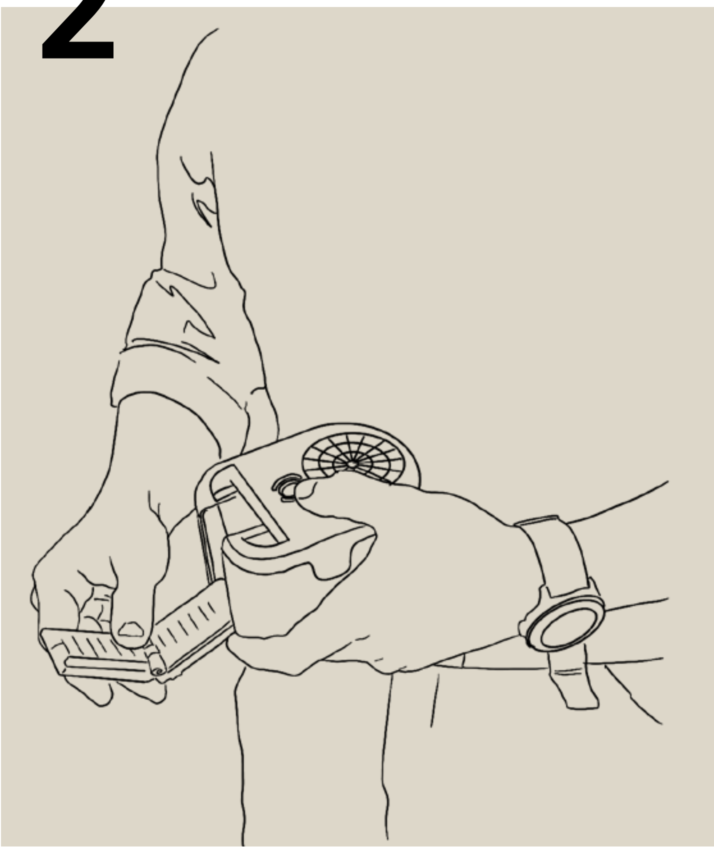
The main unit of Wanderlust has protective grits integrated making sure nothing gets in the way of the fan. Together with the locking mechanism in the button it is made sure to integrate safety and security when Wanderlust in use or packed in the backpack.

USE CASE SCENARIO

1

When you want to use Wanderlust, all you must do is to bring the compact packing bag. When you are ready to use it, take Wanderlust out of the bag.

2

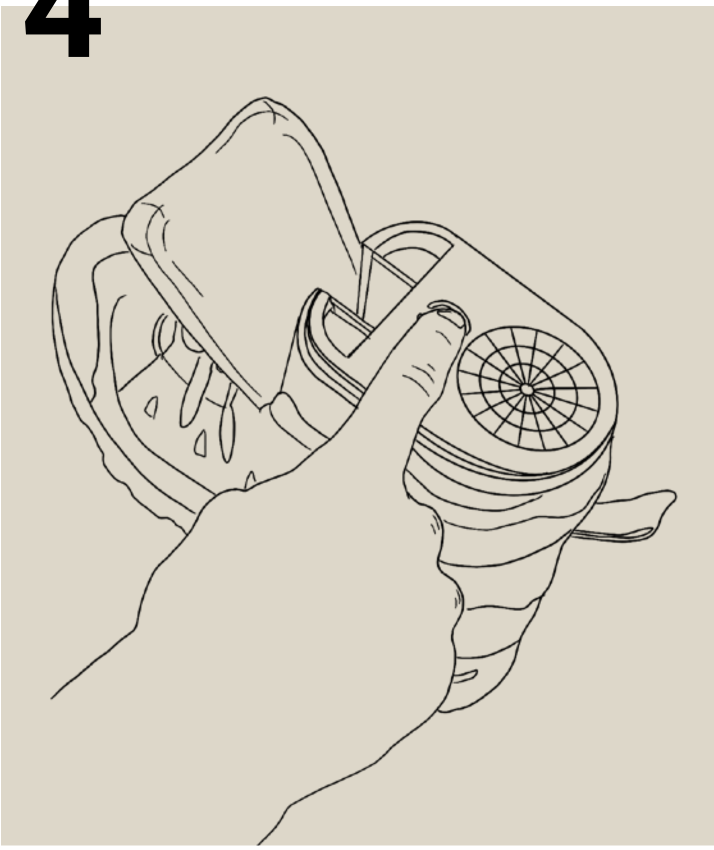


When ready to insert Wanderlust into your boots, fold of the integrated heating element out.

3

Place Wanderlust with the heating element extended into your boot. Make sure to insert it far enough into the boot. The rubber band will create friction to make sure Wanderlust is not inserted to far. The rubber band will function as a guideline for the insert.

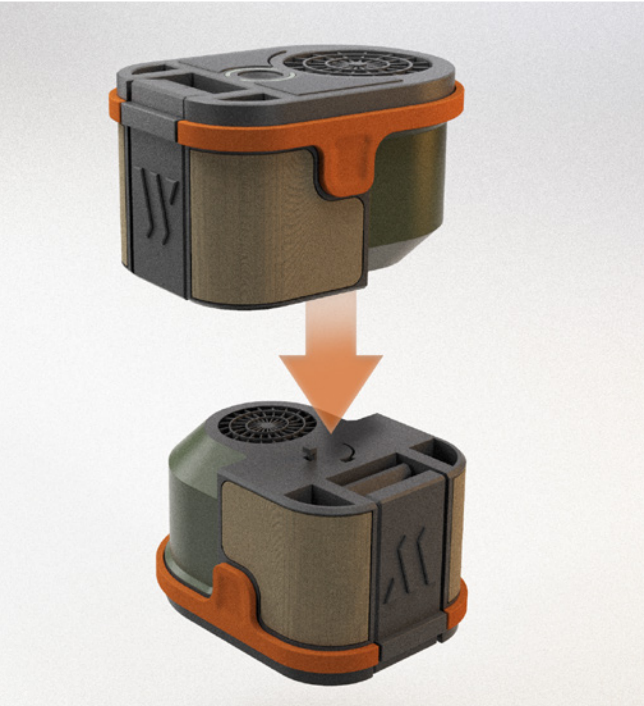
4

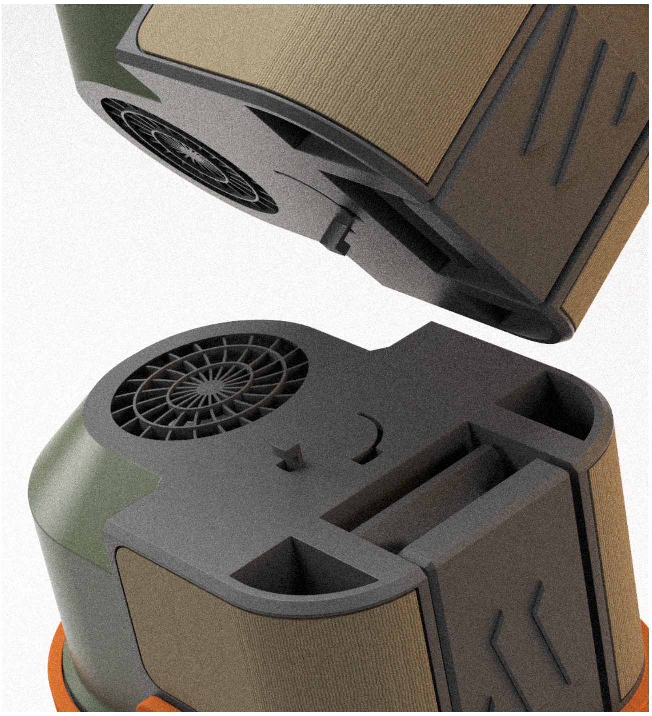


When Wanderlust is securely fitted into the boot, you are ready to turn on Wanderlust. A long press for three seconds on the button until the light flashes green and the device will turn on for 3 hours. When the green switches to a flashing white you know Wanderlust is working correctly and has started its heat up phase of 5 minutes and after 5 minutes the will kick in.

LOCKED AND SECURE

To make sure your Wanderlust is stored safe and secure, when packing down Wanderlust place the two bottoms together at a 90 degree angle and press them against each other. After the locking mechanism slots in place, all you have to do is to turn the one unit, making sure you turn it to the position of the fronts facing the same direction. Integrated in the locking mechanism is an activation of a lock switch. When a pair of Wanderlust is locked together it disconnects the ON/OFF switch on the top - this makes sure that Wanderlust at no time can turn on in your bag.



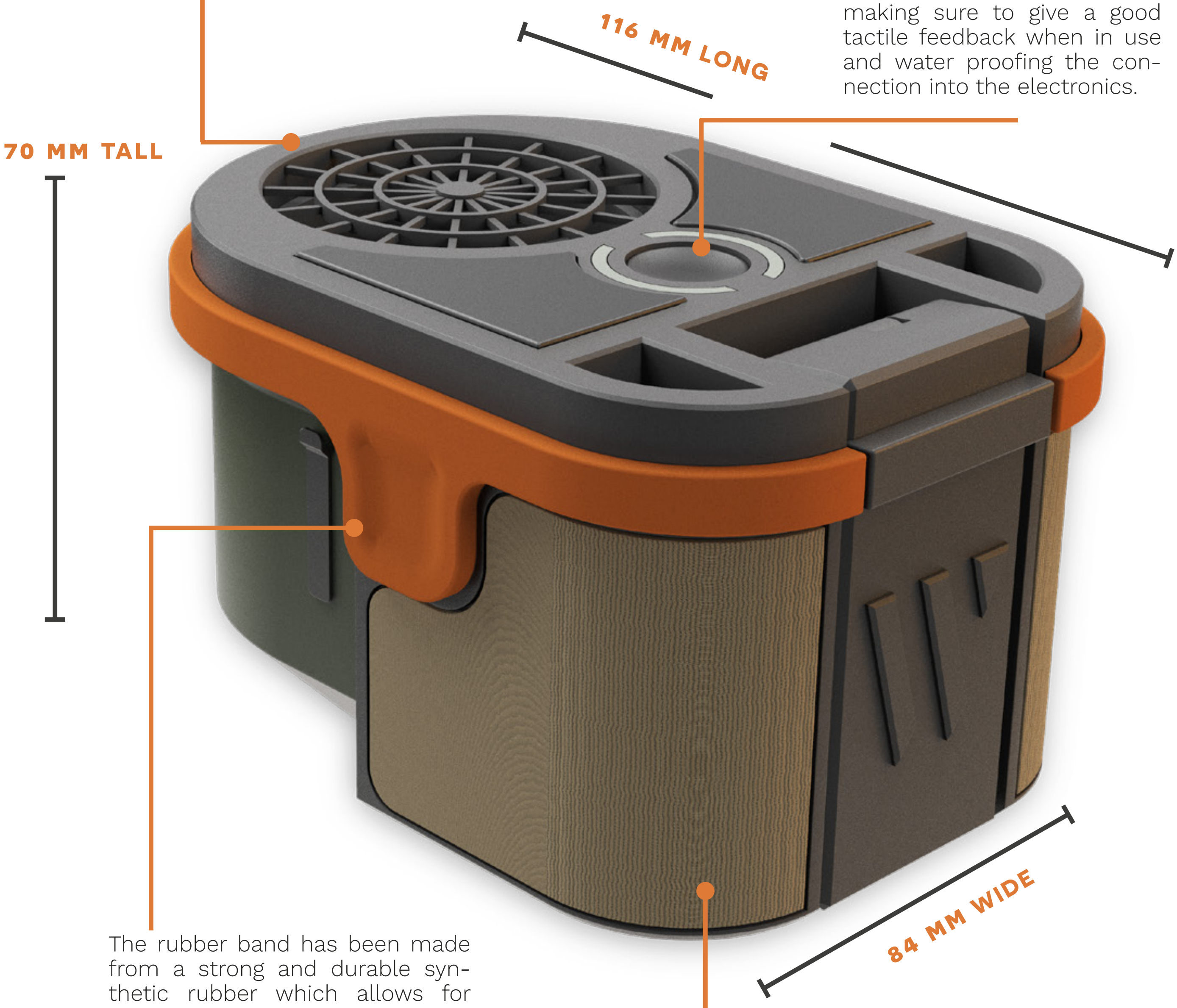


Together with Wanderlust's locking mechanism, it comes with a water proof packing bag. The packing bag makes sure you quickly can identify Wanderlust in your bag and allows full flexibility for your organisation. Instructions to using Wanderlust has been printed on the bag, making sure they are always with you - for when showing new users or just in need of a refresher on how to use.

MATERIALS AND DIMENSIONS

All the plastic parts have been made from injection moulded Polypropylene for its durable and heat resistant capabilities.

The button has been made from durable synthetic rubber, making sure to give a good tactile feedback when in use and water proofing the connection into the electronics.



The rubber band has been made from a strong and durable synthetic rubber which allows for proper grip when handling and inserting Wanderlust into the boot. Additionally the rubber give a proper grip when handling with wet hands or gloves.

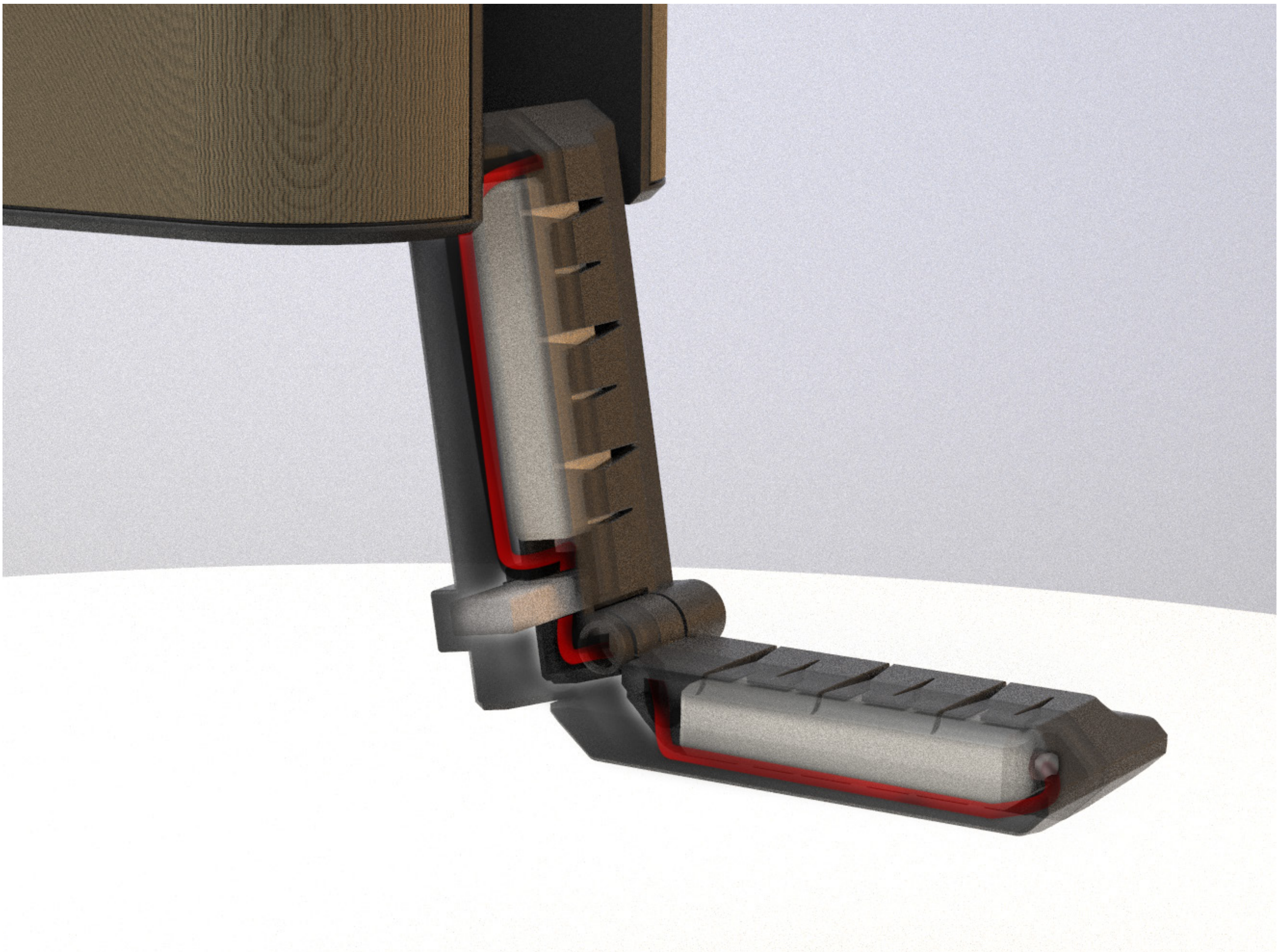
The fabric has been made from durable nylon giving not only a unique look but also a quality feel when handling Wanderlust.

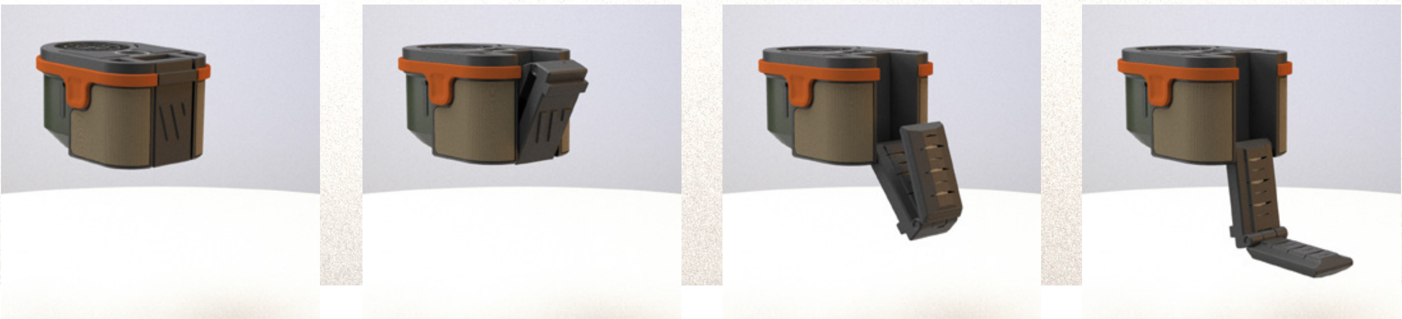
BATTERY LEVEL

To make sure the user has full control and overview of Wanderlust, a circular RGB LED indicator has been integrated in the device. Not only does the indicator flash green when starting, white when heating - but by a double press on the button the user is able to see the battery level of Wanderlust. Two full circles signals 100-76%, and three quarter of the circle signals 75-51%, half the circle signals 50-26%, and one quarter of the circle signals 25-6%. Wanderlust will flash red when the battery is below 5% and to low to power up the device.

TECHNICAL DETAILS

One of the two primary functions in Wanderlust is the collapsible heating element, that allows for heating up the boot to 40 degrees Celsius. Heating up the boot allows for faster drying, but is not high enough to damage any part of the boot nor you. Together with the ceramic heating elements, is a thermal switch that makes sure the device can never overheat.

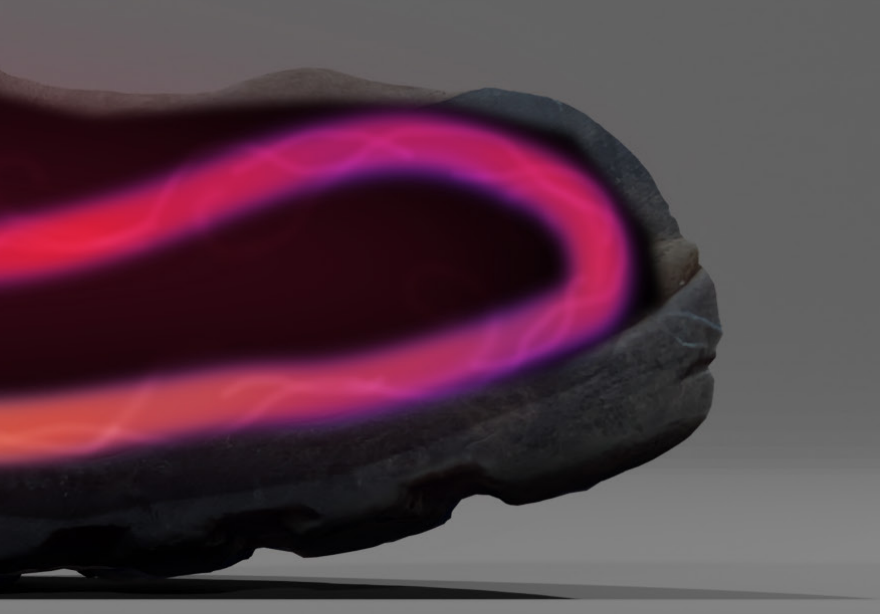




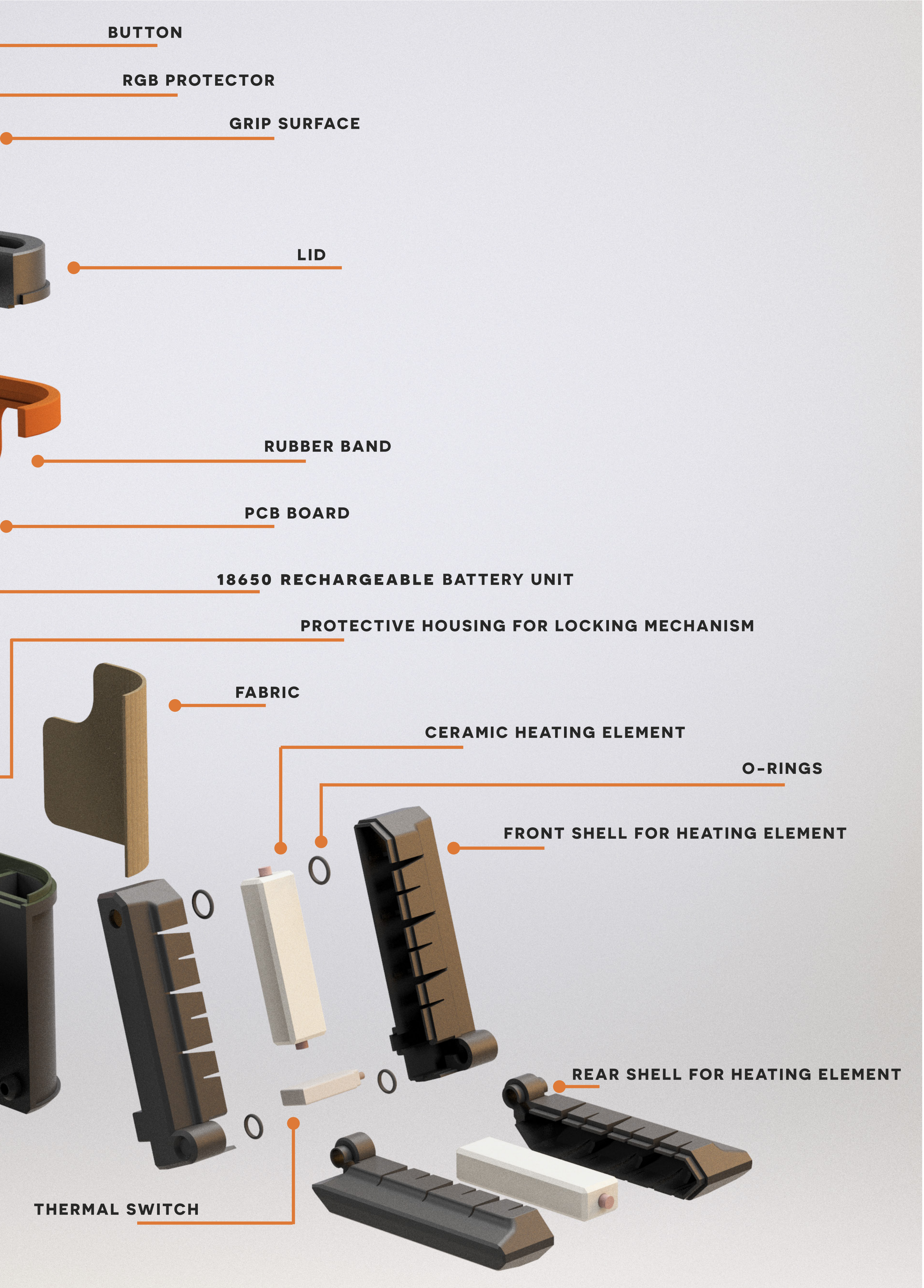
The other part of the function, is the integrated brushless and quiet fan that generates airflow in the boot allowing for moisture to extract from the boot. Together with the venting holes in the front, Wanderlust create a circulation of fresh and dry air that is heated up in the boot before extracting with the moisture.

AIRFLOW SIMULATION

The picture shows a visual representation of the circulation of the air when Wanderlust is running. The fresh dry air will flow into the boot and integrate with the already warm air, allowing for the humidity to fall without expending to much energy on heating the inside of the boot once again.

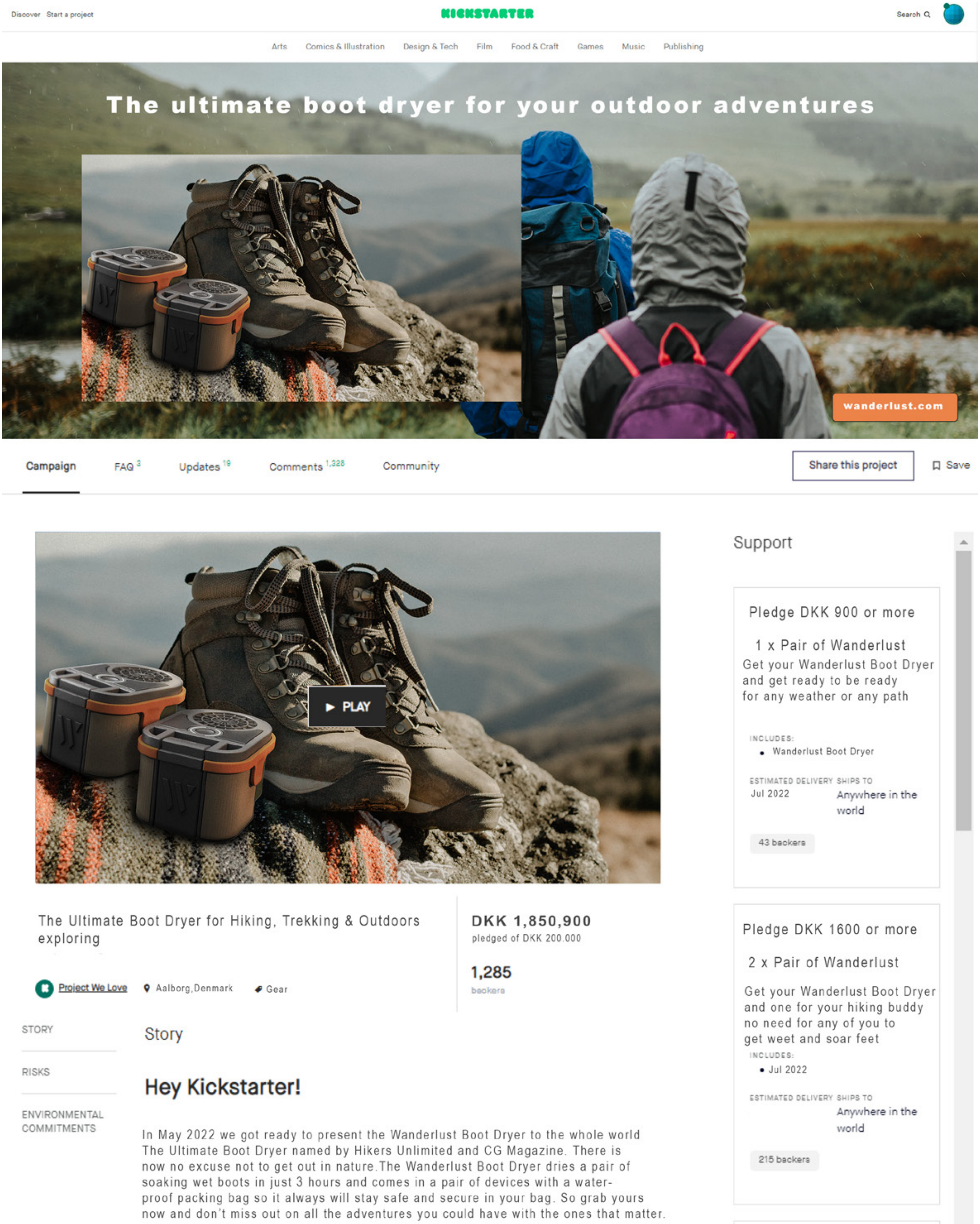


EXPLODED VIEW


BUTTON
RGB PROTECTOR
GRIP SURFACE
LID
RUBBER BAND
PCB BOARD
18650 RECHARGEABLE BATTERY UNIT
PROTECTIVE HOUSING FOR LOCKING MECHANISM
FABRIC
CERAMIC HEATING ELEMENT
O-RINGS
FRONT SHELL FOR HEATING ELEMENT
REAR SHELL FOR HEATING ELEMENT
THERMAL SWITCH

BUSINESS STRATEGY

Wanderlust will be launched as part of a Kickstarter campaign, taking full advantage of the active community of users within the hiking community. The target user spends as much time on the couch searching for new products as spend on hiking.



PRICING

One set of Wanderlust will cost 900 DKK with a production cost of 271,54 DKK this means that 11.593 units has to be sold in order to break even. Looking at similar products in Kickstarter campaigns, the estimated initial sales through the campaign will be 2000 units. Allowing for scaling up production and online sales later.

WANDERLUST

AD NYE VEJE

AALBORG UNIVERSITET

WANDERLUST

Process Report • Aalborg University • June 2022 • MSc04-ID09

Ill. 01 *Image: Freepik.com*

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TITLE PAGE

Project title	Wanderlust
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Main Supervisor	Christian Tollestrup
Co-Supervisor	Lars Rosgaard Jensen
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The Team

The team consists of Frederik Kiersgaard Lund, Mette Clausen Nielsen and Mie Charlotte Lundborg. The teams member each have competences that complimented each other and used these to their advantage in progressing the project.

Frederik Kiersgaard Lund

Mette Clausen Nielsen

Mie Charlotte Lundborg

ABSTRACT

Dette kandidatprojekt er udviklet af tre industriel design studerende fra Aalborg Universitet og omhandler problematikken i at vandre med våde vandrestøvler. Projektet resulterede i løsningsforslaget Wanderlust. Dette projekt belyser udviklingsprocessen for løsningen, samt en detaljering af det endelige løsningsforslag. Wanderlust er udviklet som et sæt af transportabelt støvletørre, som kan bringes med på vandreture. Løsningen blev udviklet på baggrund af et identificeret behov for at tørre støvle på vandreture, da våde støvler leder til ukomfortabelhed og fodkomplikationer. Årsagen til våde støvler kommer af interne og eksterne forhold, såsom sved, vand, regn eller sne. Løsningen er designet og udviklet på baggrund af en brugergruppe af midaldrende mænd, som går op i at undersøge og købe nye vandreprodukter, og defineres som grej fanatikeren. Det nuværende konkurrenter på markedet for støvletørrer, bliver anset af vandre for ikke at præsterer at tørre på kort nok tid eller opfylde deres behov. Derfor blev der analyseret frem til et potentiale for at udfordre det nuværende marked og skabe en løsning, som løser vandrerens problemer Desuden med potentialet for at skabe en virksomhed som inkorporere flere segmenter, så som jægere eller andre udendørs aktivitet hvor fodtøj kan blive vådt.

READING GUIDE

This project consist of three reports: Process report, Product report and Technical drawings. Whereas the process report is structured into six chapters: Introduction, Understand, Ideate, Conceptualize, Detail, Implement and Epilogue. References can be found at the end of the report and the Harvard citation method is used. In addition, reference will also be made to the appendix, which is separated from this report. In some of the pages there is a QR code which shows video files of interviews or interactions tests.
Throughout the report, the following icons and colours will indicate various features:

- Alignment and sum up of the activities
- Reflection of the process or alignment
- Important information which effects the process and the understanding of the project
- Some of the requirements and wishes that have a greater significance on the process

INTRODUCTION

When you are on a hike the focus are, the nature experience and the adventure of exploring the area. Thus it is a shame if something disturbs the moment. You can prepare a lot before you go on a hike, but if your boots gets wet it is hard to be prepared with a solution that can make your hiking comfortable again in a short time frame.

This project focuses on solving the problem of having wet boots on a hiking trip with no solution being reliable, lightweight and efficient. To solve this problem the project includes a thorough research to understand the hiking situation and who the hiker is. Furthermore an ideation on a possible solution could be, a conceptualizing with tests on how the solution should work and detailing on the users interaction with the solution. Lastly decisions on how the business around the product will be, a conclusion on the outcome and a reflection on the process.

ACKNOWLEDGEMENT

In helping create the foundation for the project, the team would like to thank the following people with much appreciation of the contribution to the project.

Firstly thanks to the main supervisor Christian Tollestrup and the technical supervisor Lars Rosgaard Jensen for advising during the project, as well as additional advice from Thomas Kristensen on technical and programming aspects of the project.

Secondly thanks to the experts Lykke Bitsch Overgaard and Maja Vestergaard Jensen used in the project, their expertise and feedback contributed in shaping the final solution.

Lastly thanks to Alexander Bering and Frederik Schmidt for testing the solutions and giving feedback as well hikers Peter L, Peter R, Mads and Jesper in giving insights and knowledge into the terminology and requirements of hikers.

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Ill. 02 *image: Freepik.com*

| PROCESS APPROACH

The project process is inspired and based on IDEO (2004) (Dubberly, 2004), due to the approach of the project type as a tool for B2C. Therefore it can be seen the report's chapter division is based on this methodology. However, it is important to note that the process was iterative and not as linear and that the prototyping has been included early in the process.

Due to the focus on proof of performance, the team starts to track the process by dividing the process into two main parallel paths, where converging and diverging were used as a tool to understand when the team had to converge or diverge in order to achieve the deadlines (ill. 04). On illustration 04 the dimensions are at correct scale in terms of time in accordance to the project period before submission.

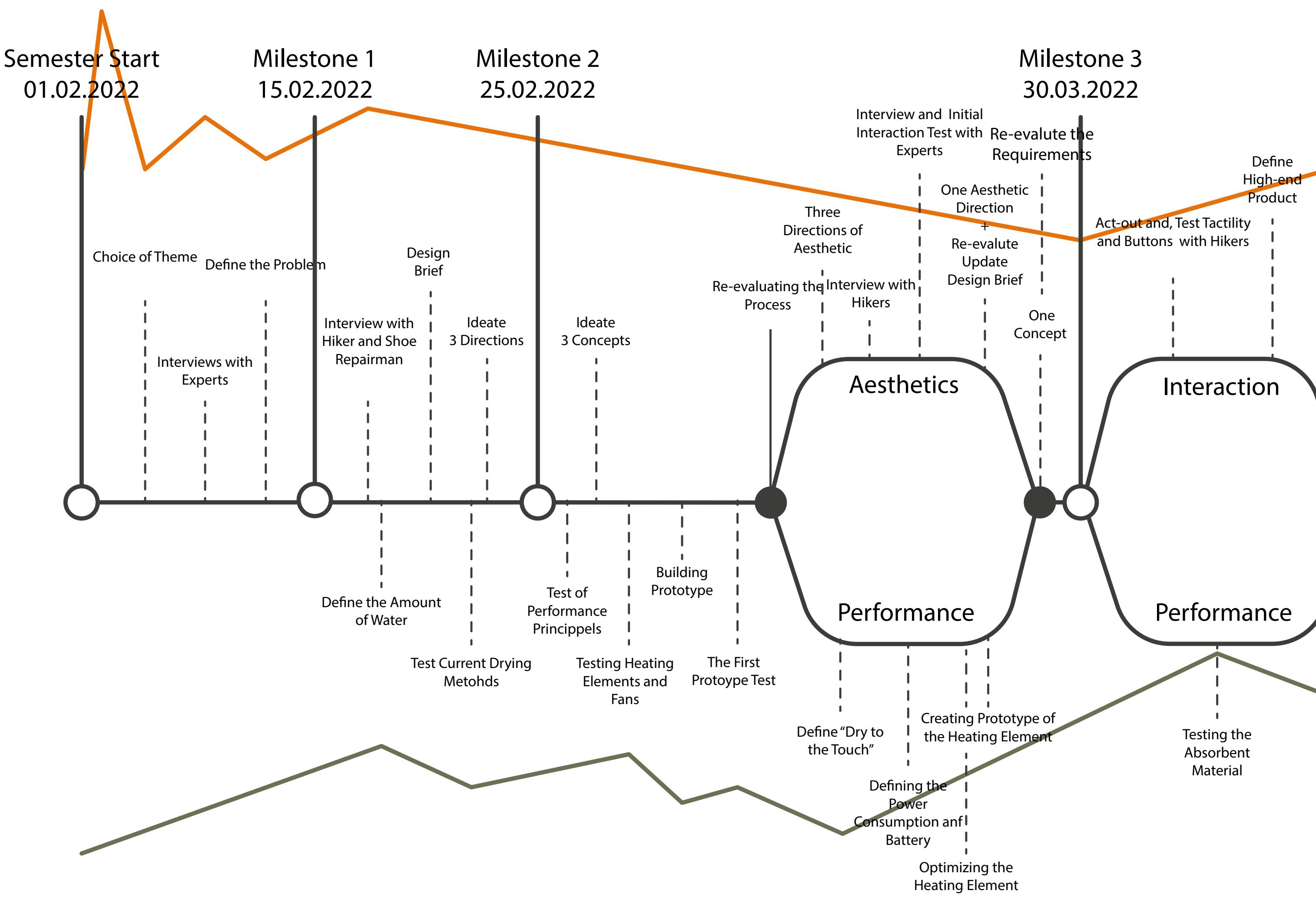
1. Understand (Observation), define and understand the user, opportunities, market and the problem.

2. Ideate (Brainstorm), idea-generation based on understanding leading to one concept.

3. Conceptualise (Rapid Prototype), Testing prototypes of the concept and defining the interaction.

4. Detail (Refining), Detailing the final concept and the technical aspect.

5. Implement (Implementation), The final material, production, and product vision to implement it into a marked strategy.



Kolbs Learning Circle

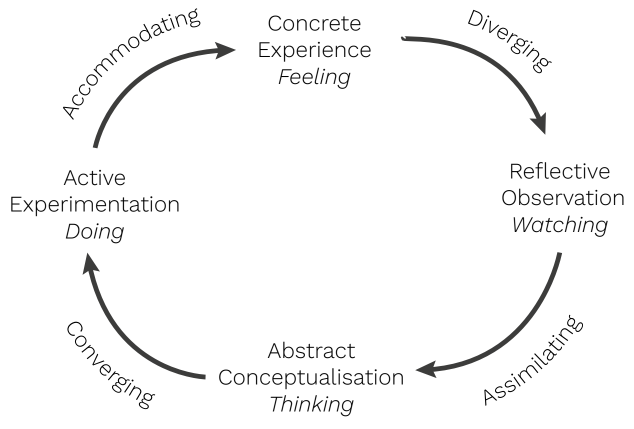
Throughout the project, Kolbs Learning Circle (McLeod, 2017) has been the approach for processing the activities. It has especially been necessary for the process of the solution's performance, as the theoretical aspect has too many unknown factors which can not be calculated and transferred directly to a prototype. This approach also covers other activities such as interaction and aesthetics. The method can be seen in illustration 03.

Concrete Experience is the process of creating an experiment and observing what is happening.

Reflective Observation is the reviewing reflection of the gained observations from the experiment.

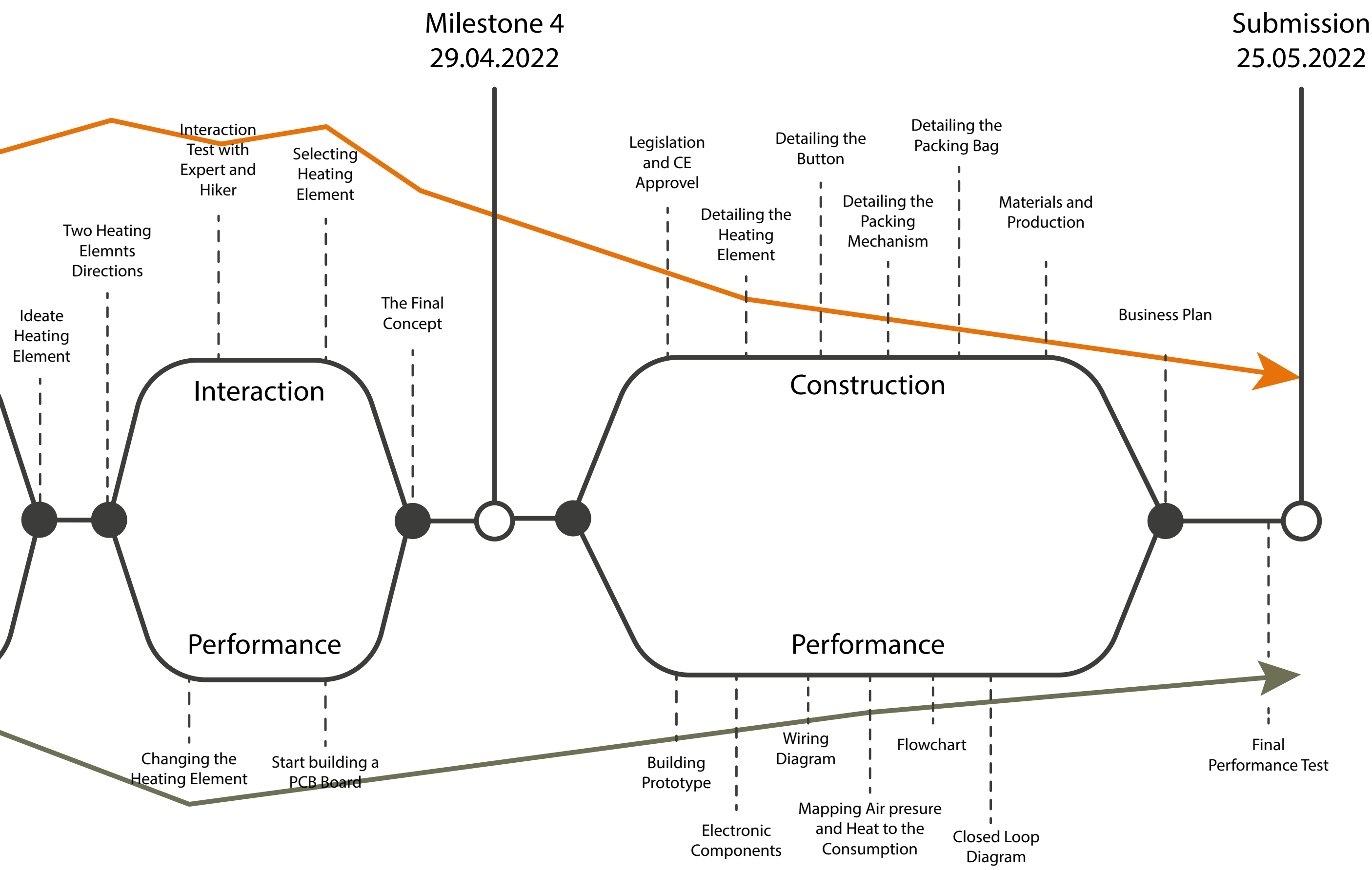
Abstract Conceptualisation will the gained knowledge be concluded and connected into a theory.

Active Experimentation from the new theory and understanding, a new experiment will be planned to test the new theory.



Ill. 03 *Kolbs Learning Circle (McLeod, 2017)*

Ill. 04 *A visual presentation of the project process. The orange line represents converge or diverge for the top of the process line and the green represents converge or diverge of the process building the prototype.*



CHOICE OF DIRECTION

At the beginning of the semester, the chosen topic *"Re-design of Shelter for firefighters"* (app. 1) was revised. The main reason for the de-selection was the accessibility and the possibility of simulating a life-dependent context and to create a functional solution within the project's time frame. Therefore, new topics and issues was assessed with pros, cons and opportunities based on desktop research and mind-mapping (app. 1). This led to topics such as insect hotels, military, hunting and camping, whereas the team chose two directions based on their issue and the team's interest in the topics:

Wet Hiking Footwear

One problem that many hikers experience is wet hiking footwear. This often leads to blisters and other foot complications, which can be uncomfortable and, in some cases, worsen.

Ill. 05 *Wet hiking footwear*

Hand Pain

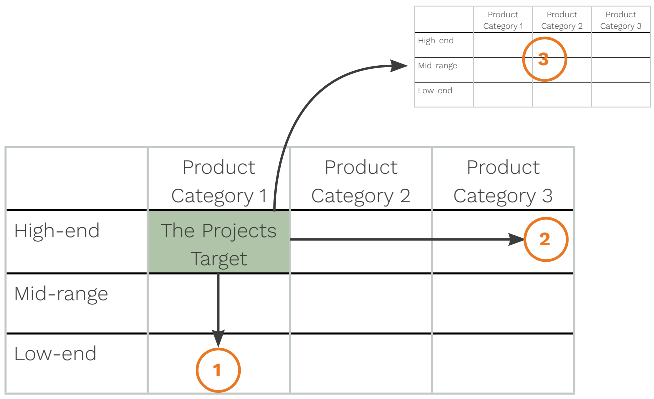
Many nursery teachers experience hand pain when changing children's diapers, due to the push-buttons in the child's clothing. This often leads to children's clothes not being closed properly and severe pain due to repeated task. Some even state that it can lead to osteoarthritis.

Ill. 06 *Hand pain*

Comparing the Two Topics

From the research, the two topics were assessed against each other in a mini-milestone, which was presented to the team's supervisor. From the feedback, the team chose to assess the two topics based on complexity, scalable options, market opportunities and availability for testing in context. Based on these points, it was assessed that hand pain will be a less complex solution and that the stakeholders would most likely be the municipality or the public sector. Due to the influences of covid-19, it is questionable whether the team would be allowed to visit the context. Even though the team have several contacts with users who have these issues. Whereas wet hiking footwear is not an equally consequential problem, there is the possibility of creating a complex solution. The context is accessible, and a solution can be scalable both vertically and horizontally (see. Ill. 07). In addition, the stakeholder would be more accessible.

Finally, wet hiking footwear are considered to be within reach of proof of concept, whereby hand pain must be tested over a longer period of time.



Ill. 07 *Platform Renewal for wet hiking footwear (Meyer, 1997) Following scaling options are; 1. Scale down to less complex solution, low-end, 2. Scale to another platform, such as different hiking climates or other products within hiking, 3. Scale to another marked.*

! This project will be focused on creating a high-end solution for drying wet hiking footwear.

Ill. 08 *image: unsplash.com*

01 UNDERSTAND

This chapter will thematically present the alignment of the project's essential knowledge of the user, the context, current solutions and the market. This aims to create a framework for the project, formed by methods such as interviews with users and experts, desktop research, analysis models and tests.

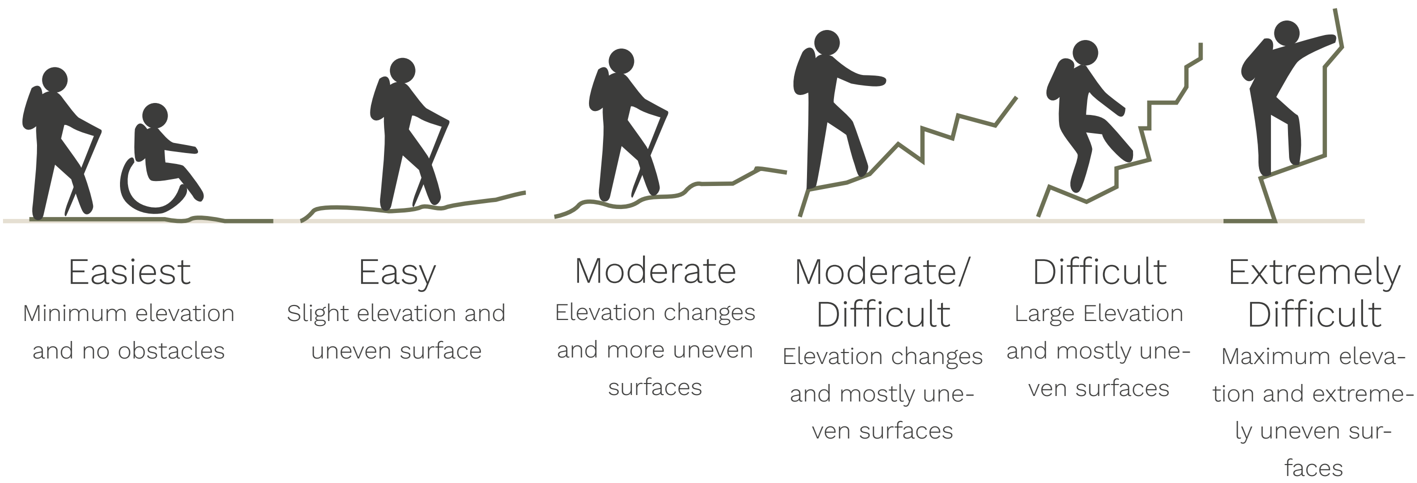
INITIAL RESEARCH

What is Hiking?

Hiking is a recreational activity that takes place in nature by all age groups. Hiking involves long energetic walks in nature or outdoor environments on hiking trails or paths. Some hikes can consist of an overnight stay in a shelter or a camp. Hikes are generally considered to range between 11-19 km for half a day or 19-32 km for a full day of hiking. These types of hikes require the capability of carrying the necessary provisions for the duration of the hike (The Editors of Encyclopaedia Britannica, 2022). The benefit of hiking in contrast to the strenuous counterpart trekking is that it requires less gear to be able to complete a hike. The middle ground between hiking and trekking is known as base-camping. Here a camp is set up in a given area and the hiker walks several trails during an extended period of time over multiple days (Total Hiker, 2022).

Difference Between Hiking and Trekking

Looking at the differences between hiking and trekking, hiking would be considered as more casual and less strenuous. This means that requirements for specialist gear or items for hiking is lower. Although hiking most commonly takes place on established trails and paths, hiking in general takes place in nature and the conditions of the trails can vary from being dry to wet or snowy. When trekking, the requirements for being able to walk through various terrain is higher and could require special footwear or gear. Trekking differentiates itself from hiking by two defining aspects. First being the length of the trail, where the activity often takes several days or weeks. The second aspect is the challenge level, and trekking is considered as more arduous and requires good fitness to participate. It often contains routes in difficult and climbing terrain (Foxfield, 2021).



Ill. 09 *Different terrain level. (City of Phoenix, 2022)*

This insight gave an understanding in the differences between hiking and trekking. Developing a product for hiking would be scalable to trekking. Trekking equipment would be more specialist from the beginning.

PANELS

Through the project, users and experts have been needed to gain knowledge and get ongoing feedback. The panel below shows people who have been involved in the project.

Experts

Expert 1, Lykke

Works at Friluftsland. Has experience in trail running and hiking. Beside Friluft-land, she works as a hiking guide for different age groups.

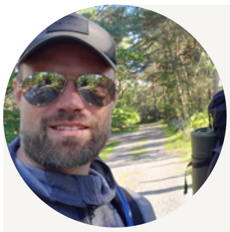
Expert 2, Maja

Works at Spejdersport. Has plenty of experience in hiking and trekking.

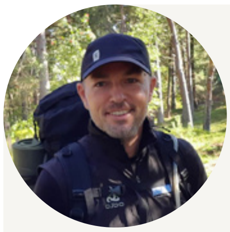
Hikers

Mads, 45
5 years experience and has previously been in the mili-tary and hikes with the social in mind. He is not a survival hiker, but a gear fanatic, who buys new gear to try it out. He often gets wet feet from sweat during a hike.

Jesper, 30
He defines himself as a gear nerd from another dimen-sion and he works at Even-tyrlyst. He hikes 2000km in a year and has experienced wet boots plenty of times.



Peter R., 47
Former military experience, has 2 year hiking experi-ence. Uses hiking to get away from everyday life. Experience wet boots from sweat. Likes to buy quality products.



Peter L., 45
Works as nature guide, has previous military experience and has several years of hiking experience. Likes the art of lightweight packing for a hike.

Test persons

Alexander, 27
He has been hiking since he was three years old and hikes a weekend trip 2-3 times a year. In this regard, he is used to testing proto-types as he is located close to the team.

Frederik, 28
He is a gear enthusiast in a lot of outdoor activities and appreciate a well thought detail. Therefore he will test prototypes as he is located close to the team.

WET HIKING BOOTS

How do Hiking Boots Get Wet?

Getting wet feet can be broken into two categories, internal and external conditions. The external conditions come from moist weather such as rain and snow or walking in wet climate such as dew, streams, or snow. These are common reasons why boots get wet. Hiking boots that are affected by external conditions are often non-waterproof boots, as they are intended to be more breathable for the feet (app. 3).

Whereas the internal conditions for getting wet boots are due to sweat from the feet. During the day a person's feet can sweat approximately 236 ml, and if the sweat has nowhere to escape it can lead to completely soaked boots and socks (LaFee, 2017). Especially waterproof hiking boots, consisting of a waterproof PTFE membrane, have proven to keep the moister inside, even though it claims to be breathable. As the membrane is effective in keeping external water out. (app. 3).

Ill. 10 *The most popular hiking boots on the market according to the two experts (app. 3). The brown boot is a non-waterproof boot, but breathable. While the green boot is a waterproof boot consisting of a gore-tex membrane, not as breathable but warmer.*

Amount of Water in a Boot

To define the amount of water in a boot, a test was performed based on a simulation of external factors. The results were concluded on the feeling of when it is uncomfortable to walk with the boot (app. 4).

The test resulted in a uncomfortable limit value of 250 ml, which will be the starting point for the future drying tests. The test also provided an understanding of how water penetrates the boot, with the toe area being the most vulnerable and exposed to water quickest.

Ill. 11 *The hiking boot was sprayed with water, in order to simulate the external conditions and control the amount of added water*

Ill. 12 *An illustration of a boot cut in half, showcasing the location of the toe area.*

! The toe area is a vulnerable area, where water gets in the boot quickest.

! 250 ml is the case 0 for future test.

Consequences of Hiking with Wet Boots

Being on a several days hike where hikers are constantly moving, wet feet and boots can occur several times. Over time, this can lead to foot problems ranging from blisters, athlete's foot or at worst case, trench foot or infections such as cellulite or sepsis (Kramer and Barrell, 2019).

Trench Foot

In worst case, hiking with wet feet can lead to trench foot or immersion foot syndrome. This is an injury to the foots skin tissue caused by prolong exposure to temperatures between 0-15°C in wet conditions. These conditions cause the blood flow to stop running to the feet and can resolved numbness, blue skin, and pain. Trench foot will typically start to develop in 1-2 days in the exposed condition and if it is not treated it can damage the skin, blood vessels, muscles, and nerves and in worst and rare cases, causing gangrene or need for amputation. Trench foot was first named and a common sickness during First World War (1914-1918). Today it is not as common problem as long the footwear fits, the foot is dry and the body is warm (Morrison and Barrell, 2018).

Athlete's Foot

Also known as tinea pedis is a common fungal infection on the skin, typically at the toes. Humid condition, such as sweaty, warm, and confined spaces, can lead to the fungal start growing (Mayo Clinic, 2022).

Ill. 13 *Image: trekaddict.co.uk*

Blisters

Wet feet and non-fitting footwear will cause blisters on the skin, commonly on the heel and toes. Blisters can be caused by friction against the skin from the footwear, which makes the outer skin layer separate from the under skin and fills the gap with plasma. Blisters usually does not require medical attention but are common within active sports and can be uncomfortable and painful (Cornerstone Foot & Ankle, 2022).

This knowledge provides an insight into the internal and external conditions that makes a pair of boots wet and which consequences it can have for the user. It made the team aware that there are two types of hiking boots, with and without a waterproof PTFE membrane. The consequences of walking with wet boots will be an issue no matter the types of hiking boots or the internal and external conditions.

The team had also chosen to focus only on hiking boots, as these are mostly used on longer and uneven terrain due to ancle support.

- A boot can get wet by internal and external conditions.
- The solution must dry a pair of wet hiking boots.

TRENDS

Hiking and trekking have become more popular than ever. Partly in due to the COVID-19 pandemic, people have been seeking to reconnect with nature. Increase number of people are engaging in hiking not only as a community sport but also as a break from everyday life.

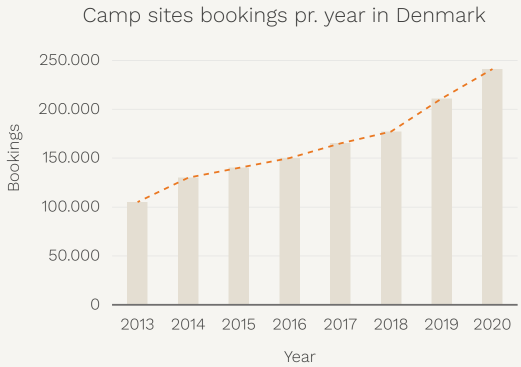
From 2019 to 2020 the *Danish Nature Board of directions in Denmark* recorded an 125% increase in visitors hiking in selected areas around Denmark (Naturstyrelsen, 2021). Furthermore in 2020 they recorded 250.000 registered bookings in shelters and camps around Denmark, which was 30.000 more than 2019, and is a total increase of 130% since 2013 (ill. 14), (Naturstyrelsen, 2021).

In the US the numbers of hikers and campers increased even further with a 52.9% increase from 2019 to 2020. Which means 8.1 million more Americans went hiking and 7.9 million more went camping from 2019 to 2020 (Outdoor Industry Association, 2021).

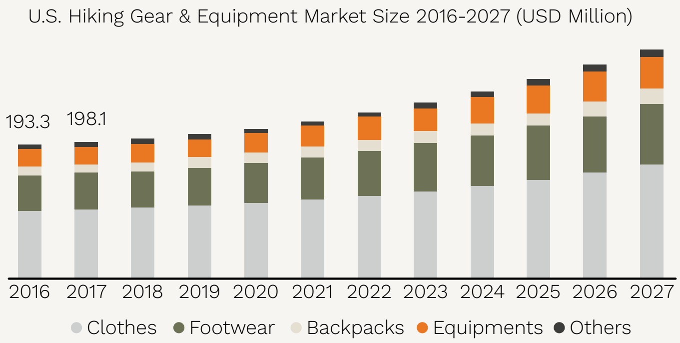
Danish Coast & Nature Tourism Board have been researched trends developing over 2020 and are preparing to scale their business in Denmark to include more trails and guided walks. They assessed the hiking culture is here to stay and will increase the following years. One of the trends they are seeing an increase in, is nature stays with slight luxury meaning better sleeping and lodging accommodations (Skovsted Kvorning, James and Halkier, 2022).

Market Potential

Furthermore, an increasing trend toward a healthier lifestyle can be seen in the demand for hiking gear and equipment. The global market size for hiking gear and equipment is estimated to be increasing within the next few years (ill. 15). In 2019, the market was estimated at 4.5 billion USD, and it is expected to be increasing by 6.3% between 2019-2027. Which is equivalent of 7.4 billion USD in 2027. *Grand View Research* states, that growth in interest from consumers lies in investing in heavy-duty boots for outdoor activities (Grand View Research, 2020).



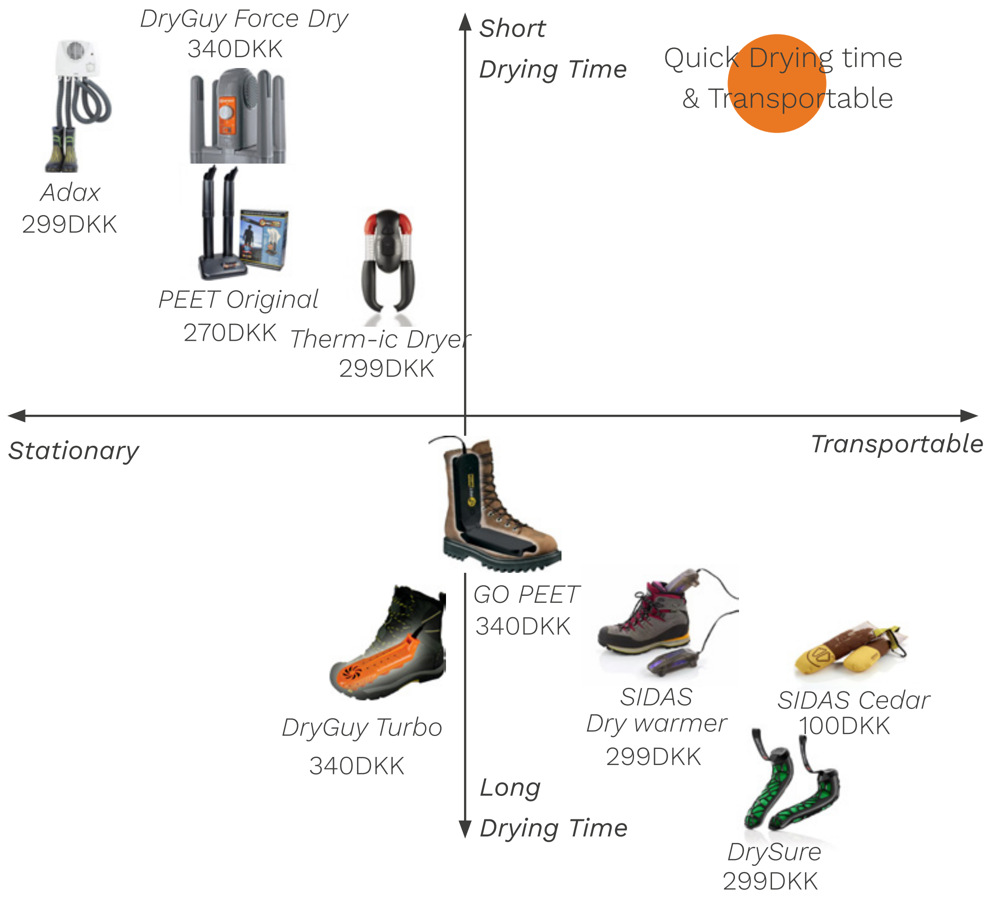
Ill. 14 *Increase in shelter bookings per year since 2013 in Denmark (Naturstyrelsen, 2021).*



Ill. 15 *Estimation of the U.S. Hiking Gear & Equipment Market Size 2016-2027 (USD Million) (Grand View Research, 2020).*

MARKET OPPORTUNITIES

To understand the market for boot dryers an investigation was conducted of competitive products through perceptual mapping (Perceptual Map, 2022). The aim was to understand the current market and how the products differentiated from each other. Furthermore, it was researched into their efficiency in drying time and the price point.



Ill. 16 *Market analysis of current shoedryer on the marked. The orange circle indicates the gap and the solutions positioning, a quick and transportable solution.*

Market Analysis

The competitive products are compared to each other on basis of their drying time and transportability (app. 5). These parameters were chosen based on the user's need through insight knowledge from experts and hikers. The analysis showed that the products with the shortest drying time were the least transportable. Mainly due to these products needing a power outlet and having a higher power consumption. However, the most transportable products were without electricity. They have the longest drying time of 8-12 hours. The analysis showed that there is a blue ocean for a transportable product with a short drying time. This position will be the aim of the solution.

An assessment of the products stated drying time and power consumption showed that the SIDAS Dry warmer was the biggest competitor, as it was the closest to fulfilling the user's need (app 5). Therefore, the SIDAS Dry warmer will be the benchmark, for the minimum performance of the project solution.

The solution must dry a pair of boots within a short timeframe and be transportable.

The solutions must be better than SIDAS Dry warmer.

THE HIKER

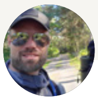
From early in the process, the strategy was to create a high-end solution. The solution must fit with the user, defined as a gear fanatic hiker. Therefore, several online interviews (Aarhus Universitet, n.d.) with hikers, within the target group, was conducted to gain an inside to their needs and values. Additionally, to look out for a common pattern in the target group.

The Gear Fanatic

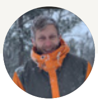
The target user is a hiker defined as a male gear fanatic, in the age between 30-45 years old. This hiker has at least two years of hiking experience and can be categorised between the moderate to an expert hiker (app 6). One of the biggest reasons he hikes is to get away from a hectic everyday life with stress. He often has a previous relationship with nature, such as childhood memories or previous work. In addition to getting out into nature, the aim is also about socializing through the hobby and achieving personal goals.

As a gear fanatic, a bunch of time is spent researching the equipment before buying them. It can be anything from product information to online reviews and through their network, as a big part of the hobby. It can take up to several months before he decides to buy the next hiking product.

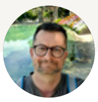
"It feels nice to buy some nice equipment and it because a sport in looking and researching" - Peter R.



"I'm a gear nerd and i like new gear and have often bought new technology when it comes on the marked. I am one of the first who buys it." - Jesper



"It is expensive to be poor" - Mads



Interview with Jesper

Interview with Mads

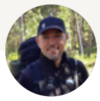
Interview with Peter and Peter

Comfortable Need

Lightweight and compact are terms that resonate amongst hikers and are two needs that users are looking for in equipment. Both terms define the user needs, as it is limited how much they can carry on a trip in weight and volume. However, both needs vary according to the product category and the hike. Based on the interview, a pattern was discovered from both needs as they describe a deeper need of which is to achieve comfort. Comfort confined by the hiking universe without "cheating", in order to be persistent on a hike (app 3 & 6).

Important factors for gear fanatics are the durability and efficiency of the equipment. It is important for the users that everything is working optimally and there is no room for error, since they have invested a large sum of money into high quality equipment. Another need for the user is the ability to show off their equipment, as there is a competition in owning the newest and smartest products. Therefore, it is important that the equipment can withstand the surroundings of drops and dirt without breaking or the performance lives up to users' expectation of a high quality product.

"Is is always fun to show of the gear you own" - peter L.



"I like to buy equipment from new, since I know it is only me who have used it. And if something breaks I can only blame myself." - Jesper

Durability is an important need for the user, since there are no turning back during a hike.

Emotional Value

During the analysis of the interviews, it was clear that their prioritization of equipment arises on the basis of their personal values. One of the hikers mentioned, that he had recently reduced the weight of the hiking bag by 3 kg without compromising on the necessary features to gain a comfortable hike. Whereas later in the interview he mentions that he likes to bring his special coffee equipment, which is a heavier than similar equipment, but he thinks it brews better coffee. This shows that if the equipment has a greater value for the user (emotional value), the users' requirements within light weight and volume will be of less importance (app. 6).

Based on the analysis of interviews, it could be defined that the gear fanatic does not appear as a hardcore survivalist who aims for the most lightweight and smallest gear on the marked. It is more important for the user to bring the equipment he needs and wants, which makes him comfortable both physically and mentally in order to have a nice hike.

The understanding of whom the gear fanatic is have become clearer in terms of the relationship and approach to equipment. Therefore, the solution must make the user feel and appear professional among the user's hiking companions.

Furthermore, it has become clear that comfort is the main value and reason for the needs such as compact and lightweight. However, needs like lightweight and compact are important for the hikers, but require further investigation in order to understand what they means.

✓ The solution must be of high quality and durable in nature.

! Words like lightweight, compact and emotional value needs to be defined. However, the user's main need is to make his trip comfortable within the framework of hiking.

Current Drying Methods

There are different ways to dry hiking boots during a hike. Where in this section the focus is on current drying methods. These methods are based on desktop research, interviews with experts and hikers (app. 3, 4 & 7).

Newspaper

Bringing newspaper is a very popular method as the material is lightweight, affordable and does not take up much space. The newspaper is placed in the boot, to absorb the water.

Towel

Like the newspaper, the towel is placed in the boot to absorb the water. The towel has multiple uses, but takes up more space.

Shoe Dryer, SIDAS Dry Warmer

This solution is not common, although it is sold by hiking shops. According to the experts, it is too much of a hassle to use for hiking and therefore it is seen mostly in hunting and skiing. It uses heat to evaporate water.

Bonfire

The boots are placed close to the bonfire to evaporate the water. This is a poor method as it can result in severe damage to the hiking boots, due to the high temperatures.

Fan

The fan solution is not as commonly used in hiking and is mostly based on the stationary shoe dryers on the market. It changes the air in order to dry the boot.

The Sock Method

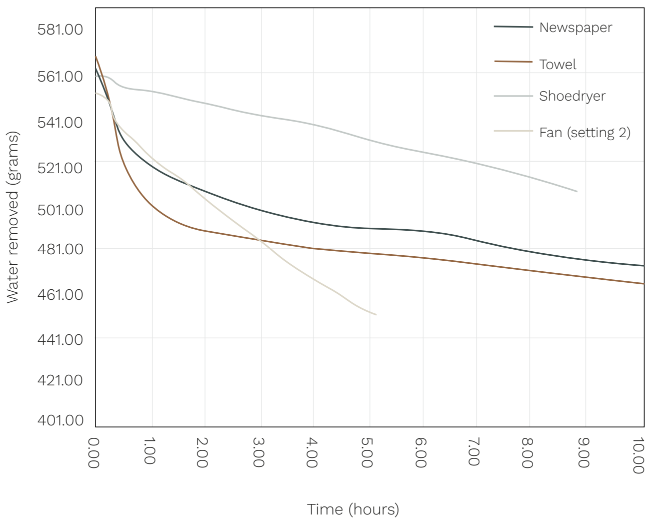
This method is common among hikers. It requires three pairs of socks. If the boots get wet, put on a pair of dry socks, the wet ones hang to dry on the backpack and a third pair in the bag for the next shift. The socks absorb the water.

The team got an inside to the most common drying method on a hike. But to understand their performance a test is necessary.

TEST OF CURRENT DRYING METHODS

Based on the insight into how hikers are drying their boots, four of the current drying methods were tested. The aim was to understand how fast they can dry a hiking boot and how the drying process develops. Only four methods were chosen in order to properly compare them against each other. To review the test in detail, see the appendix 8.

The test results showed that the fan manages to dry the boot in 5 hours, whereas the other methods did not dry the boot and the test took more than 8 hours.
In both absorbent methods, a larger amount of water was absorbed in the beginning. Hence the towel absorbed 52g of water within 30min. However, the drying acceleration slowed down, as the materials cannot evaporate the absorbed water in the stuffed boot. This concludes that it is important to change the air in order to dry the boot. Comparing the drying time of the fan and the absorbent methods demonstrates that it is important to change the air to dry the boot faster. This can be seen in the amount of evaporated water compared to the time. However, the benefits of absorbing a larger amount of water in a short time must be recognised. The test gave an insight into energy consumption.
The shoe dryer's power consumption is equivalent to a 320g power bank of 12000mAh (Backpackerlife, 2022), which results in a total weight of 520g.

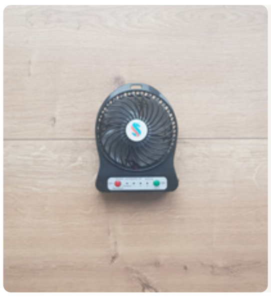


Ill. 17 *The graph shows the evaporation of water over time of the different drying methods. The towel and newspaper have an exponential curve due to absorption. Whereas the two others are more linear as the moist air cannot escape.*

Newspaper
Drying time: +10 hours
Volume: 466.2cm^2
Weight: 140g
Temperature: -
Energy consumption: -

Shoe Dryer
Drying time: +8:30 hours
Volume: 1132.5cm^2
Weight: 200g
Temperature: 33.5°C
Energy consumption: 11840mAh

Towel
Drying time: +10 hours
Volume: 1200cm^2
Weight: 405g
Temperature: -
Energy consumption: -



Fan, 3.9m/s
Drying time: 5:10 hours
Volume: 617.5cm^2
Weight: 159g (x2)
Temperature: -
Energy consumption: 4050mAh (x2)

Ill. 18 *The four different drying methods*

This study has provided an insight into how effective the current drying solutions are. It gave an understanding of what methods can help to optimize the drying process. However, it also shows that there is room for improvement.

SCENARIO

To understand the current user journey, an overall scenario is set up based on knowledge from desktop research and interviews with experts and hikers (app. 3, 4 & 7). This scenario represents a hiking trip before, during and after.

1. Preparing
Lots of time is spent planning the trip in terms of choice of equipment, food, and hiking routes. Each piece of equipment is carefully positioned according to weight and use during the trip.

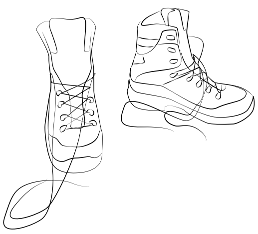
2. Hiking
At the beginning of the trip, the user is in good spirit. In the first 15min, a small break is taken to prepare and warm up the legs to prevent injuries.

3. Wet Boots
During the hike, the boots have become wet from internal or external conditions. This creates discomfort the more the boot gets wet.

4. Break or Lunch
Within hiking, there is a golden rule of taking a break in between hikes. This can vary from hiker. Eg. hiking in 60min and 10min break. At this stage, the sock method is used for drying the boot. A Lunch break can vary from 20-60min.

✓ It is a wish to dry the boots within 1 hour.

5. Hike
The hiking continues where the fatigue of the body begins to set in.



6. Camp
The wet boots are set to dry with the other drying methods. At the camp, the user might need the boots for bathroom break. This can happen both during the day and night.

✓ The solution must be quiet during use.

✓ The boots must be dry within 2 hour.

7. Hike
The next day, the hiking boots are put on. Depending on the amount of water and the drying method, the boots might still appear wet.

8. Home
Upon returning home, the bag is unpacked and some of the things are hung to dry due to moisture or odour

Ill. 19 *The current user scenario of a hiking trip. The current drying methods are being used In Steps 4 and 6. Whereas the sock method is currently the only solution during step 4.*

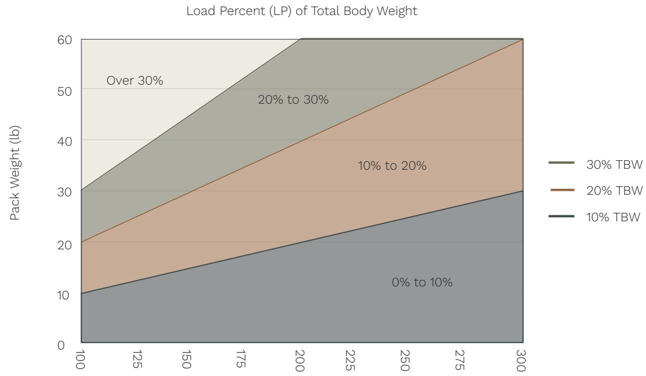
Through the scenario the team was able to form an insight into how the context takes place and how the solution can affect the user through their hiking. Whereas steps 4 and 6 represent the most direct interaction with the user, step 1 is just as important for the user. However, the weight must not be forgotten as it has an impact on the remaining steps. The team's focus is in the outlined boxes.

THE BACKPACK

As seen in scenario step 1 (page 19) there are systems and strategies for how hikers pack their backpacks. This is an important step which connects with the user's need for a lightweight and compact solutions to avoid injury and discomfort. A breakdown of the backpack's context was made to understand its relation.

The Backpacks Weight

There are some general guidelines on how heavy a backpack should be, such as keeping the weight of the backpack at max. 30% of the hiker's total body weight. However, the priorities can be different depending on the type of hiker. Seen on ill. 20 is the relation between the percentage of body weight and the packing weight (Anthony T., T., 2013). For traditional hikers it is usually above 30lb, lightweight hikers are between 20-30 lb, ultralight hikers are 12-20 lb and minimalist hikers are less than 12 lb (Anthony T., T., 2013). Where the gear fanatic can be framed in between the traditional and lightweight hiker.



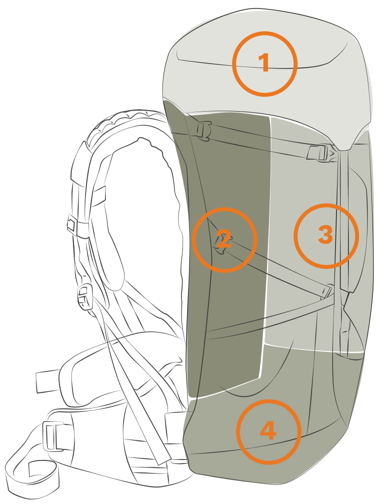
Ill. 20 *The chart shows the relation between the pack weight to the percentage of the hikers weight (Anthony T., T., 2013). A body weight of 80kg corresponds to a load percentage of 20-30%, a pack weight of 16-25kg.*

Weight Distribution

The limitation of the volume is related to the construction of the hiking bag in terms of the volume of the bag's rooms. The weight is strategically distributed to create a more comfortable trip and save energy. Therefore, the location of the centre of gravity is commonly located in the middle of back, where the height of the centre of gravity can vary according to the type of hiking trail (Anthony T., T., 2013). Overall, the hiking bag can be divided into 4 sections (Brown, 2021). However, smaller section details such as side and belt pockets, chink cords and loops will not be highlighted.

1 **Lid**
Lightest Items
Small items where there is a need for accessibility. This could be compass, lighter, rain cover and snacks. Other small items, which are not necessary for quick access can be packed in outer pockets.

2 **Middle Back**
Heavy Items
Heaviest items are placed closest to the body to decrease moment of force, keep balance and keep the backpack centre of gravity. This includes cookware, food, stove hydration reservoir, tent etc.



3 **Middle Front**
Lightest Items
Lightest items is place here to reduce the moment force. This includes pillows, clothes, toiletries, towel etc.

4 **Bottom**
Mid weight Items
Bulky medium weight gear. This includes sleeping bag, air mattress, pillow, etc.

Ill. 21 *A map-out of the backpack, showing the main four section of room division.*

This study provided an insight into weight distribution in a hiking bag, an estimate of the user's hiking bag weight and the construction and functions of the bag. Since it was desired to have a drying time within one hour during a break, the solution must fit into the lid.

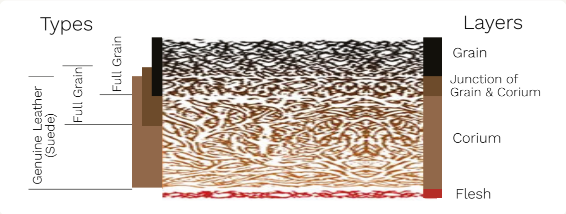
✓ The solution should be accessible and fit into the lid.

MATERIAL OF THE BOOT

Some of the most common materials used for hiking boots are leather, nylon, rubber and PTFE membrane. To gain an understanding of the materials regarding drying boots, desktop research and an interview with a shoe repairman have been conducted (app. 9).

Leather

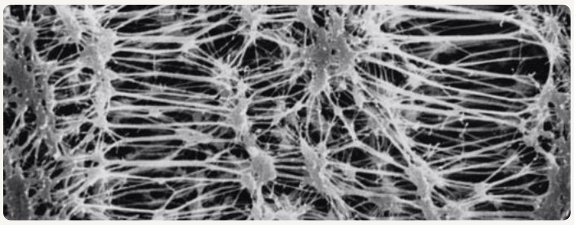
Most hiking boots consist of leather or nubuck leather. It is a durable, breathable and flexible material, which is resistant to puncture. It can absorb and disperse moisture and when the leather is steamed it can stretch 20-30% (Camotrek, 2020). If the leather is dried too fast and comes under 40% relative humidity, it can start forming cracks.
The structure of the leather consists of three-layer: grain, a junction of grain and corium, and corium. Where nubuck leather is sanded and buffed down to the top grain providing resilience (Best Leather, n.d.).



Ill. 22 *Leather Layers (Best Leather, n.d.).*

Polytetraflourethylen (PTFE)

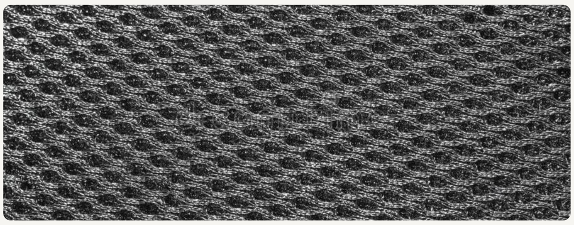
In a waterproof hiking boot a PTFE membrane (Polytetrafluoroethylene), such as Gore-tex or eVant, is included in the laying underneath the outside shell of the boot (Camotrek, 2020). It is a durable and elastic material that keeps external water outside of the boot. Just as with other materials, the membrane wears down during use and loses its effect over time. This can be caused by wear from dirt, repetitive movements with weight or a puncture of the membrane.



Ill. 23 *PTFE Membrane. Image: yanpai.de*

Nylon

A common synthetic material is nylon. It is used for several parts of the boot, such as mesh, lining or smaller parts on the sole. Its common use is partly due to its lightweight, strength and can be a breathable material (Real Diapers, 2022). It is unclear what type of nylon is used for hiking boots. But based on nylon 6, the glass transition temperature (Tg) begins at 50°C, whereas its melting temperature is at 220°C (Industrial Netting, 2022).



Ill. 24 *Nylon mesh. Image: dreamstime.com*

Cotton

In older hiking boots cotton or other organic materials are used for the lining. Whereas in newer hiking boots it is mostly leather or synthetic textile. Cotton fibres are soft, breathable and can withstand heat. While it is proven to absorb water and is slow at drying (Camotrek, 2020). If the cotton textile gets wet and untreated it can shrink about 3% (Rathore, 2022). This can lead to the boot shrinking a half a shoe size. This changes the fitting and will increase the chance of blisters (app. 9).

Ill. 25 *Cotton. Image: reperci.org*

CONTEXT OF THE HIKING BOOT

To understand and define the context of a boot it is necessary to break its autonomy and functions down. Therefore a hiking boot was cut in half and the interview with an expert in repairing shoes lead to further understanding (app. 9). In this section, the highlight from the research is presented.

1 Collar

The collar of the boot helps to create support for the foot. It often has a thicker layer of foam on the inside to create comfort around the ancle.

2 Lining

The lining is the inside surface, which protects the foot and creates comfort. There are different types of lining and layering used for different needs, spanning from soft leather, cotton and synthetics fabrics. However, the most commonly used is synthetic textiles, such as woven nylon, due to its properties of being lightweight, durable, less absorbent and quick-drying ability (Camotrek, 2020). In a waterproof hiking boot, a PTFE membrane is included in the laying underneath the outside shell of the boot (Camotrek, 2020).

3 Outsole

This part often consists of rubber. As with other types of hiking equipment, there are different functionalities properties for the outsole, where the most common is durable and slip resistance (Camotrek, 2020).

4 Midsole

This part function as a support and cushion for absorbing shock from the terrain. The most common materials are EVA (Ethyl-vinyl acetate) and PU (Polyurethane) (Camotrek, 2020).

5 Tongue

This part of the shoe is softer and flexible as its function is to provide access to get the foot into the shoe. Like the lining, the tongue consists of similar materials. However, there are often one or more layers of foam to create comfort from the tightening of laces. (Camotrek, 2020).

6 Toe Area

This area is furthest away from the opening of the boot, which will make it harder to get rid of the moisture. Often a nylon mesh can be seen on the outside of the top, which provides the necessary ability to breath for the shoe and foot. This also creates a more vulnerable area for the toe area and faster wear of the lining materials, since dirt and water have an easier time penetrating (Camotrek, 2020).

7 Insole

The insole is a cushion, which often can be taken out of the shoe. It can consist of fiberboard, nylon, synthetic foam or leather (Camotrek, 2020). The most important thing about the insole is that it is flexible, supports the foot and is durable. However, it is important to note that the shoe has difficulty breathing under the insole as the surrounding materials block the ventilation. If the water is trapped and can not evaporate, the shoe will start to smell, due to bacteria and fungi will begin to grow within 1-2 days (app. 9).

Joints

The shoes' materials can be assembled in various ways, such as sewing, casting or glueing together. In particular, adhesive joints can be extracted, discoloured or dissolved if it's near radiant heat or high temperatures (Garde, 2018).

Interview with expert in repairing shoes

Ill. 26 *A hiking boot cut in half shows the hidden construction and component of the boot.*

The insight into the boot's construction and knowledge of the materials created an essential understanding of the limitations of the solution. Hence, it is important to meet the requirements as a broken or deteriorated boot can worsen the user's comfort or in the worst case, harm the user.
Therefore, the construction of the boot must not be extended too much during drying, as it will affect the fit. It is especially important for the user that the boots fit. The same is applicable with too high temperatures, where the boot can shrink by half a shoe size. In general, heat has a great impact on the durability of the boot. If temperatures are above 50°C the joints may dissolve, and the leather may crack over time if the relative humidity reaches below 40%. Whereas an RH above 60% will cause fungi and bacteria to thrive, which will degrade and make the boot smell within 1-2 days. Therefore, a boundary is set between 40-60% as the optimal relative humidity in the boot. Below are some of the extracted requirements:

- ✓ The boots internal temperature must not be over 50°C
- ✓ The boot must not shrink or expand during the drying process
- ✓ The relative humidity must not go below 40% due leather drying out fast.

CLIMATE CONTEXT

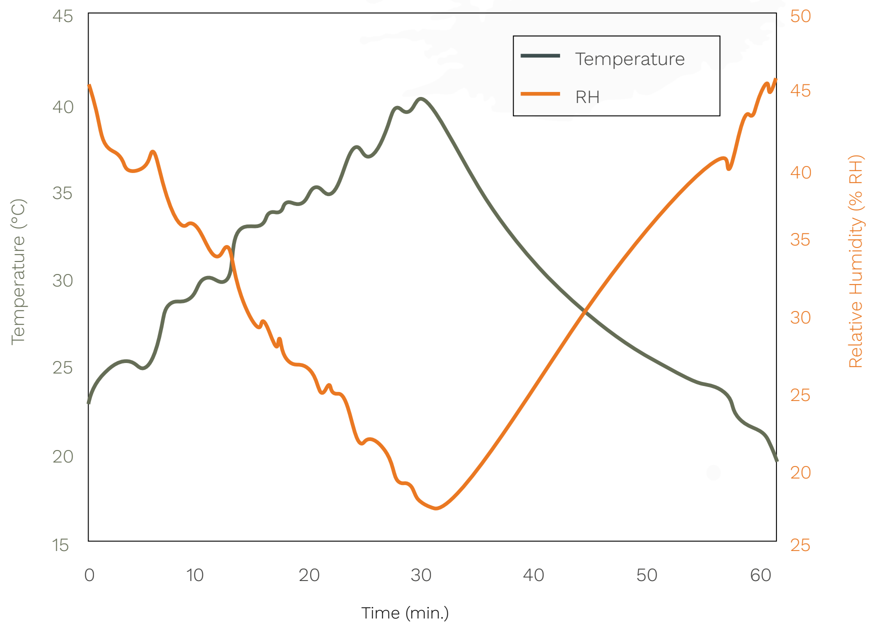
The climate is different around the world. The level of humidity and temperature affects how easy it is to dry a pair of boots. Therefore, it was necessary to limit which climate the solution should be designed for. Hence, the necessity to set up boundaries for the climate, to define the worst and best scenarios.

Relative Humidity (RH)

Humidity can be measured with different methods. The two most common terms are Absolute Humidity and Relative Humidity (RH). Absolute humidity is the total mass of water vapour divided by the total mass of dry air in a given volume at a certain temperature. This means an expression of grams of water per cubic meter of air, measured as (g/m3) (Chandler, 2021).

Relative humidity is a ratio of the current absolute to the highest possible absolute humidity at a given temperature. Therefore, it is a percentage based on the current temperature to the absolute. If the relative humidity is at 100% it means the air is not able to contain more water. The total amount of water vapour air can contain differs when the temperature changes because air molecules are affected by temperature. This means that in the summer when the air is warmer and expands it can hold more water, giving a lower relative humidity compared to the winter season (Chandler, 2021).

The relative humidity can also be pushed to the extreme, towards the absolute humidity as for places like the Amazon or Antarctica where both places have 100% relative humidity because of the extreme temperatures and climate. Therefore, graphs of the relative humidity will have their maximums in both the lowest and highest temperatures and the minimums in the middle ranges of temperature in a given place (ill. 27).



Ill. 27 *The graph shows the relationship between temperature (green) and humidity (orange) to time. When the temperature is low, the humidity rises. When the temperature is high, the humidity drops (Liu et al., 2019).*

The temperature of the climate and relative humidity will affect the drying time of the solution. It will be more difficult to dry a pair of boots in winter compared to summer, due to the amount of moisture per. m3.

From the same theoretical aspect, it will be very different how the boots will dry from a different location in the world and it is necessary to narrow in our geographical location.

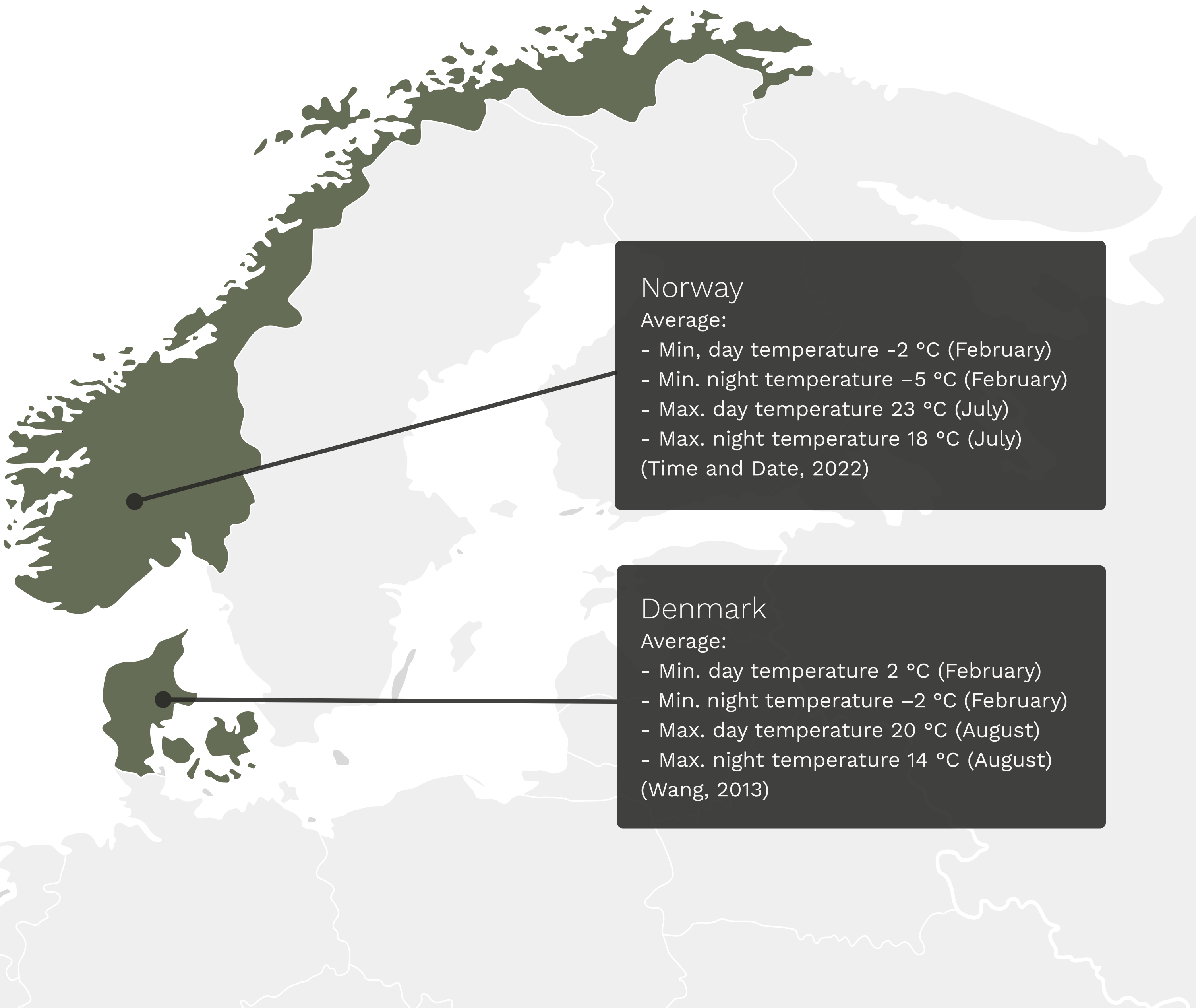
Geographic Location Limitation

It was chosen to design the solution for hikers hiking in Denmark and Norway. Denmark was chosen based on availability for tests and simulating the real climate. Norway was also chosen as its climate is very similar to Denmark, and because many hikers who hike in Denmark also hike in Norway (Wang, 2013). Especially Denmark has a climate with high humidity (Time and Date, 2022). Consequently, it is a climate where it takes a long time to dry a pair of boots outdoors. Therefore it is likely that if the solution works in Denmark, it will work well in warmer and dryer climates (app. 10).

This leads to a climate boundary for the solution as it must be able to dry a pair of boots within a climate temperature and RH:

Max RH 91% at -2°C
Min RH 70% at 20°C

It is chosen that the solution will work in Denmark and Norway.



Ill. 28 *A part of the world map, highlighting Denmark and Norway as the context for the solution*

DESIGN BRIEF

One month into the project, the design brief was completed and was established from the collected investigations and limitations of the hiking scenario, context and gap in the market.

Problem Definition

How to design a portable device that can dry a wet hiking boot fast, during a several-day hike, without damaging the hikers boot.

Vision

The vision is to create reliable solution that makes drying hikers boots on the go accessible and helps saving the feet, thereby giving the hiker a comfortable hike.

Value

A 5 min. Brainstorm (Tollestrup, 2004) of adjectives in relation to the user's needs was conducted and processed through the Triangulation method (Lerdahl, 2001) to form a common understanding of the values the solution should create (app 11).

Heroic
"A fireman saving a kitten from a tree"

Accessible
"Like an apple on the counter"

Reliable
"A pets unconditional love"

Sum Up

The team has gained an insight into the users' hiking environment and the potentials of the current market. Furthermore, the field was made more tangible by narrowing the climate, define a wet boot and the type of footwear.

Challenges

- Create a solution which is "compact" and "light weight", while drying the boot fast without damaging the boot.
- How to keep the power consumption low
- Understand the relation between the users emotional values against the practical needs

Wishes

- Dry a pair of boots within 1 hour
- To support the shape of the boot during the drying process

Requirements

- Must dry a pair of waterproof or non-waterproof hiking boot
- Remove water from the toe-area
- The solution must not injure the user
- The solution must be transportable
- The solution must be durable in nature
- Must not fail during a hike
- Must make the user more comfortable
- Must be quiet during use
- The boot must not shrink or expand during the drying process
- Must not expose the boot to chemicals and oils
- Make RH between 40%-60%
- Must work in climate of RH 90% at -2C
- Must work in climate of RH 70% at 20C
- It must be a high quality
- It must be compact
- It must be lightweight
- Must dry a pair of boots within 2 hours
- The internal temperature must be below 50°C
- Must fit into the backpacks lid

Ill. 29 *Render from milestone 3*

02 IDEATION

From the essential understanding of the hiker's universe, a chronological sequence of the process will be presented in the following chapters. In this chapter, ideation will be formed and investigated through drying tests, prototypes and the hiker's feedback in order to align the process to one concept. Furthermore, the aesthetic direction will be explored and defined.

INITIAL SKETCHING PHASE

Building upon the knowledge from the test of the current solutions for drying hiking boots (app. 8), it is apparent that most of the drying solutions were either heat, airflow or absorption in the boot. However, the team has no knowledge of how they affect each other in order to dry the boot most efficiently. To explore the possibilities, the initial sketching phase was begun consisting of three rounds of sketching (app. 12).

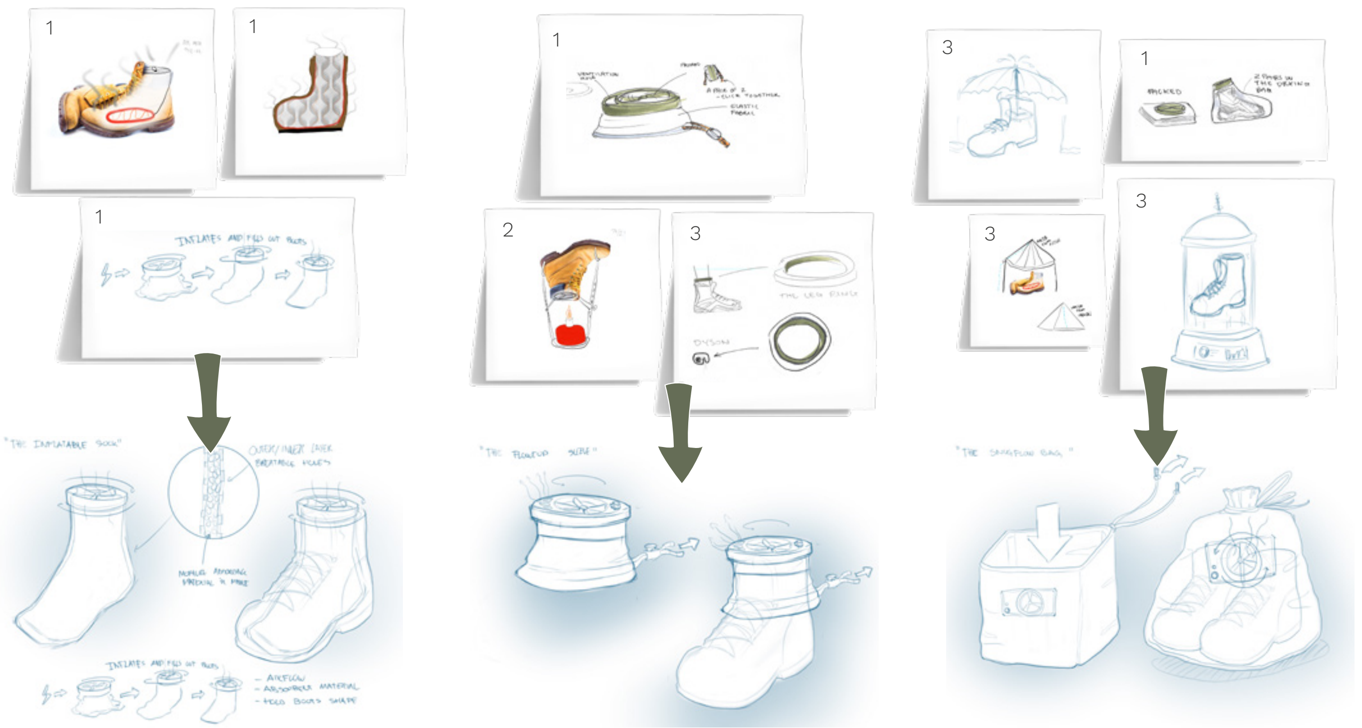
1. Round was a 30 minutes free sketching, due to a need for the team members to get their initial thoughts out after collecting the essential research.

2. Round was based on the challenge the mechanics of drying by using something else than electricity to power the drying. This time using propane or steam as a driving force.

3. Round the team used "What if" sketching method (Tollestrup, 2004), which where build upon three different scenarios; What if it was under water, in the future and in the rain.

Based on the initial sketching, the sketches were discussed between the team members. This resulted in a clustering of the sketches which formed three categories. This strategically divided the sketches according to locations on the hiking boot.

Ill. 30 *A selection of sketches from the three sketching rounds which were grouped into three directions*



Inside the Boot
An inflatable absorbent "sock" is inserted into the boot with the fan to lower the internal humidity.

Semi Inside-Outside on the Boot
A fan is tightened around the opening of the boot and dries the inside with warm air, which replaces the internal humidity.

Outside the Boot
A pair of boots is placed in a bag with a built-in tab, which dries the boots in a closed environment.

Milestone 2

The essential knowledge of the theme and two of the concepts were presented to Milestone 2 (app. 13), where the feedback indicated an absence of a deeper understanding. This involves understanding how the water can be removed and its relation to the hikers' context. Furthermore parts of the scenario were unclear, including the framework of when a boot can be defined as dry and which energy sources will be ideal for the context. Therefore, the next step was to clarify the removal of water and specify the constraints of the context.

TEST OF PERFORMANCE PRINCIPALS

To understand the performance of the concept's principles, replications of their constellations were simulated and tested. The purpose was to gain an insight into how the different drying sources relate to each other and their drying efficiency. In appendix 14, an elaboration of the test's structure, data, analysis and result can be read more in-depth.

Ill. 31 *Pictures of the 5 tests*

Test 1
Drying inside: 40min
Air speed: 10.9m/s
Temperature: 36-38°C
Energy consumption: 2121 mAh

Test 2
Drying time: 1h20min
Air speed: 10.9m/s
Temperature: 36-38°C
Energy consumption: 4275 mAh

Test 3
Drying time: 3h20min
Air speed: 3.9m/s
Temperature: 33°C
Energy consumption: 3030 mAh

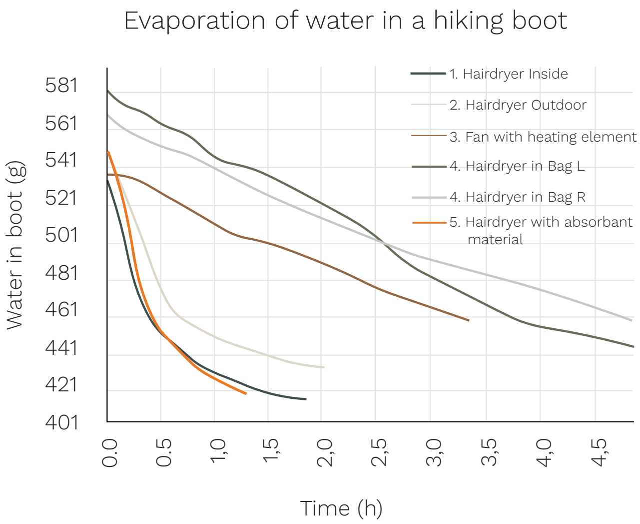
Test 4
Drying time: 3h50min-4h50min
Air speed: 10.9m/s
Temperature: 36-38°C
Energy consumption: 12.310 mAh

Test 5
Drying time: 50min
Air speed: 10.9m/s
Temperature: 36-38°C
Energy consumption: 2571 mAh

Comparing the tests, it is clear that the bag concept (test 4), can be eliminated due to the lack of effective drying and time. This leads to narrowing the solutions framing to the boot being dried from the inside to optimize energy consumption and focus on the user's need for comfort. The definition of comfort is not necessarily equivalent to a complete dry boot and therefore needs further investigation.

Throughout the test, it was observed that a temperature of 26-30°C would be the effective ambient temperature of all the solutions.

Furthermore, to understand how big of a difference between outdoor and indoors a comparison between tests one and two shows a 40min increase in drying time outdoor (9°C). Due to the weather changing, the future test will be conducted inside, in order to compare the test.



Ill. 32 *The graph shows the effectiveness of the different drying constellation by comparing time to how many grams of evaporated water in an hiking boot (app. 14).*

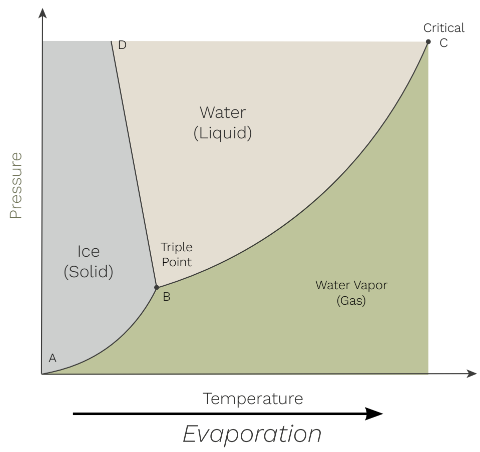
This test proved that a combination of air and heat reduced the drying time. Although the hair dryer is much more powerful than any finished portable solution would be, this still creates a good benchmark for the solution moving forward. This test made the team reflect on what is the main value the solution should offer to the user. This concluded in the primary unique selling point is to create comfort for the user, which does not mean a completely dry boot. However, a complete dry boot is a wish, which builds more on the "prolonging the lifetime" of the boot. Therefore, "dry to the touch" must be defined in order to benchmark the goal of the performance.

! For the best result for the user the boot must be dried from the inside.

HOW TO REMOVE WATER IN THEORY

Several different methods could be used to remove the water from the boot. To determine which method would be the most effective with the least use of energy, the different methods must be assessed. The assessment will be from either the theory behind and / or from tests of the methods.

Water can be removed from the boot with several methods. One method is transferring water to another absorbent material, like a towel, as this will absorb moisture and withdrawn it from the boot. Another method is to transfer water to the air. This can be done by bringing water to a boil. No matter what method is used to remove the water, it transforms one type of energy to another. No matter what method is used to remove water, it transforms one type of energy to another to change state. Illustration 34 shows the phase diagram for water, and shows that in order for water to change state, it changes the energy in form of change in pressure or temperature.



Ill. 34 *Phase diagram for water (Inspirit, n.d.)*

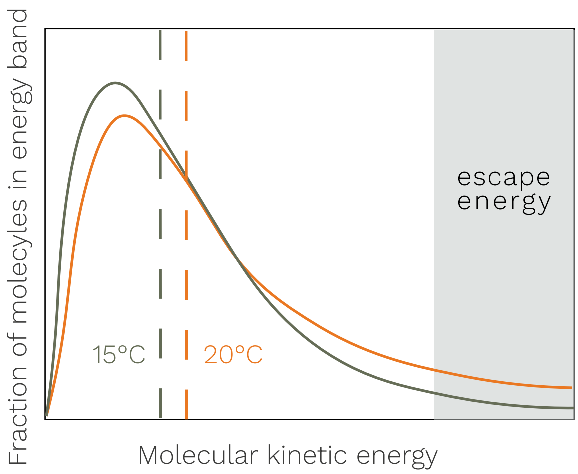
Boiling the Water

Boiling the water and turning it to vapour to transfer to the air seems at first like a simple method to remove water. Whether it is a good solution for drying the boots can be determined by calculating the energy this method demands.

To vaporize all the water from the boot the water must be heated to its boiling point, 100°C. The heating can determine a certain amount of energy which can be calculated. To get one gram of water to boil it takes 100 cal equal to 418 joules. To get it to vaporize it takes 540 cal equal to 2260 joules. Though, it takes 632.374 joules to vaporize 236 grams of water equal to 175 Wh. This requires 14583 mAh at 12V (Arthur and Saffer, n.d.). To have 14583 mAh per boot available on a hiking trip it would require 3 large powerbanks of 12.000mAh each (Backpackerlife, 2022).

Energy Used with Evaporation

Another change of state for water is when water is evaporating. Here it transfers from liquid state in the boot to the air as water particles in gas state. In order to determine if the best method of transferring water from the boot to the air is through evaporation, a understanding of evaporation is necessary. For the evaporation of water to happen the molecules need enough energy to be able to escape the surface and transfer into the air. As water needs to change state, from liquid towards gas, in order to transfer to the air, it needs energy. The energy used in this transformation is kinetic energy stored in the water, that affects the thermal energy in the air making the air colder (Bengtsson, Segel, Havsteen-Mikkelsen and Padfield, 2004).



Ill. 33 *The relation between the kinetic energy in the molecyles and the temperature (Bengtsson, Segel, Havsteen-Mikkelsen and Padfield, 2004).*

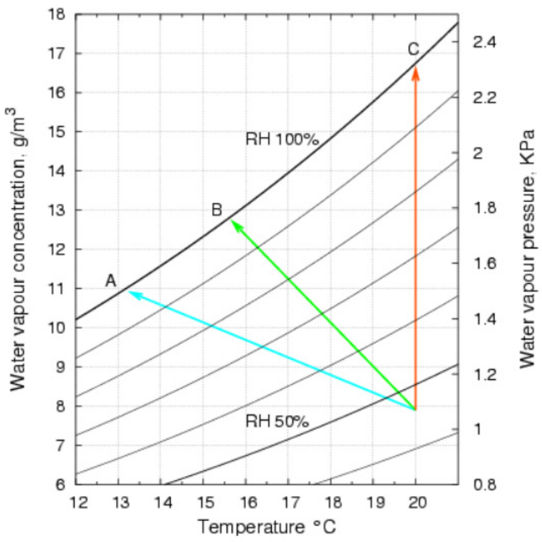
Illustration 33 shows how the energy in water molecules at 20°C at the orange curve, and at 15°C at the blue curve. When water in the boot gets colder the evaporation will be slower, as it needs energy in the air in form of heat to transfer to the water, for the water to have enough energy to escape the surface and into the air (Bengtsson, Segel, Havsteen-Mikkelsen and Padfield, 2004). Though, by heating the air the evaporation will happens faster.

Ventilation During Evaporation

Besides the temperature of the air, the speed of the evaporation depends on more factors, one of these is the humidity of the air. There are constantly water molecules transferring from the surface to the air and from the air to the surface. The higher the humidity the air has, the more water molecules will transfer back from the air to the boot. Which means, that the higher the humidity of the air, the slower the evaporation of the water from the surface to air will be (Bobrowsky, 2020), (NASA, n.d.).

The warmer the air is the more water it can contain as the air expands allowing for the absorbing of more water, the more molecules can be contained in the air as an intermediary and be used to transfer moisture from the boot (see section about relative humidity page 24), (Bobrowsky, 2020), (NASA, n.d.).

However, at some point the air will not be able to contain more water even when the temperature is higher. This can further be explained by Ill. 35, where relative humidity is compared to the temperature at a given molecular pressure (measured in KPa). By raising the temperature, the water vapour concentration at a given temperature rises. Although the air then contains more water, if the relative humidity in the boot rise, but the air is not exchanged, the relative humidity will rise to 100% and the boot will never dry.



Ill. 35 *Vapour pressure diagram in comparison to relative humidity (Bengtsson, Segel, Havsteen-Mikkelsen and Padfield, 2004).*

This is where ventilation during evaporation makes a difference. Additional by adding ventilation through draft or directed airflow, blowing dry air into the boot would decrease the RH and thereby allowing the new air to contain more water molecules as it is passing through the boot and out again (Bengtsson, Segel, Havsteen-Mikkelsen and Padfield, 2004).

Hypothesis

As there are multiple factors that effects the speed of the evaporation of water, it is difficult to calculate the energy use and time spend on evaporating 236 grams of water from the boot. Though, a hypothesis will be set instead, and this hypothesis gives basis for comparing it to the results of tests in practical application instead of on a theoretical level. The factors that effect the speed of the evaporation is the temperature of the air inside the boot (up until a limit), the humidity of the air and the rate of air exchange.

The hypothesis is therefore that *by heating up the air in the boot, and simultaneously creating an airflow allowing for rapid air exchange in the boot, 236 grams of water can be removed in less than 2 hours.*

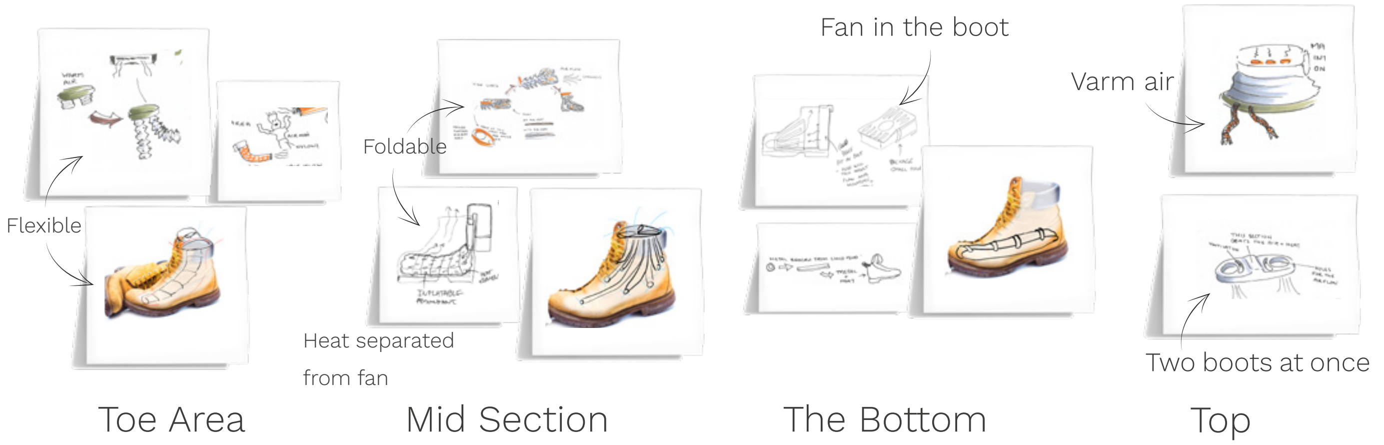
Comparing Hypothesis to Tests

The test of different drying methods showed that the most effective method was to use a hair dryer inside the boot (ill. 32 page 29). By using the hair dryer, the air is both heated, and there is a rapid air exchange. Furthermore, the relative humidity was lower inside than outside. This proof that by heating the air and increasing the wind speed with air that has the lowest possible humidity, results in faster evaporation. In the test using a fan, whereas only the airflow changed and not the temperature, the drying time increased from the hair dryer. This proves that heating the air will to some degree make the evaporation faster as the relative humidity decreases with the temperature. When the boot is dried from outside, in a closed bag, there is less added new air and there is no air circulation inside the boot. Though this method of drying was the least effective in the test. This proves that rapid air exchange in the boot leads to faster evaporation of the water.

Increasing Heating and wind speed makes a positive difference for the drying time.

SECOND SKETCHING PHASE

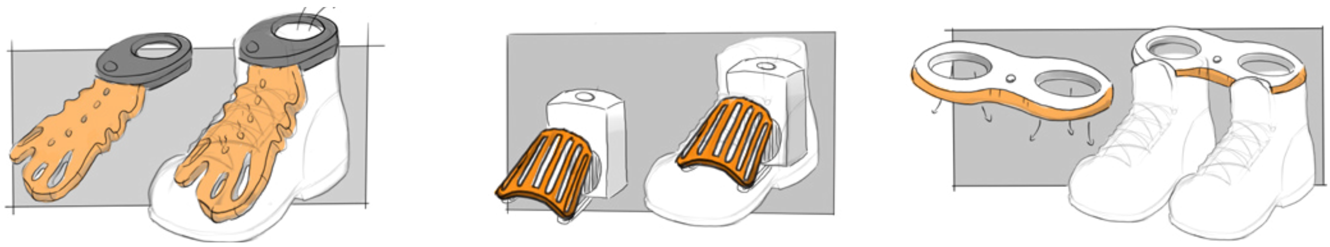
The next sketching phase was commenced based on the understanding evolved from the test of principles and theoretical. The focus of the sketching was to dry the boot from the inside in different locations and conceptualise ways to optimize the drying process. Two sketching rounds of 15min each were conducted and evaluated by the team (app. 15).



Ill. 36 *An excerpt from the sketch phase.*

The sketches were evaluated by the team, where the choice of the three concepts was formed on the diversity of the ideas. In particular, the positioning of the fan and how each concept differences in their unique selling point (USP), were elements that would be interesting to investigate further in a performance test and interaction study.

Three Concepts



1 Concept
The fan is placed at the top. Uses resistive heating. The fan is removable for multiple uses. The insert is flexible and devise the air in the boot and absorbing the water.

2 Concept
The fan is placed inside the boot for direct airflow to the toe area. The heat is located in the insert. Is foldable and adds support to the boot

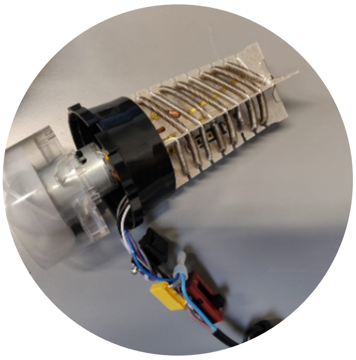
3 Concept
Uses a bladeless fan. Dries two boots at once. Works as one unit. The fan is placed at the top and uses resistive heating

Ill. 37 *Sketches of the three concepts*

The team was in the same situation as the first sketch round, where “proof of performance” was in focus and crucial for the team in order to weighing the concepts performance of drying time against each other. Therefore, the next step was to build three "performance prototypes", which could exclude the location of the fan and mapping the drying time.

THE HEATING ELEMENT

The first step towards a working prototype was to investigate which heating elements would be ideal for testing the concepts and a possibly candidate for the final solution. In the test of the principles (p. 29), the team used drying methods that were out of proportion in terms of energy consumption compared to the hikers options. Therefore, in this phase, power consumption is taken into account with the intention to retain the test realistically.

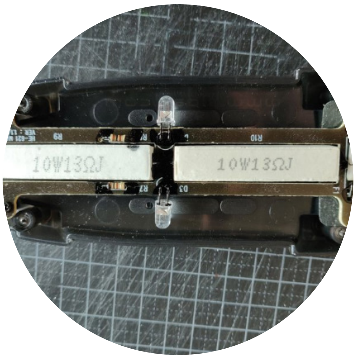


Heating Filament

A hair dryer were open to test the efficiency of the heating filaments. Using 30V (the maximum output of power supply) only resulted in 0.3A and generated just enough heat to where it was unpleasant to hold for longer periods of time. However, the heating element did not generate a lot of radiant heat. It was not possible to get a exact temperature.

Pros
- Flexible
- Comes in various length and thickness

Cons
- Needs a high amount of volt to generate enough radiant heat



Ceramic Heating Element

The exiting shoe dryer consisted of two ceramic heating element. By supplying 5V (as it was intended from the manufacture) at 0.737 A and generated 28.5°C, less than the proclaimed 33.5°C. Further testing, it was achieved a temperature of 45.3°C and outputting 12.5W by supplying 9V at 1.4 A.

Pros
- Little power was needed to heat the ceramic element

Cons
- Not flexible
- More expensive than the others

Carbon Fibre Heating Element

The carbon fibre at various length have enough internal resistance to generate temperatures at the desired watts, meaning the output would be similar to the ceramic heating element. Testing the heating element at various length, in series and parallel gave a better understanding of the temperature output at the lowest power consumption. The closet comparison to the ceramic heating element was two pieces of 25cm long wires in parallel running outputted 43.2°C and 12.2w by supplying 1.75A at 7V.

Pros
- Flexible
- Cheaper than the ceramic heating element

Cons
- Not as energy effective as ceramic heating element

△ **Ill. 38** *Pictures of the various heating elements that have been tested. From top to bottom: Heating filament, Ceramic heating element and Carbon fibre heating element.*

The reason for choosing carbon fibre over the other elements, are the flexibility of the element. However, the fibres would need to be cast into another material in order to work in a practical solution. This could be done by casting in a rubber.

AIR AND ABSORPTION

Warm Air

In order for the air to be heated up, a heating element is needed. In hair dryers ceramic elements are used to produce 2.000 watts of energy in order to quickly heat up air as it passes through the hair dryer. This is known as resistive heating and requires an immense amount of energy to heat the air in a short time span, in this case in less than a second. Hair dryers operate at 60-80°C effective temperature, but in order for the air to increase, the heating elements in the hair dryer are maximised at 300-400°C. It would not be possible to construct a solution that uses resistive heating, without using large amount of energy or creating a very hot internal heating element. Therefore this solution is excluded in the a portable solution and other alternatives are needed to created a heated environment within the boot.

Ill. 39 *The picture above is a hair dryer drying a hiking boot from the principal test (p. 29). Even though it dried the boot in 1h20min it need 3.214Ax-1h20x1000 = 4499.6mAh.*

It is not possible to create hot air in a transportable solution. Therefore, the solution must separate the heating element and the fan, to keep power consumption down.

Absorbent Material

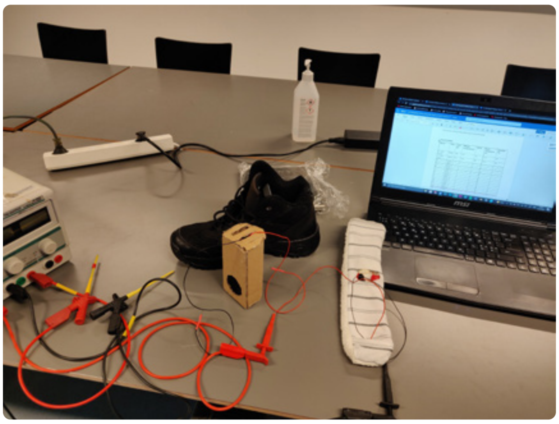
Before testing the different elements, absorbent material was investigated since the test with a towel of the current drying method, absorbed 52g of water within the first 30min (app. 8). Absorbent solutions were looked up which resulted in researching super absorbent materials such as silica gels or Super Absorbent Wonder Sponge (app. 16). However, a dog blanket called Wet2Dry uses a combination of viscose and bamboo to absorb 90% of moister, within 15 minutes (Siccaro, n.d.). Due to this impressive drying time and flexibility, a similar material was chosen as the absorbent material for concepts 1 and 2. Furthermore, a prototype of this combination was made in order to experiment with its effectiveness (app. 17). Regarding the theory of moisture being transferred out of the boot either by being absorbed by another material or air as explained in the theory (p. 30).

Ill. 40 *The picture shows concept 2 as a prototype, which includes air, heat and absorption for fasten the drying process.*

THE FIRST PROTOTYPE TEST

Based on the research of the components, a prototype of concept 2 was built to make the first performance test. In order to make the prototype work, it was necessary to experiment with the heating elements. By a similar set-up as the previous drying test (app. 18), the prototype was only able to withdraw 32g within the first hour. This is less than the combination of the shoe dryer and fan (p. 29), at higher power consumption and the temperatures did not even reach room temperature. Conclusion was that something had to be wrong. The following was determined;

- The heating element need to work so the watt output remains at 12.5W to increase temperatures enough.
- The absorbent material was blocking the airflow and the was saturated after 30 minutes, with not enough heat or air to transfer moisture out of the boot.
- Working in parallel with various aspects of the concepts could help move the project forward.



Ill. 41 *A picture of the set-up of the first test.*

Reaching this test was time-consuming and required time to understand the system and new heating element. Which makes it difficult to estimate when "proof of concepts" can be carried out. This concern was brought up at the next supervision meeting.

Re-evaluation of the Process

Halfway towards milestone 3, the team's focus was on developing the solution's drying performance. This act can be reflected in how the current sketches were selected and in the directions of the process, such as focusing on building a performance prototype in 1: 1 to the three concepts.

A supervisor meeting was arranged to discuss the team's frustrations in regard to how time-consuming building a functional prototypes was and obtaining performance test results. The meeting created clarity for the team as the focus had been too much on proof of performance and too little on the solution's use in the scenario and the visual identity. This shows an importance of working on different aspects simultaneously and have something to fall back on.

This reflected in a bigger picture of a necessity in utilizing the available time and creating knowledge which can be reused in other contexts, due to uncertainty about the performance of the concepts.

Therefore, the next step was to explore the gear fanatic's aesthetic and tactile preferences to translate it into the product identity.

Furthermore, a reflection of the supervisor meeting led to a reassessment of the current handling of the process. Of which the team began to visualise the tracking of the overall process by dividing it into parallel paths such as prototype building and aesthetics research. The purpose was to communicate the project direction and get an overview of the goals of the main task.

THREE DIRECTIONS OF AESTHETICS

As a result of the team's reassessment of process management, the next step was to define the solution aesthetically based on the gear fanatic.

Gear v. Gadget

To understand the contrast between the expression of gear and gadget, and their relation to different levels of quality, a perceptual mapping was created (app. 19). The mapping was based on existing hiking products, which were placed on the scale through conversation to form a mutual understanding. This activity was evaluated based on the placement of the solution vision, which leans closer to gear and of a high quality.

> The team got a collective understanding of gear being a necessity and gadget being nice to have.

Ill. 42 *An extract of perceptual mapping, shows the desired placement for the solution regarding the relationship of quality level and gadget vs gear.*

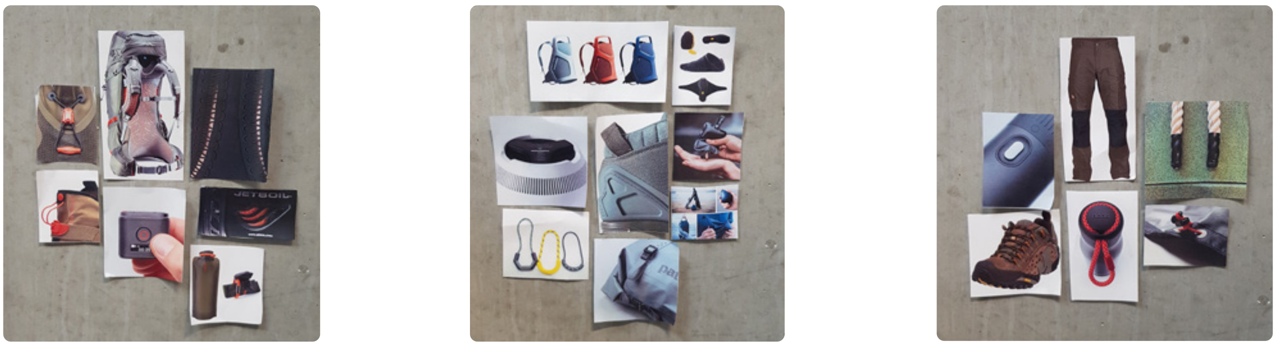
Three Aesthetic Style Boards

Clustering (Tollestrup, 2019) was used as a warm-up before the aesthetic directions were created (app. 19). The purpose of the activity was to discuss possibilities within aesthetic details based on the vision and to point out tendencies for the gear fanatic's aesthetic.

Based on the perceptual mapping, (ill. 42) through the clustering and a previous mapping of different hiker aesthetics (app. 19), three different style boards directions were formed (ill 43). The strategy of the directions aims to examine what the gear fanatic is best identified as.

Two interviews with hikers were conducted to get their association with hiking equipment and their description of the three style boards (app. 20). The interviews showcased the importance to emphasize the expressions of functionality and quality through the design. This can be enhanced through line guidance, materials transition and colours. Illustration 43 shows three aesthetic directions and feedback on their perception of each direction.

> Having an outstanding colour highlight the products function or feed forward.



1. Modern

- Modern hiker
- Categorised as mid-rang to high-end
- Leans more towards gadget.
- The functions are more in focus, compared to the quality
- Technical expression

2. Next Generation

- Appears as less experienced hiker. If not categorized as being younger.
- Categorised as low-end to mid-range
- Futuristic and leans more towards urban

3. Survival

- A classic hiker aesthetics
- Is strict and mature
- Categorised as high-end
- Expresses more experienced hiker
- Quality

Ill. 43 *The three aesthetic directions, with bullet points from the interviews*

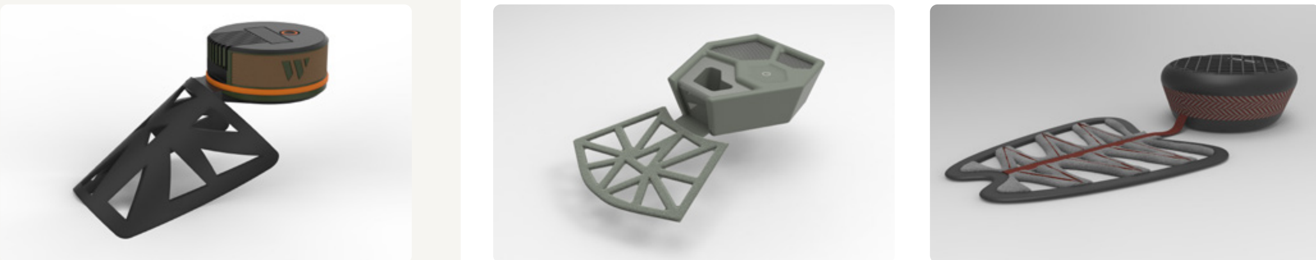
AESTHETIC TEST WITH THE EXPERTS

Based on the feedback from the interviews and the three style boards, the three directions were translated into 3D renderings, based on concept 1. The purpose was to transfer the abstract aesthetics to a specific form. In order to examine the degree of detail of the directions. The three renderings and an initial interaction test were conducted through observations and interviews with the two experts (app. 21).

The Aesthetic Direction

The experts was presented to the three renderings and asked to describe them regarding the expression, the user and price range (ill. 44).

Ill. 44 *Rendering of the three direction of aesthetics.*



1. Modern
Recognizable within their product range and fits the best with the gear fanatic. One of them even compared it to the Jetboil (ill. 61, p. 49). Some of the main features were its solid expression and the use of a familiar colour range.
Expert 1: Expensive
Expert 2: Cheapest

2. Next Generation
Targets the younger hiker and appears robust in shape and materials, but also a bit clumsy. One of the experts expressed that it focuses too much on looking cool in relation to what you get for the money.

Expert 1: Middle
Expert 2: Expensive

3. Survival
Very elegant and simple, where the function is more in focus than the design. However, it expresses the least one of a hiking product and will only hit a few users.

Expert 1: Cheapest
Expert 2: Middle

In addition the teams understanding of compact was unfolded in terms of the user's need to organize and optimize the space in the hiking bag. Although directions 1 and 3 have relatively round geometries, direction 3 was considered to have wasted space in the conical shape in relation to organization. Whereas direction 1 had a simple basic geometry and was considered more compact.

Expert 1 further elaborated that most hikers including the gear fanatic prefer a bag for hiking products as it gives the product an extra value in terms of organization and storage.

Interviews with hikers and experts clearly showed that the first aesthetic direction was best aligned with the gear fanatic identity. This is due to the geometric design which expresses robustness and colours that are familiar to other hiking products.

! Direction 1 will be the direction of the solution

This research also gave a further insight to who the gear fanatic is. So far the team have mainly focused on the use of the solution and performance, whereas the before and after scenario is just as importance for the user. Therefore:

! Organisation is considered as an important part of the gear fanatic and must be looked into.

TESTING WITH THE EXPERTS

Initial Interaction Test

3D printed mock-ups of the three concepts volume were tested with the experts to examine how the shapes and size affected the interaction in terms of placement in the boot and use (app. 21).

The test showed that the concepts would only be switched on when they were in the boot and therefore the on-off function must be accessible when it is placed in the boot.
The feed forward was not very clear as expected. But the test showed where improvements could be made in terms of how it should be placed in the boot.

Ill. 46 *The two expert trying placing the mock-ups.*

The interfaces of the solution must be accessible when the solution is in the boot.

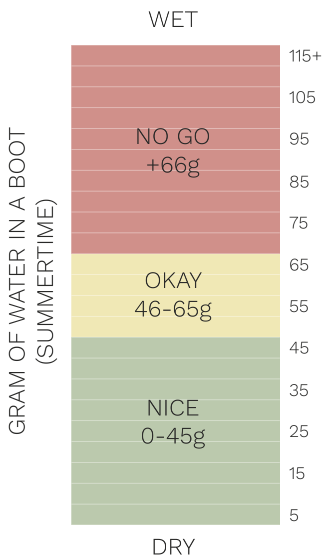
Re-evaluation of Framing

After the meeting with the experts, it became clear that the location of the solution in the hiking bag will be closer to the bottom or middle front, rather than the lid. This was reflected in the feedback on the size of the concepts, the hiker's cultivation of organizing and whether the solution is a necessity for quick accessibility. Therefore it is necessary to investigate the user's relationship to organization.

In addition, the requirement for a drying time of 2 hours was revised, since a drying time of 4 hours in the camp will be sufficient, as the camp site is the resting for the next day.

Defining "Dry to the Touch"

The team still had to define when a boot is considered dry. Based on the previous tests (app. 8 & 14), a measurable pattern could be formed by when the boot feels "dry to the touch" on the inside. This pattern was based on the feeling of dryness with the fingers to the amount of water left in the boot. However, there is a difference in the feeling senses between the hands and feet. Therefore, a test was conducted with a user, who used his foot to describe when the boot starts to feel wet and uncomfortable (app. 22). The test was carried out from the previous test 1, using a hair dryer. To simulate the hiking context the user wore the two most common types of hiking socks, cotton and wool (app. 21).



Ill. 45 *The scale shows the benchmark based on the amount of water and when the boot feels "dry to the touch". From 66 g and up, the boot feels wet. Between 46-65 g, the boot feels dry with socks on. Below 45 g, the boot feels dry with the fingers and socks on.*

Ill. 47 *The user testing the comfort while wearing wool socks*

From the results of the tests, the benchmarks of the feeling of comfort was formed into a scale (ill. 45)
Observation: the user uses his hands to check if the boots a dry before wearing them.

Acceptable moisture level between 0-65 grams of water left in boot.

UPDATED DESIGN BRIEF

The test with the experts gave the team a new insight to who the user are. Therefore, the mood board was updated and an interaction vision was created as the team was starting to focus more on the interaction.

Interaction Vision

To create the vision, a 5 minutes brainstorm was conducted of adjectives in relation to the user's needs (Tollestrup, 2004). Which was processed through the triangulation method (Lerdahl, 2001) to form a common understanding of the vision for the interaction of the solution (app 23). From the interaction vision a mood board was created to describe a common understanding of what feeling the solutions should provide or express to the user.

Interaction Vision:
"The solution must give the user control through a simple interaction and practical application making them feel professional."

Control
As a driving instructor who can control the situation if the student loses control

Simple
Kiss: Keep it simple stupid

Practical
Like a tree living through all season of year

Ill. 48 *From the left. Image: finespind.dk, Image: dorcadental, Image: amazon.com*

Mood board

Robust

Ill. 49 *Top Image: Theatlantic.com, Buttom: thejjreport.com*

Effective

Ill. 50 *Top Image: dictionary.cambridge.org, Buttom Image: topcarnews.net*

Proud

Ill. 51 *Top Image: dfs.no, Buttom Image: freepik.com*

POWER CONSUMPTION

Simultaneously with the aesthetics, work continued on the prototype, where decisions of power source and improvement of power consumption are explored.

Power Supply

By comparing the power consumption of the carbon fibre heater with the drying time of 4h50min from the previous test with the existing shoe dryer and fan (p. 29), the total power consumption of 4h50min would be 1.75Ax4h50x1000 = 8458mAh for one boot or 16916 mAh for two. Although there are power banks which contain a larger amount of mAh, the solution will consume most of the power and it can be discussed whether the gear fanatic would rather save this power for a "need to have equipment", such as a smart phone or light. An alternative to the power bank is to contain its own battery. Compared to a 320g power bank with 12000mAh (backpacklife, 2022), three batteries weighing 108g together can offer 12600mAh (Kikkert-Teleskohuset.dk, n.d.). From the test with one of the experts (app. 21), it was mentioned that electric hiking products such as headlamps contain batteries and most of the newer hiking products on the market contain rechargeable batteries.

Ill. 52 *One of our experts showed the store's section of power banks, where the range is between 10000-20100mAh with a weight between 240-491g.*

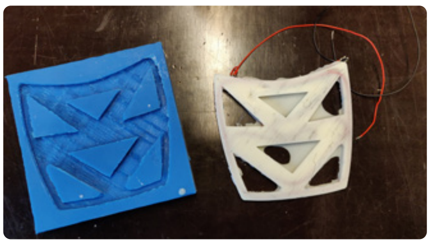
- ✓ The solution must be powered by its own battery
- ✓ The batteries have to be rechargeable

Optimizing Power Consumption

In re-evaluating the carbon fibre heating element, the power consumption of this solution was still too high to work in a practical solution, as drying one pair of boots would require 16916mAh. This meant, looking at optimizing the carbon fibre became a critical point. Changing the heating elements from two 25 cm wires to two 55cm wires running in parallel outputted the same watts but at lower ampere, resulting in 12,5W with 11V at 1.1A. Lower than the previous 1.75A at 7V (app. 24). Both configurations output 46°C in a dry boot, but allowed for the full use of the 3x3.7V batteries. This would decrease the power consumption with about 3300mAh per boot.

Shaping the Heating Element

With the power consumption sorted out, the next step was to create and cast a flexible prototype of the carbon fibre elements. Before casting, the heating element was shaped through cardboard mock-ups, which were cut and measured into the boots (app. 25). For the casting material, polyurethane rubber was used as it provided a flexible heating element that would not retain too much of the heat, since it has a thermal conductivity of 0.29 W/mK in comparison to silicone of 0.63 W/mK (Watts per meter Kelvin), (Lasance, 2001). This could be greatly improved by using ceramics as for the most common use of Aluminium Nitride ceramics have a thermal conductivity of 180 W/mK and are used in electric devices (Lasance, 1999), (Green, 2022).

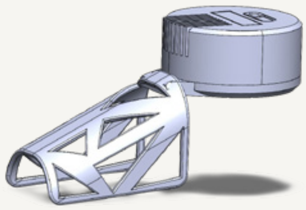


Ill. 53 *The prototype & the heating element.*

CONCEPT SELECTION

It was clear to the team that it would not be possible to test the drying performance of all three concepts before milestone 3 and it was necessary to converge the project in order to reach the team's deadlines. For that reason, it was decided to narrow it down to one concept based on the gathered knowledge. Therefore, pros and cons were set up for each concept to compare them to each other (app. 26).

Concept 1



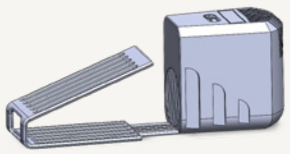
Pros

The cylindrical shape aligns with the users need for organising as it is optimal for compact packing. The heel and toe area get exposed to the air flow and the fan get air from the back.

Con

The cylindrical shape is not an optimal fit to the boot. The resistive heating is unlikely to work do to a higher energy consumption. The feed forward of the concept position in the boot depth is unclear.

Concept 2



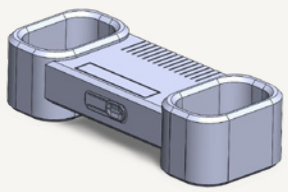
Pros

Fits into the boot. The heating element uses less power consumption and located in the boot. The airflow is directed to the toe area.

Con

The fan does not get direct air from the back, which requires more energy and it blocks the heel from getting dry. The shape does not fit all boot sizes.

Concept 3



Pros

The construction is considered more durable because of the minimum amount of joints. The shape is compact and it dries a pair of boots at the same time.

Con

It needs both boots to keep levelled and it is a waste of energy if only one boot needs to be dried. The resistive heating is unlikely to work do to a higher energy consumption and it is unsure if there is room for the heating elements.

Ill. 54 *3D drawing of the three concepts.*

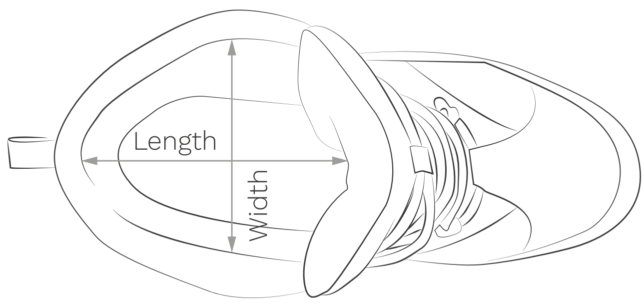
This lead to a combination of concept 1 and 2. Including thoughts behind the design regarding the user's needs, and the location of the fan from concept 1. Additionally implementing heating element in the insert from concept 2 to reduce the power consumption. This became the direction for the project.

DIMENSIONS

The next step was to define the dimensional constraints and set the dimensions of the concept size. Therefore, research of different shoe sizes' inner dimensions of the opening and component sizes was made to define the dimensions of the solution.

Measurements of the Boots

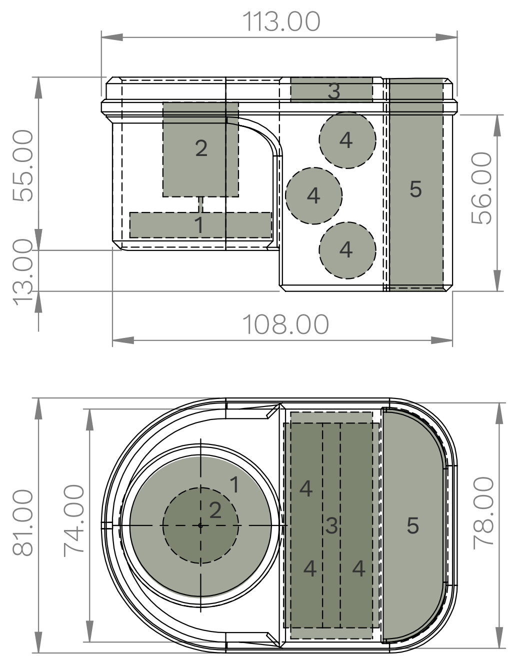
The opening of different shoe sizes of hiking boots (EU size 39-45) was measured up (app. 27) and the result can be seen on ill. 55. The boots were measured in a relaxed fit, since the solution must not stretch the shape, as it can change the fit of the boot in the transition from wet to dry. However, the anatomy of the hiking boot (p. 23) is made with flexibility in the give to the measurements, to make room for the ankle and to get the foot in the shoe, such as the extended length. Therefore the measurements must be seen as a guide. The dimensions of the boots opening are between the following: Width: 7-8cm, Depth: 11.5-13cm, Length 9-10cm and Extended length: 12-13.5cm.



Ill. 55 *Dimensions of the boots opening between a EU size 39-45*

Location and Sizes of Components

Based on the size limitations of the boots and the selected components, the boot dryer will have the following dimensions (ill. 56).



Ill. 56 *2D drawing of the concept main parts dimension based on the components size. The concept will be placed 56mm down into the boot, have a width of 78mm and a length of 108mm.*

1. Fan
Due to the dimensions from the research (ill 55), the fan can not have a bigger propeller than 45 mm in diameter.

2. Brushless DC Motor
24x30mm, 51g (Ke Gu Motor, 2021).

3. PCB board
Includes button and LED diodes, 72x26x8mm, 20g

4. Battery 4200mAh
18x65mm, 36g pr. Battery (Kikkert-Teleskohuset.dk, n.d.).

5. Ventilation
The dimension of the ventilation is based on the "available" space.

6. Heating Element
The carbon fibres have a diameter of 4 mm and in cast polyurethane, gives a outer dimension of 13x13.5x7mm, 101g (app. 28)

Based on the size of the concept and components, the weight of the current configuration was estimated at approx. 285g for the main part and 101g for the heating element, which in total is 772g for a set. The next step is to perform an interaction test, to examine how well the concept corresponds to the hikers need. Both in turns size and weight and not at least the interaction.

THE FINAL CONCEPT

The final concept was presented to milestone 3 and was based on the current knowledge. In the picture below is an overview of the concept which consists of knowledge based on the prototype, the feedback on the aesthetics and mapping of dimensions.

1 **Fan**
The fan creates airflow inside the boot in order to change the relative humidity and dry the boot faster.

2 **Ventilation**
To change the air in the boot ventilation helps the airflow system to release the evaporated water and lower the relative humidity.

3 **Rubber Band**
To indicate how far the boot dryer should be placed in the boot the orange rubber band indicates the limit and provide a secure grip.

4 **Textures**
The different texture add a physio-pleasure to the user, in order to give et a quality feel consisting of fabric, rubber and hard plastic .

5 **Heating Element**
The heating element is placed in the boot to absorb moisture using a combination of bamboo and viscose. To evaporate the water a carbon fibre heating element are placed inside its structure.

6 **Transportable**
The solution uses three battery to make it transportable, which is placed in the centre.

SUM UP

Milestone 3

For milestone 3 (app. 29), the concept was presented and it was clear that the interaction was not refined at all. This was highlighted through comments on the current design, as its details and functions was not well thought through with the gear fanatic hiker. The solution needed to more high-end in order to aim the user. This was further unfolded in a need for refinement of the interaction of how the solution is packed and neglect what happens when the solution is not in use.

Regarding the performance it was mentioned how the airflow is controlled and make sure the air gets out through the ventilation. It was even stated that a too fast airflow would make it difficult to heat it up.

Sum Up

From the initial interaction test with the experts, the team became aware that the user satisfaction about package and organize is an important element to create value for the solution.

Through the ideation phase and the feedback from milestone 3 it was clear that there was a need to involve the user more in order to proof the concept. Especially to test in a simulated context to go in depth with the detailing of the use.

Beside the need of organization the team got an better understanding of the gear fanatics visual identity through the interview and the final aesthetic direction. However the solution must make the user feel professional, so he can show off. To understand the direction of the ideal gear fanatic product the team started to use the motto: "*Like the Jetboil, but for boot dryer*", in order to describe the aim for at high-end hiking product.

Regarding the prototype, it starts to look more like the concept 1:1 and is considered to be a performance model, where the team starts to look into creating PCB board and internal electronics. However, it is still necessary to improve the performance.

Challenges

- Make the user feel professional
- Make the prototype transportable
- Optimizing the solution in size, weight and power consumption

Requirements

- Must dry the boot from the inside out
- Material of touching surfaces much have friction
- Must be powered by internal rechargeable battery
- Must include aesthetics of direction 1
- Must reflect function through aesthetics
- Must be organizable
- Interface must be accessible when in the boot
- Must dry till 65 g water left in boot

Wishes

- The solution should include a packing bag
- Must make the user feel and look professional
- Can dry till 45 g water left in boot

Ill. 57 *Picture from interaction test (p. 46-47).*

03 CONCEPTUALISE

Once the aesthetics was in place, the next step is to focus on the interaction of the concept. In this chapter, the prototype will be tested and several interaction tests will be performed, as well as further analyses to understand the user. The end of this chapter will lead to the final concept.

INTERACTION TEST

After the aesthetics had been given a direction and the team had chosen a concept, the next step was to examine the interaction. The interaction test took basis on the feedback from milestone 3, where a need for refinement of the team's understanding of how the solution is packaged was emphasized. Furthermore, a bag and an elastic band were added to the model to explore the hikers desire for organization from the expert's comment (App. 21).

The Act-out

The test was conducted through an act-out (Bagger & Sperschneider, 2003 p. 45-46) in the outdoor, where two test persons were asked to use the 3D printed boot dryer from unpacking, to use, to packing it back. This action was repeated three times, one with cold hands, one with cold and wet hand, and one with gloves on. During the act-out the test persons were observed and asked questions. The act-out was followed up with an interview. The data was afterwards analysed and broken down through clustering (app 30).

Unpacking


It was observed that the model was easy to get out off and into the bag. Even one of the user expressed an enthusiasm for the bag and defined it as compact and a nice detail, due to the square shape being easy to pack.

Inserting the Model


A struggled was observed as they had difficulties by inserting the heating element. It was a challenge to fold it and get it properly into the boot, due to the size and the friction between the heating element and the boot.

Removing the Model


Just as inserting the concept, both test persons looked clumsy when they tried to insert and remove the heating element. Even at their third round it looked as if they did not know what they were doing or as if something was wrong. Mainly due to the heating element being stuck in the boot.

Packing the Model


Ill. 58 *An excerpt from the interaction test.*

The elastic band which hold the two boot dryers together did not work as intended. It was difficult for user to get the band around the models, and it tended to slide of and did not hold them together properly. It was even described as when losing control of a pop up tent. However, the user thought it was necessary to hold the two boot dryers together.

Test with user 1

Test with user 2

Ill. 59 *Interview with the user after the act-out.*

Feed Forward and Feedback

Although the test persons were not told how to use the boot dryer, it was observed that they placed the main part according to the intentions. Afterwards, one of the test persons commented that the curve of the main part and the push button helped to indicate the direction and position.

The heating element was placed according to the intention by one test person. However, the feedback were ambiguous and both expressed uncertainty whether it was done correctly.

Material Transitions and Textures

After the act-out, the test persons were asked about the tactility of the materials. It was mentioned that the transitions of the different materials gave a feeling of quality. In particular, the fabric provided a physio-pleasure of quality in its rough surface structure. Where the rubber surfaces at the top and the rubber band, gave a sense of security.

However, the heating element was defined to be too stiff to fold and the absorbed material gave a cheap expression. The rough surface of the fabric elevated the tactility and the perception of quality.

Robustness

Both models had a weight equivalent to a realistic solution. One test person highlighted that the weight of the main part gave a perception of quality to the solution. However, he would not bring the solution with him on the Camino, as it will be too heavy. However, he could well see it in use on shorter trips, such as a weekend hike.

The biggest concern of both test persons was the cord between the two parts. It appeared too fragile and affected the accessibility of the interaction. By making the heating element snap on, it was occasionally easier than a permanent assembly. However, the hassle of accessibility during the interaction was still an issue.

The test showed that the main part of the solution was used as intended, and that the test persons understood how to use it. However, the heating element of the solution did not work as intended, due to its size, stiffness and friction.

The cord also made the solution seem fragile and was in the way of accessibility during use. Overall, it was cumbersome to insert and the test persons appeared clumsy. Since the goal is to make a high-end boot dryer that makes the user look professional in use, the heating element must be further developed.

In this test, organization was also tested for the first time, where the bag gave the desired value. However, the elastic band had the same challenges as the heating element and for the same reason, the joint between the two boot dryer needs to be explored.

TESTING THE ABSORBENT MATERIAL

Based on the act-out (p. 46), it was clear that the current size of the heating element did not work and it did not express as high-end hiking gear. Therefore, a test of the solution was conducted with and without absorbent material to understand the real effect of the material and to hold it up against the practical use of the solution (app 32).

Parameters	Without Absorbent Material	With Absorbent Material	Difference
Start weight of water (gram)	126g	110g	16g
First 10min. (gram)	6g	19g	13g
“Dry to the touch” (time)	2h40min	1h50min	50min
Weight lost to “Dry to the touch” (gram)	70g	55g	15g
Average weight reduction per 10 min. (gram)	4.38g	5.5g	1.13g
Evaporated water at 2 Hour (gram)	51.3g	57.6g	6.3g
Total weight loss to the same time (gram)	77g	72g	5g

Ill. 60 *The table shows key figures from the two tests. The green fields highlight which solution is best within the parameters.*

Evaluation of the Two Test

In the evaluation of the result, two elements were taken into account. The drying performance and the solution in practical use.

At first glance, there is no doubt that the heating element with the absorbent material is the best choice in form of performance. It can be estimated that it absorbed 13g of water, within the first 10 minutes. However, the test has sources of error, which make the result indicative. Since the starting weights are different in the tests, the actual difference in drying time is 30 minutes and not 50 as indicated in the schematic (ill 60), (app. 32). Based on a difference of 30 minutes, this will most likely not affect the use, as the requirement for drying time is within 4 hours.

Whereas from the user’s aspect, a solution with an absorbent material with electrical components will be more difficult to clean and will be wet after use, in regards to packaging.

Regarding the act-out (p. 46), the heating element must be smaller, as the current solution is too large for the different shoe sizes. It can be assumed, that the smaller amount of absorbent material, the less it will absorb.

! Based on the comparison, the absorbent material is deselected.

! The test without absorbent material has a "dry to touch" drying time of 2h40min.

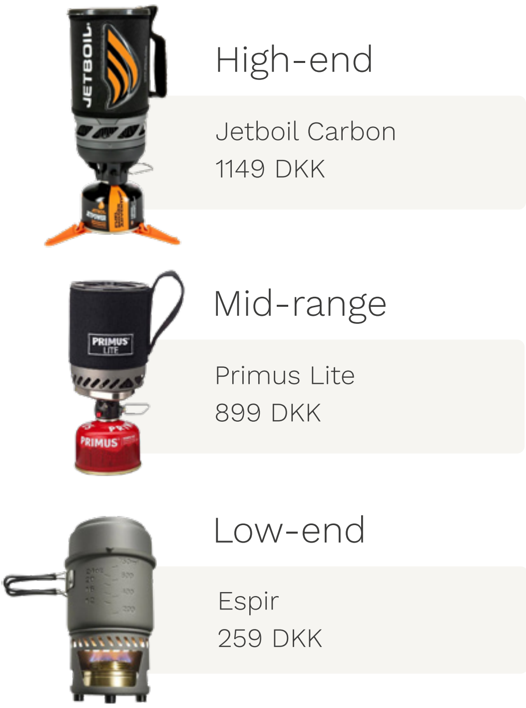
HIGH-END HIKING PRODUCT

Before conducting ideation for a new heating element, it was necessary to understand what makes a hiking product high-end. This action was based on the feedback from milestone 3 and the results from the current interaction test (p. 46). Therefore, an analysis was made of hiking products' price ranges and a study of the Jetboils construction.

Price Point

The average price for the current boot driers is around 310DKK (p. 15). However, portable boot dryers are not as prevalent in the hiking environment, and the high-end products does not align with the gear fanatic perception of high-end. Therefore, the solution was compared to other hiking products (app. 33).

The portable stove was decided as the most comparable product, as the stove on the market range from basic function stoves to more advanced and effective stoves. This scale also reflects the gear fanatics' position in the high-end range, since a high-end solution is about optimization, convenience and functionality. Compared to the stoves a high-end price would range between 800-1200DKK, based on to this research and the experts' estimation (app. 21).



Ill. 61 *Jetboil Carbon (Friluftsland, n.d.), Primus Lite (Friluftsland, n.d.)* and *Espir (friluft.dk, n.d.).*

The solution should be in the price range between 800-1200DKK.

Jetboil

Jetboil is a high-end hiking stove, which is a compact and efficient burner system that can boil water under 100 sec. (Backpackerlife, 2022). For this reason, the product was used to compare and reflect the quality which the concept must be able to offer. Team motto and vision: ***"Like the Jetboil, but for boot drying".***

Furthermore, the interaction and construction of the product were analysed to understand the details of a high-end hiking product. This resulted in the following observations through videos:

The simple geometry makes the solution compact and organized, as all its components can be packed into the container (ill. 62). Moreover, it does not hide its joints and most parts are locked together by turning. Most parts have several functions, regarding protection or in use. It consists of different materials and transitions. On the side it has a printed instruction guide, which is common in hiking products.

Ill. 62 *The Jetboil unfolded (Friluftsland, n.d.) and folded (Academy Sports + Outdoors, 2022).*

DEVELOPMENT OF HEATING ELEMENT

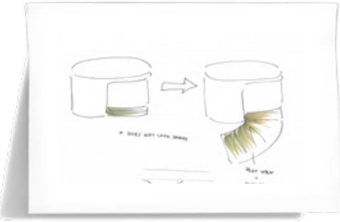
Based on the test results from the test with absorbent material and the interaction test 1, it was determined that the heating element needed further development. But this time, the focus was on compact packaging and making the interaction better (app. 34).

Development of the Heating Element

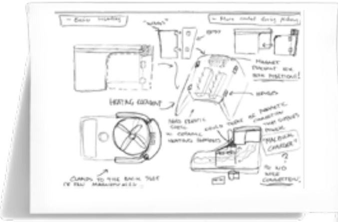
Like the Jetboil and from the act-out, the solution must be cohesive to the main part both in a compact stage and in use. Therefore, a sketching round was conducted with the focus on how the heating element could connect to the main part and still provide ease of handling.

Main Points to Improve

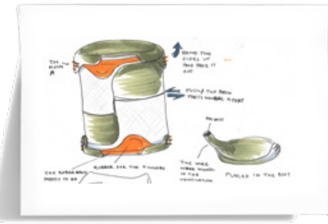
- Easy insert, communicate how far the main part goes into the boot and it makes a good seal in the boot
- Communicate how it should be packed, more control during packing
- Protect the button



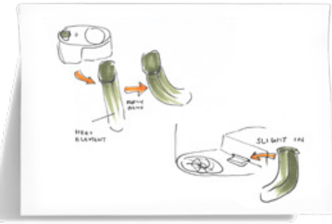
Ill. 63 *Placed in the button. It directs the air and heat towards the toe area*



Ill. 64 *Clamps on to the side and in use it is placed inside the boot.*



Ill. 65 *A lid, which protects the button, when it is packed*

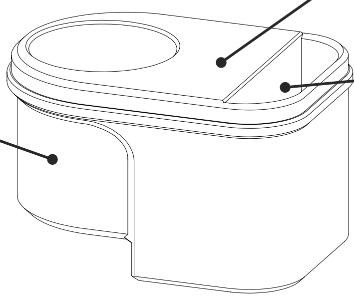


Ill. 66 *Store in the ventilation space and slides under the model in use*

Since sketches have their limitation in broadcasting the size and ease of use. Mock-ups were built in relation to the heating components, the main part and to test the interaction.

Ill. 68 *The lid protects the button and fit to the top. The wire did not seem cohesive with the interaction.*

Ill. 67 *The Clamp makes a cohesive fit to the main part.*



Ill. 69 *It fits in the ventilation, but was difficult to test due the mechanism.*

Ill. 70 *The box fits in the ventilation, but it was too short to close to the fan.*

Ill. 71 *During the mock-up examination it was tested at the ground to simulate the user scenario.*

Based on the mock-ups and the sketches, it was difficult for the team to choose one direction, as each idea had its advantages and disadvantages and it was necessary to get others' perspectives and to perform the interaction. However, the team were able to remove the box as the heater was too close to the fan. Aswell for the lid as the cord did not create robustness or coherence in use.

THE TWO DIRECTIONS

From mock-ups, the following two ideas were selected for further testing with the user.

The Clamp

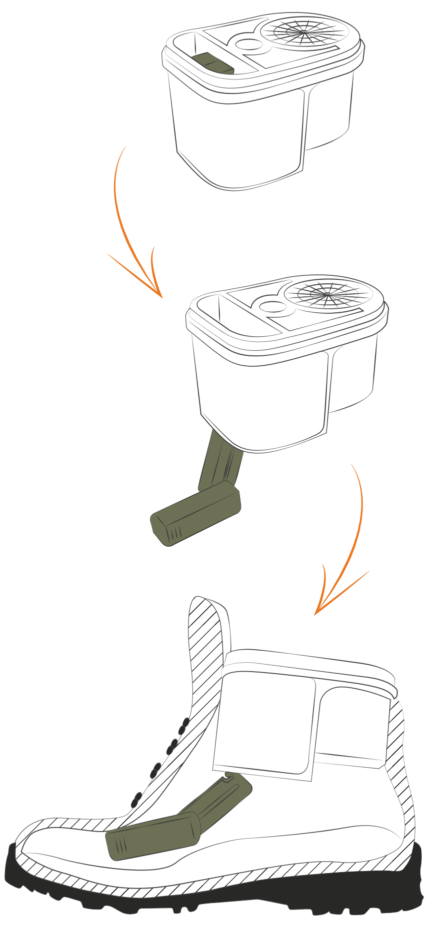
The Clamp is pulled off the main part and inserted into the boot. From here the main part is inserted where a magnetic socket joint will connect the power from the main part to the heating element. When the boot is “dry to the touch”, the clamp is picked up and clicked on the main part for compact storage.

The Elephant Trunk

This solution is stored in the ventilation room. By pulling it out from the bottom, the “trunk” is unfolded and the whole model can be placed in the boot at once. When the boot is “dry to the touch”, the “trunk” can be folded back into the ventilation room.

Ill. 72 *The Clamp Scenario*

Ill. 73 *The Elephant Trunk Scenario*

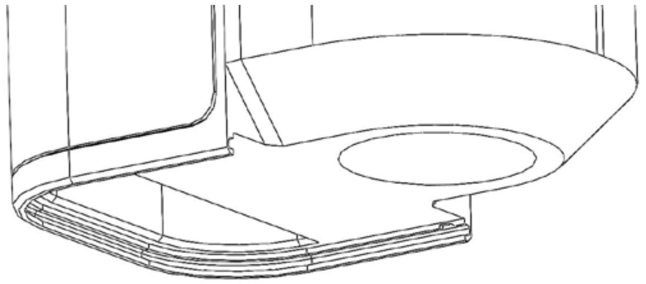


FURTHER CONCEPT DEVELOPMENT

From the act-out, details were added to the solution. Mainly to incorporate them into the interaction test to see if they provide any difference.

Packing Mechanism

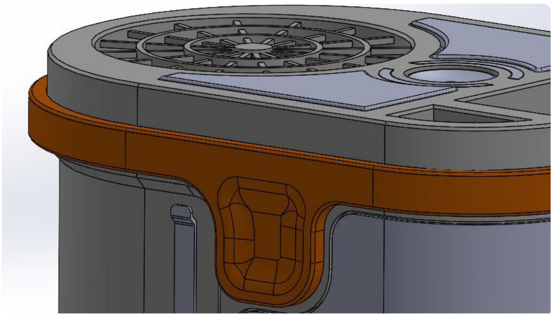
From the act out, the packing bag worked as intended, however, the elastics were troublesome and therefore needed further development. The assembling method was changed to the slider at the bottom of the main part to lock the two boot dryers firmly to each other.



Ill. 76 *The slider are placed at the button of the solution as it is less seen surface and are more given to wear. On the ill. she slider is shown.*

Rubber Band

To get a better grip and clearer expression of robustness, the rubber band was made wider and thicker. In addition, it was observed during the act-out that the users used the rubber surfaces on the top and sides to press the boot dryer down. Therefore, rubber grips were added to the fingers to indicate through the feed forward which direction to hold and press it down with a comfortable grip.



Ill. 77 *An extend of the rubber band to provide a better grip and support to the fingers.*

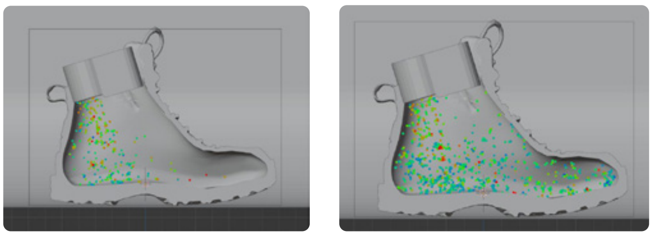
Airflow Simulations

In parallel to working with the heating element, one of the aspects that could optimize the performance was the airflow in the boot. Throughout the project, the airflow and the direction of the fan had stayed the same.

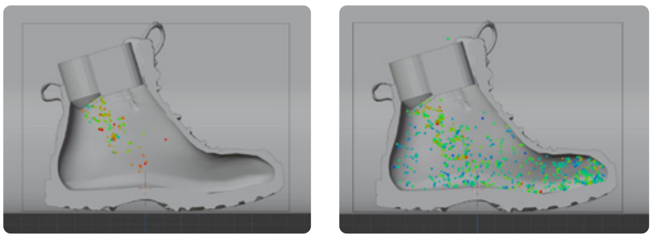
Looking at the muzzle of the fan, this could be optimized to direct more of the air towards the toe areas as this was the most exposed area of water. In order to figure out any effect on the airflow, a simulation was set up in *Blender Inc.* to simulate how the air move inside the boot (app. 35).

By angling the muzzle of the fan and creating a slimmer opening for the air to pass through, the airflow could be optimized and reach the front of the boot better (ill. 53). There would also be a slightly higher muzzle velocity due to the tighter opening.

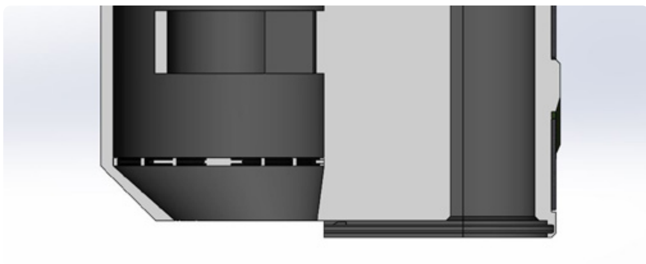
! For the best reach to the toe area, the muzzle needs to be angled.



Ill. 74 *Without any angling on the fan muzzle.*



Ill. 75 *With 15 degree angle on the fan muzzle.*



Ill. 78 *A cut section of the model, which show the angel of the muzzel.*

SELECTION OF HEATING ELEMENT

Since the team could not choose one concept based on their own interaction, both concepts were 3D printed to be tested with expert 1 and a user (app. 36). The interaction test was evaluated with the test persons on parameters within interaction and expression.

The test persons were asked to unpack the concepts, place them in the boot and then repack them. Based on their experience, they were asked to express their opinion regarding interaction and expression.

Interaction Test

Through observation and feedback, it was clear that The Elephant trunk was the easiest to use. The Clamp had become easier to put in the boot and the attachment to the main part worked fine for both users. However, it had the same challenges as the the heating element insert, in terms of being too large and indistinct of how it should be placed in the boot. Both even expressed a concern that it would stretch the boot too much. Whereas the elephant trunk was overall easier to place in the boot, it was clear how it was to be used and it is possible to fit in different sizes of boots.

Expression

Subsequently, the test persons evaluated the concepts through parameters; durability, cohesiveness and coolness. Whereas The Clamp seemed robust, the expression fitted in with the gear fanatic and its cohesiveness to the main part was more united. The Elephant Trunk was evaluated to be more fragile in its size, movable joints and less robust than The Clamp.

Packing Mechanism

During the interaction test, both test persons were presented to the packing connection between the two main parts. Both could see the value in assembling them. The user even mention it was an improvement from the elastics (p. 45). However, observation during the interaction showed that the rails had too small tolerances and therefore need to be further developed (p. 52)

Test with expert

Test with user 1

Ill. 79 *Expert 1, testing the Elephant trunk*

Based on the test, The Clamp is the most cohesive solution and is closer to the gear fanatics identity. On the other hand, the Elephant Trunk has solved the biggest interaction challenge and gives a controlled use, but it is too fragile for the outdoor environment.

!

The team have also gained an insight into the connection between the main parts. Which, requires more development of the locking mechanism.

Choosing a Heating Element

From the interaction test, the team had to decide which direction would be the best for the solution. In order to hold them up against each other, the following parameter was set up:

- Interaction (do the user have control)
- Size
- Coolness (do it match the gear fanatics identity)
- Robustness (is it durable)
- Complexity (how complex is construction)

Through the assessment, The Elephant Trunk was the most compact solution and gave the user the most control. However, its construction was over-engineered. On the opposite The Clamp was assessed as the most robust and least complex but did not solve the interaction problems. However, both concepts had an equal amount of coolness in terms of expression or interaction.

Due to the importance of the interaction and compact, it was decided to develop further with The Elephant Trunk. The team saw opportunities to lower the construction complexity and make it more cohesive to the main Part. Whereas, the Clamp would require more tests due to the interaction.

!

Based on the assessment, The Elephant Trunk was chosen.

SUM UP

Milestone 4

From the feedback given at milestone 4 it was clear that the concept needed further development (app. 37). Especially the heating element could be more simple and more durable based on the environment and the use of the solution. Furthermore, the material and construction of the heating element were questioned, if it could be more flexible and have less joints. The purpose and choice of position of the heating element were not clear, and it was questioned if the heating element could be in the main part of the solution near by the fan. Secondly it was clear that the packing of the product needed more development. The solution presented could slide together in pairs, the need of this solution was questioned, and it were described as not durable. It was clear after the feedback that the concept needed more development regarding the heating element and the packing of the product.

Sum Up

There were no doubt that the heating element was over-engineered, however the team saw the potential to simplify the mechanism.

The same goes for the packing mechanism, which were too small in dimension and not proper in a hiking environment, which was clear during the interaction test.

Challenges

- Make the heating element cohesive to the main part and the gear fanatics identity
- Simplify the heating elements construction, to fit into the hiking environment
- Make the prototype transportable

Requirements

- Heating element must have visual interaction surfaces
- Must have a price between 800-1200 DKK
- Must be and look cohesive

Wishes

- Must make the user feel and look professional
- Must be and look cohesive

Ill. 80 *Picture from the mapping of temperature and airspeed*

04 DETAIL

Entering the detail chapter, the solution will be divided into smaller parts based on the feedback from the expert and milestone 4. These parts will be detailed, where the focus will be on coherence and simplification of the solution. In addition, this chapter will shed light on the composition and use of the electronic components.

OVERVIEW OF THE CONCEPT

The next part of the process was detailing the concept. From the interaction test and the feedback from milestone 4 (app. 37), parts of the concept still lacked a coherent expression, and parts of the concept's interaction still needed to be further detailed. Below is an overview of the elements which need to be further developed and detailed:

Ill. 81 *Overview of which parts of the solution that will be detailed in the next part.*

1 Packing Bag

The packing bag material needs to be specified and if it needs to protect and secure the product. Furthermore, an instructions guide should be added based on the interaction test.

2 Electronics Placement

It needs to be detailed where the charging should be placed regarding interaction and construction. Moreover, it needs to be detailed how the electronic parts should be placed.

3 Packing Mechanism

The sliding mechanism which locks the two main pairs together needs to be more durable.

4 Button

When the product is in the backpack it must stay off in order to avoid starting without the users' intention and enhance the quality. Furthermore, the button needs to be detailed based on the interaction with wet and cold fingers.

5 Heating Element

The heating element needs to be simplified, more cohesive to the main part and constructed more durable.

LEGISLATION AND CE APPROVAL

When working with electronic devices there are some standards that need to be met. Furthermore when working with heating elements that affect the temperature of the material in solution, a specific standard need to be upheld. In this section a walk through of the important legislation is present i relations to the solution (app. 38).

Protection from Heat

As for the working with a heating element, a perticular standard for Ergonomics of termic environments, *Methods for the assessment of human response to contact with surfaces, Part 1: Hot surfaces DS/EN ISO 13732-1* need to be taken into consideration. In order to eliminate the risk of development of burn marks or other heat related injuries when in contact with human skin, certain temperatures need to be applying to specific materials. As for uncoated metal, the temperature of this material cannot reach temperatures higher than 55°C before the risk of burn marks appear. As for plastics the temperature cannot exceed 70°C before the risk of burn marks appears (Danish Standards, 2008).

The standard further states that, when extending the period of touch all materials should not exceed more than 48°C for 10 min. and 43°C for 8 hours or longer. As the product would not be handle for more than a couple of minute, with the chance of the product being handle for up to 10 minutes, the maximum temperature of the product should not reach more than 48°C. Furthermore in accordance to standard *ASTM C1055,* people can start feeling pain at around 44°C. This means to be on the safe side, when users are handling the device after heatup the temperature should not exceed more than 40°C.

! Heating element cannot exceed more than 40°C.

Table 1 presents burn thresholds when a surface is touched for contact periods of 1 min and longer.

Table 1 — Burn thresholds for contact periods of 1 min and longer

Material	Burn thresholds for contact periods of		
	1 min	10 min	8 h and longer
	°C		
Uncoated metal	51	48	43
Coated metal	51	48	43
Ceramics, glass and stone materials	56	48	43
Plastics	60	48	43
Wood	60	48	43

Sensation	Skin Color	Tissue Temperature deg. C	deg. F	Process	Injury
Numbness	White	72 68	162	Protein Coagulation	Irreversible
	Mottled Red and White	64 60	140	Thermal Inactivation of Tissue Contents	Possibly Reversible
Maximum Pain Severe Pain Threshold Pain	Bright Red Light Red	56 52 48 44	111		Reversible
Hot Warm	Flushed	40 36		Normal Metabolism	None
		32	93		

Ill. 82 *Protection from heat in touching hot surfaces with skin. The table to the left (Danish Standards, 2008) and to the right (Danish Standard, 2020)*

Ingress Protection Coding

As for the IP (Ingress Protection) code, the code is given when the product is tested, but an estimation of the need can be established beforehand. The IP code is international standard IEC 60529 but corresponds to the European standard EN 60529 (European Standards, 2018).

As for electronics it corresponds to a dimension scale regarding connections between different enclosures in electronic devices. As for the solution, in order to dust proof and water proof it, all components need to be enclosed. The two most exposed components would be the ceramic heating elements and fan. It is difficult to get a complete rating of the device, but by looking at pc fan solutions and competing shoes drying solutions on the marked, could result in a rating of IP54 or higher.

! Must have an IP rating 54 or higher

CE Approval

In order to receive CE approval the following standard need to be met under these criteria DS/EN 50581:2012; This standard relates to the approval of electronic devices, their construction and ability to work with circular economy. These have been noted and been taken into consideration although difficult to implement in the solution (Dansk Standard, 2012).

1. Agreeance with supplier declaration and that possible sub-assembly of the product in correspondence with EN 62474.
2. Material declaration and correct flow of information according to EN 62474.
3. Analytic tests and results in correlation with EN 62321.

FINALIZING THE HEATING ELEMENT

The heating element's complexity and cohesiveness still need to be finalized in order to fit into the gear fanatic's identity and context. Therefore, it was necessary to simplify the construction, design and mechanics without sacrificing the desired interaction of the current solution.

Through sketching together (Tollestrup, C., 2004 p. 285) in the team, different solutions and locations of the heating element were discussed through dialogue and sketching. During the ideation, important bullet points were written down, to showcase which aspects the solution have to take into account.

Technical Aspect
- Wiring and power

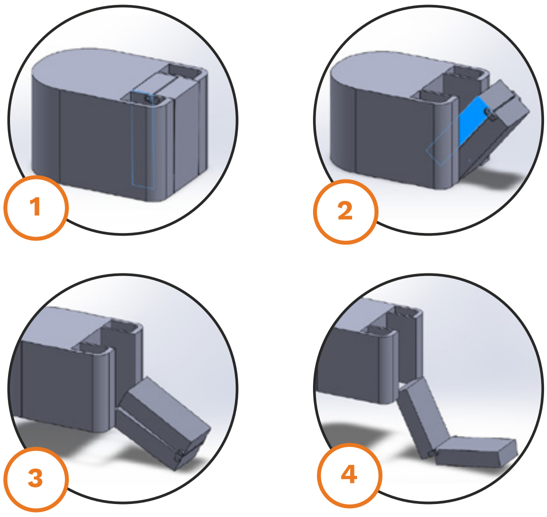
Durability
- Joints regarding the context, no sliders
- Movement

Cohesiveness
- Gear fanatics identity
- Size and fit to the Main part

Simplifying the Movement

When the team was determined on a common idea, the first detailing was to simplify the movement by removing the sliders to a lower complexity. Mainly due to lower the risk of dirt and debris building up. Secondly, was to make it easier for the user to pull it out. By exchanging the sliders for a piano hinge, the heating elements could stack flat against each other and in use rotate out from the Main part (ill. 83).

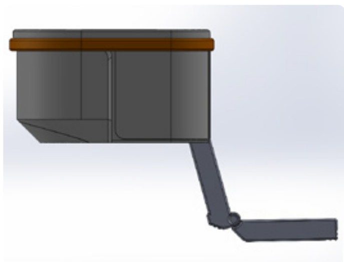
When the overall dimensions and movement were in place, the next step was to simplify the rotational joint between the two heating elements and creating a secure connection. This was worked on while constantly keeping cohesiveness in mind to integrate it with the main part both in use and a packed stage.



Ill. 83 *The movement of the solution*

Angel of the Heating Element

A mock-up of the two heating elements was created to measure the angle for the best position of the trunk (app. 39). This resulted in 105 degree in top and 115 degree in the join between the two heating element.

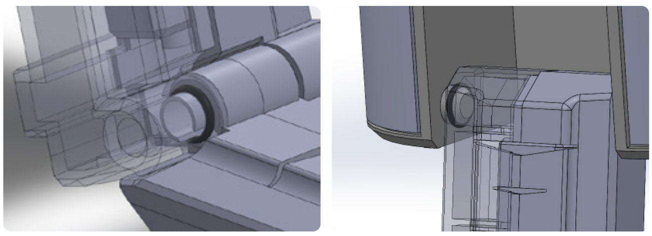


Ill. 84 *The final angel for the best position in the boots.*

Sealing the Construction

To ensure that dust and dirt cannot build up in the rotational joints, o-rings had been implemented to secure the joint. Furthermore these o-rings serves as tension disks in the joints, given the rotation a tighter fit as well as giving the user the feeling of a more secure construction.

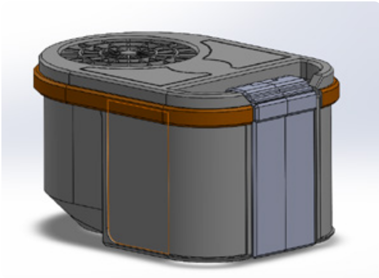
The rotation of the heating elements should be locked together using friction. This is to simplify the adjustments made by the user.



Ill. 85 *An o-ring have been added to protect the joints from dirt and create tension for at more secure fit.*

Creating a Cohesive Appearance

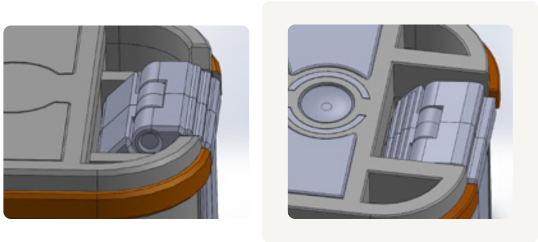
In creating a cohesive expression between the main part and the heating element, the rubber edge was transferred over to the heating element, creating a continuation of the lines and creating a robust look (ill. 87).



Ill. 87 *The final angel for the best position in the boots.*

The Top of the Heating Element

To make the top of the rotational joint more cohesive with the main part, an interaction surface was integrated into the top. The purpose of the interaction surface was to create feed forward and a grip to communicate where the users should place their fingers to pull the heating element out. Therefore, grooves were added to give a sturdy grip for the fingers and had been moved to the rear element to accommodate the correct placement.



Ill. 86 *Different shapes were set up against each other, where the team continuously reviewed the shape together by dialogue. By giving ongoing feedback, the choice was on the solution to the right.*

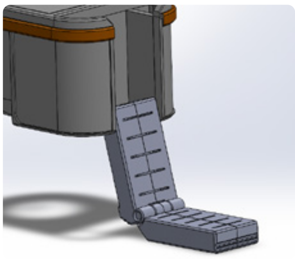
Heating element should have visualise interaction surfaces

The Overall Cohesiveness

The shape of the heating element was still a bit dull compared to the gear fanatic's identity. The design language did not match its function or its adventurous setting. Therefore, it was necessary to rework the shape of the heating elements to create a more dynamic appearance. The heating element needs to convince the user that it is robust and effective, and give an expression of professionalism (p. 39). In short terms, the interaction needs to make them look cool in order to show off (p. 37).

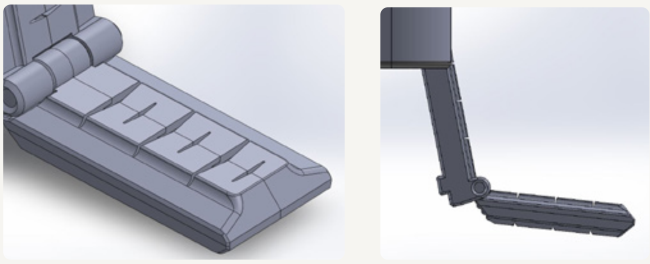
Accommodating Production Methods

For the heating element to be able to be produced with integrated hinges and slots for the heat to escape, the elements were split down the middle and slot simplified in order for the shells to be removable from a mould. For that reason the air holes had to be simplified, there the final detail can be seen at ill. 90.



Ill. 88 *The overall shape and the air holes was too passive*

Ill. 89 *A subtle movement of the air holes direction and dimensional shaping to the overall construction*



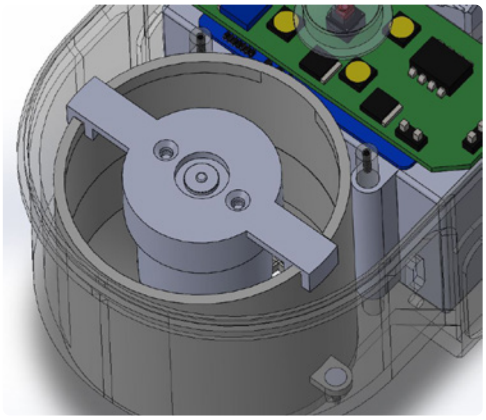
Ill. 90 *To simplify production, the air holes were changed to triangular expression.*

DETAILING THE FINAL CONSTRUCTION

Detailing the final construction, fitting the electronics and making room for charging was the last step in completing the product. This page highlights the additions that had to be made to accommodate all the necessary functions.

Fitting the Electronics

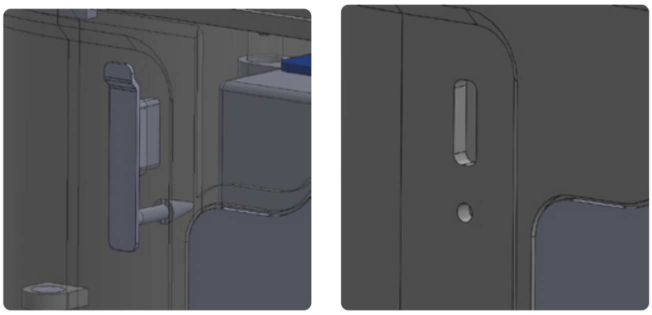
Fitting the electronics meant making room for both the internal processing, such as the PCP board with components, and the power supply from the 18650 cells that needed secure housing. Furthermore, the housing for the motor and fan was changed to allow for easier assembly and a more secure fit. Making a secure fit meant that the housing for the batteries had to be incorporated with the sealing of the lid to the main unit.



Ill. 91 *Illustrations of the new fan housing*

Charging

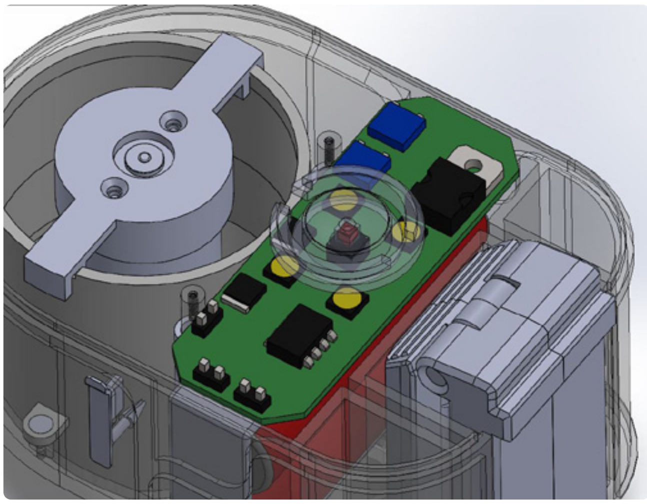
To make sure the product can be charged, USB-C was incorporated for faster charging time. The placement of the port had to be accessible when the two devices are locked together. Therefore, the placement of the charging port was on the side. To secure the port, a rubber sealing plug was incorporated. The placement of the USB port also makes for easier assembly and wiring within the housing.



Ill. 92 *Illustrations of the USB-C port*

Feedback and LEDs

A large part of fitting the electronics was the need to make sure the RGB LEDs were placed on the board, so the user would be able to get visual feedback on various processes during the drying. The placement of 4 RGBs allows for a combination of various coloured lights to signal. Most notably flashing lights during heat up, red lights for warnings and with a double press of the button - the ability to see the battery level, split into quarters. This allows the user to see if the battery level is at 100%, 75%, 50% or 25%.



Ill. 93 *Illustrations of PCB and button*

DETAILING OF THE BUTTON

The shape, function and tactility of the button lacked detail. Therefore, an interaction test with different types of buttons was executed. Based on the test and the hikers' environment a button was designed.

Two test persons were presented with five different buttons after trying the solution (app. 40). To simulate the environment the test persons were testing all buttons with cold hands and wet hands. During the test, they were asked to describe their experience and afterwards ranked the buttons based on four different parameters. The test showed that the slide button was uncomfortable and hurt with cold and wet hands. One of them even stated it is the wrong button in nature and it did not seem durable in the environment.
The turning dial did not fit the function of the solution, as it was stated to be a better fit for fine tuning products. However, they found this button as the most secure when packed.
Both liked the tactile feedback of the click sound of the regular push button. However, they feared it would turn on in the backpack and dirt gets under the button to destroy it. The buttons with rubber surfaces gave them a pleasant grip. Furthermore, it was important for them to feel and see the button, as the interaction have to be quick due to impatience with cold and wet hands. One of them expressed mistrust of hidden buttons as it can be difficult to understand where the button starts and a need for security in physical feedback.

Ill. 95 *Five different buttons were tested. From the left: flat button with rubber on top (2), convex button with rubber on top (3), a regular push button (1), the sliding button (4) and the turning dial button.*

Test with user 1

Test with user 2

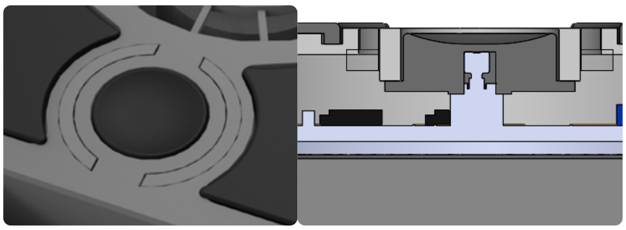
Based on the feedback the regular button gave a clear feed forward. However it lacked security when packed which needs to be explored .

Protection of Button when Packed

It was clear from the interaction test and the feedback from milestone 4, that the solution needed to be secured when it is in the backpack. To develop a solution for securing the product, several different solutions were set up and assessed against each other (app. 41). Some of them included programming the button to lock when pressed down for 10 sec or using the packing bag as a protective case. Whereas the other was to include a second locking button or create a lid for the button. It was decided to lock the button by integrating it into the locking mechanism of the two main parts. Mainly due to the interaction of locking the two main parts together communicates a locking movement and signal to the user is finished using the boot dryer.

The Final Button

The final button is based on the test results and is developed to be waterproof using rubber. It is also visible by its convex design to give a physio-pleasure when pressing.



Ill. 94 *The final button and a cut section from the side*

The protection of the button should be through programming and integrated into the locking mechanism of the two main parts.

DETAILING OF PACKING MECHANISM

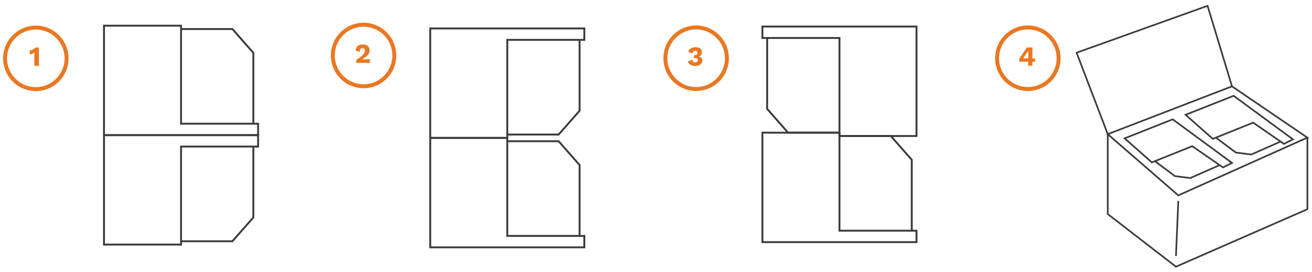
The packing mechanism which locks the main pairs together needs to be detailed further. It was clear after the feedback at milestone 4, that it needs to be more durable and fit better with the context of the environment and the use of the solution.

The Slider Connection

The slider connection presented at milestone 4 was placed at the bottom of the main part. During the interaction, it needed too much precision in order to slide the main parts together based on the small tolerances and the slim construction. However, this type of connection does not fit with the outdoor environment, due to sand and dirt that would easily clog the slider. Therefore, this part of the concept needed further detailing, and an assessment of different locking positions was made (app. 42).

Development of New Solution

First part of developing a new packing mechanism was to find the right placement on the product for the mechanism. Based on the current knowledge different positions were set up and assessed against each other.



Ill. 96 *Illustrations of the various positions*

1. The first position was to develop a mechanism on the top of the solution and connect the parts with the tops against each other. This would protect the button when the product is not in use, but marks from wear will be too obvious on the most visible side.

2. The next position was to develop a mechanism on the bottom of the solution and connect the parts with the bottoms against each other in mirrored position. However, in the current solution, there will be an imbalance in the proportions of the shape.

3. The third position was to develop a mechanism on the bottom of the product and connect the parts in a non-mirrored position. This creates balanced in the proportions of the shape. However, it would require bigger changes to the main part in order to create a cohesiveness packed state.

4. The last solution was to develop a case for the product with a room for each part to fit into. The last solution was to develop a case for the product, which replaces the package bag solution. The case consists of compartments where each part will fit in. The button would be protected, but the solution would require more space.

Solution No. 2 was chosen as its mechanism and wear will be hidden in the bottom, which is the least visible surface for the user. Furthermore, the current solution will have the most cohesive expression when packed. By utilizing the locking mechanism in a mirrored position, both parts can be produced into one mould.

Type of Connection

The new step in the locking mechanism was to determine whether the mechanism should be snapped, slid or twisted together. Having a rotational twist lifted the users perception of the units locking together, and gave a better sense of security. Here the twist can be compared to other hiking products (p. 49).

Using rotational twist can be seen in other hiking products.

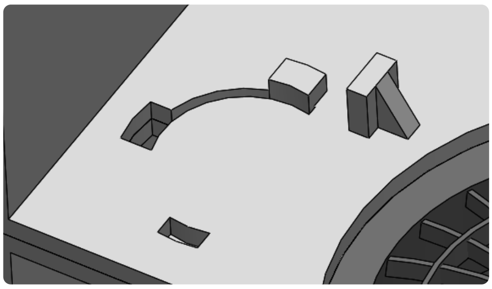
Protection of the Button

Since having the mechanism on the bottom of the device does not solve the issue with protection the button, integrating a different way of securing it would be necessary. The idea of programming the button seem reasonable, however having it integrated with the locking mechanism as a switch, seem to simplify the users interaction. This is because the locking of the button would happen simultaneously with the locking of the two units.

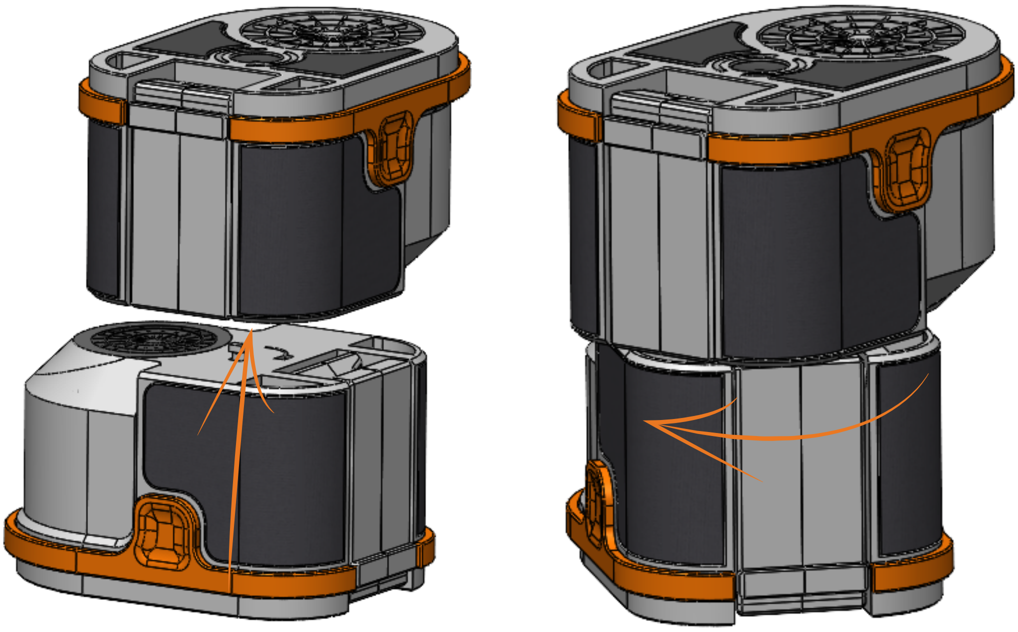
To simplify the security of the button, integrating it with the locking mechanism would result in simultaneous acting to secure the device.

Final Solution

The final solution is a rotating locking mechanism which consists of a male and female connection on each part. When the user wants to lock the parts together, the user pushes the bottom of the two parts together and makes 1/4 of a turn until it makes a click. When it clicks, both parts a locked together and the button is turned off.



Ill. 98 *Close up of the packing mechanism seen from inside the product*



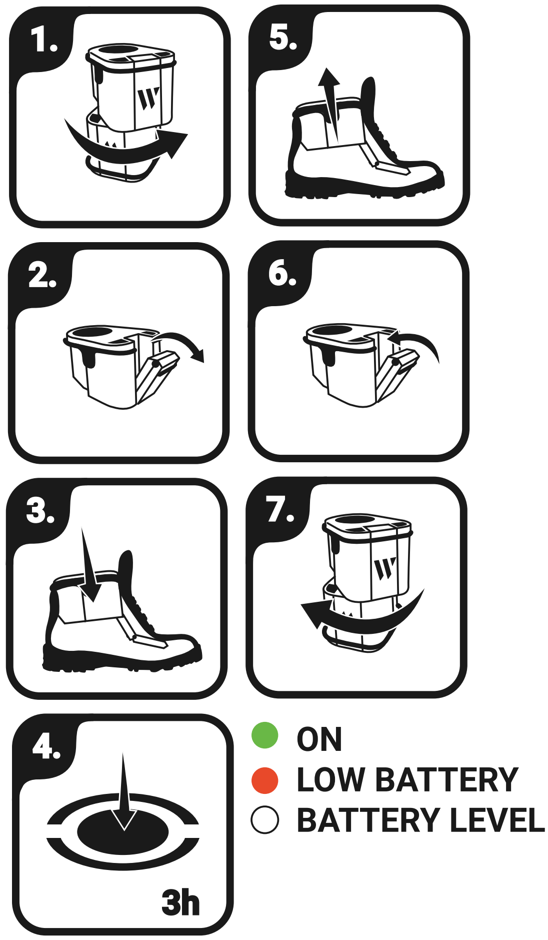
Ill. 97 *The movement the user do with the product to lock the parts together with the packing mechanism*

DETAILING OF PACKING BAG

From the first interaction test with the experts, it became clear that there is a demand for packaging bags, which gives the user satisfaction in their organization system. This was also confirmed by the one user's expression of enthusiasm for the bag during the act-out (p. 46). However, it was mentioned in the interaction test with the heating elements (app. 31) that a bag is not necessary, but there are sales in including it with the product.

Although it is not necessary with a bag, the team chose to include it in the solution. Especially as it provides an extra quality detail and can be used as storage during and after a hiking trip.

As a further detailing of the bag, it was observed that some other high-end hiking products have printed installations on the product. To create further clarity of the product's use, pictograms of the instruction guide were printed on the bag. Likewise, the logo was also added (ill 99).



Ill. 99 *Instruction guide, which will be printed on the packing bag.*

Ill. 100 *The packing bag with the instruction guide printed on and dimension.*

Lifetime of Product

In calculating the lifetime of the product, the most affected aspect of the solution is the choice of batteries. Lithium-ion batteries have a lifetime of 500 cycles before the risk of deterioration. Lithium-ion cells are cheaper and more commonly used in electronic devices, but come with the downside of a lower cycle lifetime.
In comparing the lifetime of the product with the use cases put by the use (app. 6) the unit will be used at most four times per month. Considering the user will most likely charge the batteries each time, this gives a total usage per year of 48 including charging. With the life cycle of the cells of 500 means, the lifetime of the product would be about 10 years.

! The life cycle of the cells of 500 would be about 10 years for the product.

ENERGY CONSUMPTION CALCULATIONS

In optimizing the heating element and switching to ceramic heating elements, there have been made improvements to the energy consumption of the entire unit (app. 43). The two most energy consuming components in the device are the heating elements and the fan. With the heating element taking up most of the available power.

The chosen batteries for the device is 3 * 18650 Lithion 3.7V batteries at 4200 mAh each giving a total power capacity of 12.600 mAh. The benefit of using the 18650 cells are their ability to drain til 0% without damaging the batteries, however over time these can lead to damage, so the BMS (battery management system) is set in place to limit the batteries to 5%, giving 11.970mAh of available power (Danielle D., 2021).

Total Energy Consumption

The total energy consumption of the solution per hour is 675 mAh, and with a drying time of 3 hours per boot. The total energy consumption for drying a pair of soaked boots is 2.019 mAh per unit. Meaning with the available 11.970 mAh the units can dry just under 6 pairs of boots.

Primary Components

Ceramic heating elements; 11V at 0.46A = 5W power
0.46A X 1 000 = 460mAh

Fan motor; 6V at 0.18A = 1W power
0.18A X 1000 = 180 mAh

Secondary Components

WS2812B RGB diodes; 5V at 0.06A = 0.3W
0.06 X 4 X 1000 = 240mAh
However the RGBs will run only 2 minutes per cycle and consumes only 4mAh per minutes in use.

ATtiny 85 processor; 5V at 0.008A = 0.04 W
0.008 X 1000 = 8mAh

> ! Battery capacity is over-dimensioned and can be reduced to 2 batteries of 8400 mAh total.

Reducing Battery Capacity

Looking at the calculations, based on the power consumption of the new ceramic heating elements, the weight and space of the main unit could be optimized by reducing the batteries to two 18650 cells instead of three cells (app. 43). This will save 36g of weight at make more room for the electronics to fit in the main unit.

Updated Power Consumption

Knowing that the only component that would be affected by the change in batteries would be the heating element as it was previously run with 11V. In switching to two 3.7V 4200 mAh batteries the total available current is now only 7.4V, changing the power output of the heating element. Knowing the heating element needs 5W of power to produce the right temperatures, the calculation for energy consumption can be calculated as follow;

> ! Two batteries in one unit can dry 3 boots with a full charge.

Ceramic heating elements use 0.68A at 7.4V to produce 5W.

5W / 7.4V = 0.68A

To calculate the total energy consumption;
0.68A X 1000 = 680 mAh

680 mAh + 180 mAh + 28 mAh = **888 mAh** for all components for 1 hour of use.

Usage Calculation

The components use 888mAh per hour of use, with a drying time of 3 hours - the amount of times the unit could be used on a full charge becomes;
888mAh x 3 hours = **2664 mAh**

The available energy of the two cells
(4200 mAh X 2) - (5%) = 7980 mAh
7980 mAh / 2664 mAh = **3 uses**

ELECTRONIC COMPONENTS

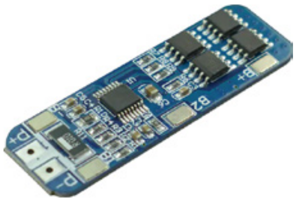
Based on product specifications and calculation of the power consumption the following electronic components are needed to make the bootdryer to work.

Dimensions	18x65mm
Weight	36g
Voltage	3,7V
Capacity	4200mAh
Price	49 DKK

Ill. 101 *Battery (Kikkert-teleskophuset.dk, n.d.)*

Rechargeable Li-Ion Battery (lithium)

For the boot dryer to be able to dry at least one boot two times per unit, it is important that the product have enough battery power. Furthermore, it is important that the battery can deliver enough ampere for the heating element to get hot enough. Therefore it is decided to use 2 3.7V 4200mAh battery cells in each unit (Kikkert-teleskophuset.dk, n.d.).



Dimensions	50x16x1mm
Weight	12g
Voltage	12V
Amps	max 10A
Price	5,12 DKK

Ill. 102 *BMS (Let Elektronik, n.d.)*

BMS

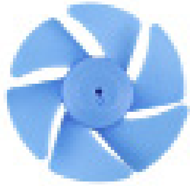
To manage the power from the batteries a BMS is used. The BMS makes sure that the batteries are discharged equally and that they are not discharged more that 95%, as this would damage the batteries. The BMS is selected to fit the type of batteries selected. The BMS used in the product is 18650 Battery Protection Module (12V 10A) (Let Elektronik, n.d.)

Dimensions	7x10x4mm
Weight	-
Voltage	5V
Amps	-
Price	3,6 DKK

Ill. 103 *USB-C Charging Port (Helmholt Elektronik A/S, 2016)*

USB-C Charging Port

For the user to be able to charge the batteries a charging port is necessary. As there might come a demand from EU to use USB-C charging ports in electronic product, and as it is the common in most new electronic products today, it is decided to use a USB-C charging port in the product. The USB-C charging port selected is HELMHOLT IMP. - LIION BATTERI OPLADEMODUL (Helmholt Elektronik A/S, 2016).



Dimensions	Ø49mm
Weight	-
Aperture	2mm
Material	Plastic
Price	2,5 DKK

Ill. 104 *Fan ((Aliexpress, n.d.)*

Fan

To be able to create airflow in the boot, it is necessary to have a fan blowing air into the boot. The fan selected for the product is a standard fan. It a standard part because it is selected to be as cheap as possible. Furthermore, it is selected to fit to the dimensions of the product. The fan used in the product is a SIX-BLADE PROPELLER DIAMETER 49mm (Aliexpress, n.d.).

Dimensions	Ø24x30mm
Weight	51g
Voltage	6~26V
Wolt	1~8W
Price	7,3 DKK

Ill. 105 *Motor (ke gu motor, 2021)*

DC Brushless Motor

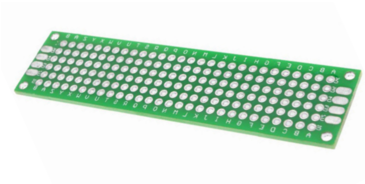
To make the fan spin and create airflow in the boot we need a motor. The motor is selected based on its rpm, which gives the wanted wind speed at the voltage from the selected batteries. Furthermore, it is a brushless motor, which makes less noise. The motor used in the product is BL2430 (ke gu motor, 2021).

Dimensions	8x17.5x4mm
Weight	4g
Voltage	12V
Amps	2.5A
Price	1,44 DKK

Ill. 106 *Thermal switch (RS Components A/S, n.d.)*

Thermal Switch

The product contains a heating element, which by itself could keep heating until it is turned off. Though, to make sure that the product will not get to hot and potentially turn the boot on fire, it is important to have a thermal switch. The thermal switch in the product is selected to turn off the product if it gets hotter than 55°C. The thermal switch selected for the product is a LIMITOR TERMISK SIKRING 2,5 A +55°C (RS Components A/S, n.d.).



Dimensions	72x26x8mm
Weight	10g
Voltage	-
Amps	-
Price	2,12 DKK

Ill. 107 *PCB board (cablematic, n.d.)*

PCB Board

To be able to connect the electronic parts we need a PCB board. The selected size of the PCB board is 72x26x8mm, with this size there is room for all the needed electronic parts, and it fits in the product. The following parts are located directly on the board
.

Dimensions	72x26x8mm
Weight	1g
Voltage	16V
Amps	-
Price	1,71 DKK

Ill. 108 *Capacitor (ElectroPeak, 2019)*

Electrolytic Capacitor

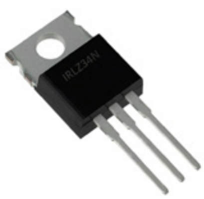
It is important to deliver a constant flow of power to the heating element and the fan to not constantly turn it off and on. To make sure that the power is constant we need capacitors. The capacitors used in the product is one SMD 0.33nF Capacitor and two SMD 0.1uF Capacitors.

Dimensions	40x16x8mm
Weight	10g
Voltage	5V
Amps	680 mAh
Price	14,85 DKK

Ill. 109 *Heating elements (Amazon.com, 2022)*

Heating Elements

The selected heating element is a ceramic heating element. This is selected because it creates the wanted temperature at the lowest power consumpsion. Can be made to desired specifications.



Dimensions	8x12x3mm
Weight	4g
Voltage	12V
Amps	-
Price	1,44 DKK

Ill. 110 *Mosfet (AliExpress, n.d.)*

Mosfet Transistor

To control the power sent to the motor a mosfet can be used. With a mosfet it is made sure that the motor will get the right amount of power and it will run the right way, which makes the motor turning the right way and with the right speed. The mosfet used in the product is a IRLZ34N mosfet.

Dimensions	5x5mm
Weight	2g
Voltage	5V
Amps	4 mAh
Price	5,95 DKK

Ill. 111 *RGB LED (Digi-Key, 2022)*

RGB LEDs

To give the user feedback on whether the product is turn on or off and how much battery is left on the product, it is selected to use light. To be able to show different colours of light is it necessary to use RGB LEDs, as these can show many colours. Furthermore, it is necessary to use 4 LEDs to be able to show different levels of the battery. The RGB LEDs selected for the product is four WS2812B RGB LEDs (TME, 2022).

Dimensions	5x5x9mm
Weight	2g
Voltage	30V
Amps	100 mAh
Price	0,15 DKK

Ill. 112 *Push Switch (Digi-Key, 2022)*

Push Switch

For the user to turn on the product and check the battery level, they push the button on top. To be able to collect this input it is necessary to use a push switch.

Dimensions	12x6x5mm
Weight	3g
Voltage	5V
Amps	8 mAh
Price	5,41 DKK

Ill. 113 *Microcontroller, (An Avnet Company, 2022)*

Micro-controller, Processor

To be able to get the input from the user and control the output to the fan and heating element a processor is needed. The processor selected is selected based on how advance the product is. The processor used in the product is a ATtiny85-20P processor.

Dimensions	8x12x3mm
Weight	4g
Voltage	5V
Amps	-
Price	3,6 DKK

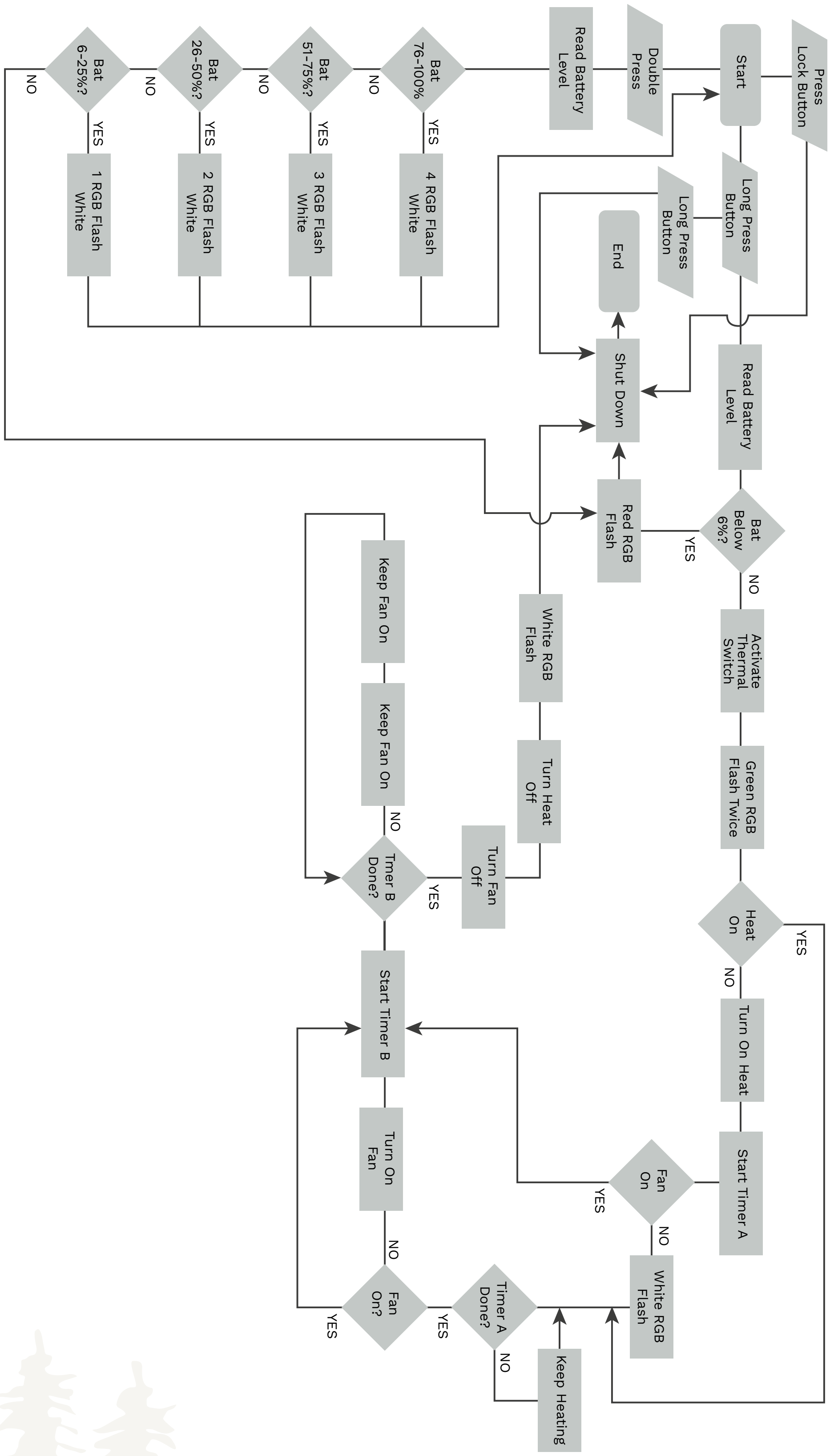
Ill. 114 *Voltage regulator (Eppes, Milanovic and Quarshie, 2011)*

Voltage Regulator

The selected processor uses 5V, the voltage from the batteries is 7.4V. To change the voltage from 5V to 7.4V a voltage regulator is necessary. The voltage regulator used is a T Package 3-Lead Plastic TO-220.

FLOWCHART

To better understand the process of use, when users interacts with the product the flowchart is put in place to also determine what processes the electronics go through. The use of the product goes as followed, whereas at any time in the process if the user double taps the button after start up, the user will be able to see the remaining battery, divided into the 4 RGB Leds.

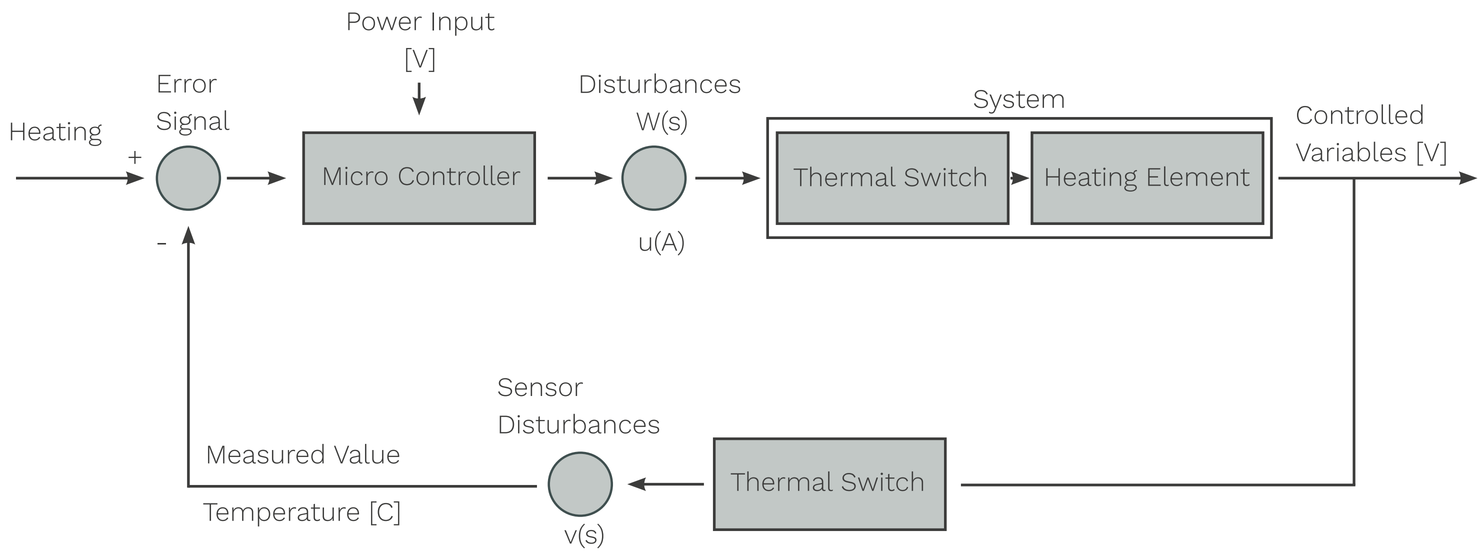


Ill. 115 *Flowchart*

CLOSED LOOP DIAGRAM

To not overheat the heating elements a closed loop system is integrated, using a thermal switch as a safety measure to continuously measure temperature changes over time from the heating element. This is a necessary precaution as the internal resistance within the heating element gets lower as temperatures increase resulting in a continuous increase in temperature.

An important component is the thermostat switch also known as a thermal switch. It is a bimetal normally close safety switch, that reads the incoming ampere to regulate the flowing current as the heating elements increase in temperature. When the temperature rises above the allowed temperature, the switch shorts the circuit to the heating element allowing the temperatures to fall below the allowed working temperature. These switches are used in most household appliances and decrease the risk of overheating.

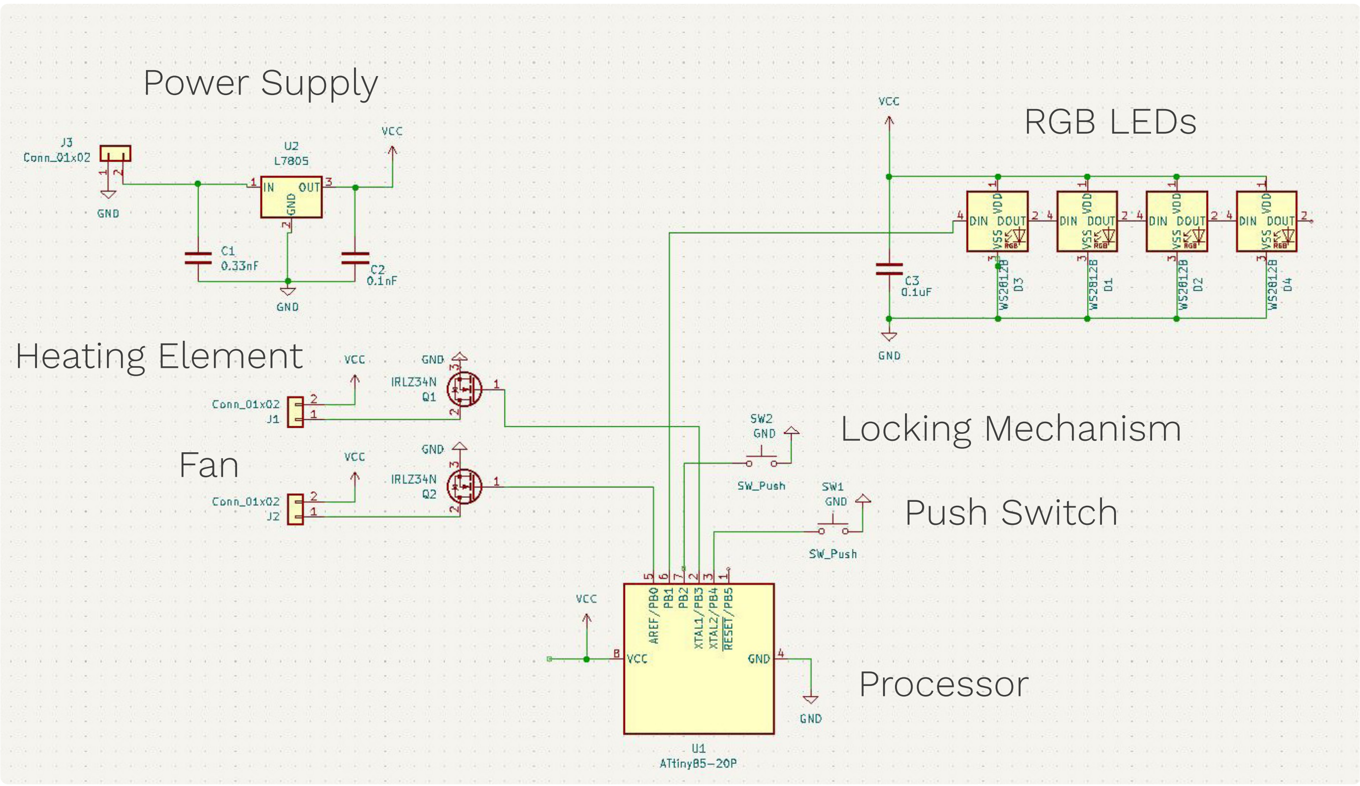


Ill. 116 *Closed Loop Diagram*

WIRING DIAGRAM

In the overview of component choice and wiring diagram, the components chosen have been made on the basis of readily available components for prototyping the solution, but would also work in a final version of the product.

To give a better overview of the wiring of the device, the power supply has been placed as its own sub assembly to the entire diagram. The processor of choice ATtiny 85 is capable of running both RGBs, heating element and fan on separate ports making the wiring and solution much less complex and cheaper than using an arduino base microprocessor. Both the heating element, thermal switch and fan would have a pin connections to the main board and is thereby not illustrated in the wiring diagram but under the components list.



Ill. 117 *Wiring Diagram*

THE FINAL PERFORMANCE TEST

To test the final performance of the solution, a test mapping different temperatures and airspeeds was performed. However, the team experienced a complication with the prototype, which resulted in the following results (App. 44).

Mapping Temperature and Air speed

The purpose was to test three different temperatures and three different air speed settings in relation to the power consumption and chose the best combination. However, the team noticed that there was no difference between the test results and the amount of water evaporated was very small. This resulted in an investigation of the issue, which lead to an assessment of defect motor (app. 44). As the air speed could barely provide 0.3m/s to any of the power settings and previous test provided 1.6m/s.

Furthermore it was discovered that despite working in simulations the narrowing of the fan muzzle to increase the air pressure, worked against the function and resulted in most of the air being blocked from exiting the muzzle.

Due to the time restriction, the mapping test had to be discontinued in hopes of fixing the issues identified and prepare for a final performance test.

The Final Performance Test

The team managed to find a new motor in order to conduct the final performance test. Since the results from mapping could not be used, the temperature and the air speed were chosen based on previous experiences. However the temperature have been decreased from 48°C to 40°C due to requirements from standard (p. 57). The test resulted in only evaporated 41g of water within 4 hours and did not reach "dry to the touch". Which is far less than the previous test (p. 48). This was not the desired result that the team had hoped for. But from the test, it has provided a further understanding of how heat and air relate to the drying process in the boot.

Hypothesis for the Test Result

Analysing the data, the identified errors resulting in a slower drying time could be:

- The new heating element blocking the airflow within the boot.
- The lower thermal conductivity of PLA.
- The decrease of temperature from 48°C to 40°C
- The direction of the fan.
- The decrease in surface areas of the new heating element.
- The size and shape of the fan used.
- For more see appendix 47

The result created frustrations in the team as it was not what the team hoped for so far in the project. Based on previous drying results, the team knows that it is possible to dry a pair of hiking boots within 4 hours (p. 48). Therefore, it will be necessary to take a step back in the development after handing in the project to explore the options for improving the correlation between the interaction and drying performance. However, the team gained new understandings from the test results. These understanding can be implemented through the following changes:

Drastic changes in the size of the heating element can have affected the efficiency of the internal heat developing in the boot, which can be compared by the results (p. 48). Since the rate of heat transferred is based on the surface area and the temperature, this means a larger surface will expand the heat to a larger area also known as thermal conduction, which produces radiant heat (Engineering ToolBox, 2003).

The blade-less fan technology was abstained from being included in the solution due to the limited space. However, Bernoulli's effect can still be included in a current solution by allowing for more volume of air to be affected by the fan by increasing the distance from the fan to the muzzle.

SUM UP

With the unit being able to still dry 3 boots, (3 pairs of boots when a set of the unit is considered) while decreasing the batteries from 3 to 2 gives a better optimization of weight, cost and space of the overall product. The choice of switching to 2 batteries late in the process, was optimizing the need for more space for the electronics and locking mechanism (p. 60-63). Due to the projects parallel process of working on both energy consumption calculation of the new ceramic heating elements as well as the construction of the final product - these two sections of the report overlap. To clarify further, the changes to battery quantity was made in regards to giving more space for both electronic components and locking mechanism to work within the dimensions of the main unit without increasing the existing size of the product. Although the dimensions of the main unit was to accommodate three 18650 cells, it did not accommodate for an internal locking mechanism. With these changes the final dimensions of the product could be decreased, lowering the overall height of the product.

Requirements

- Heating element must have visual interaction surfaces
- Temperature of product must be maximum 40C
- Electronics must be enclosed
- The joints must be tight
- Must include a thermal switch

05 IMPLEMENT

An even more detailed stage of the solution is explored through materials, production, estimate of price and which business strategy will be best for this type of solution.

Ill. 118 *The Team visiting a rubber factory*

MATERIALS

The materials of the product were selected based on requirements regarding the properties of the materials, price, production method and durability of the materials in the environment.

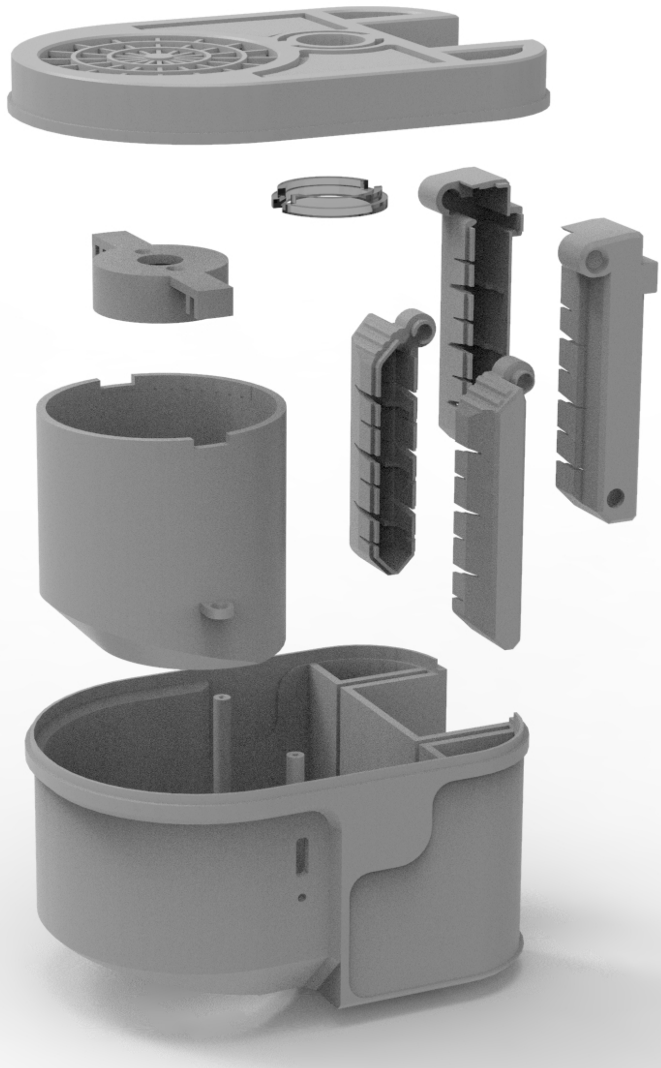
Plastic Components

Most of the product consists of plastic components, which must be durable to withstand the demands of the hiking environment (ill. 119). It is especially important to stand up to drops, wear from use and tension from the motor etc. Furthermore, the plastic components need to be UV resistant due to the weather and the sun. Besides being resistant to UV the plastic also needs to be resistant to heat due to the ceramic heating element. Furthermore, the plastic components constitute the largest part of the product and for that reason have to be as lightweight as possible. Three different types of plastic were considered due to their low density: PP, PEHD and GFPA (app. 45), (Thompson and Thompson, 2017).

Polypropylene (PP)

Polypropylene is a widely used material due to its tough properties. It is lightweight and resistant to water and chemicals. It is a tough, resilient, and inexpensive plastic, which is possible to produce with injection moulding.

Polypropylene is not UV resistant, however, an UV stabilized additive (HALS) can be added to the material. Based on its properties polypropylene is selected as the material for the plastic components as it is more lightweight, inexpensive, harder and has higher tensile strength than PE. Furthermore, PP is more resistant against scratches than GFPA and is opposite to GFPA hydrophobic (Thompson and Thompson, 2017), (Craftech Industries, 2022).



Ill. 119 *Exploded view of the plastic components.*

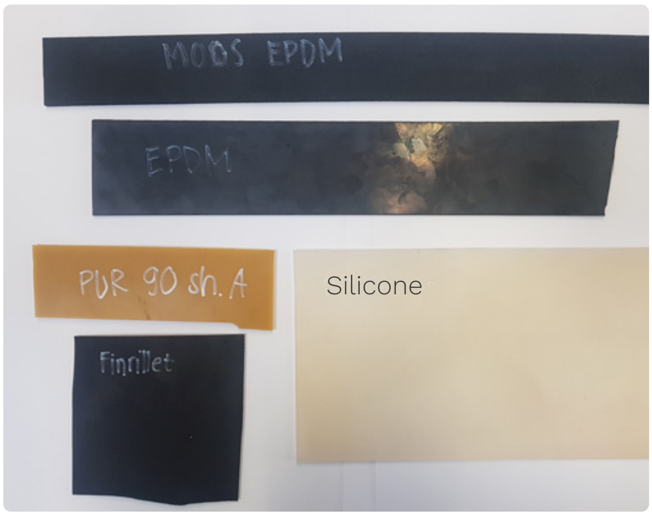
Rubber Parts

The rubber components of the product are either contact surfaces or parts which make the product waterproof (ill 120). For the contact surfaces, the tactile feeling of a secure grip is important in the assessment. Furthermore, the durability of the material was important, as the plastic components, withstand wear from use, weather and drops. Four different types of rubber were considered for the product, TPE, silicone, synthetic rubber, and natural rubber. It was difficult to assess the tactility of the written theory and therefore a visit to a rubber factory was arranged to test and collect samples of materials (ill 121). Tests were made with the samples to try the tactile experience with both dry and wet hands (app. 46).

Ill. 120 *Rubber components*

Synthetic Rubber (EPDM)

Based on the test EPDM was chosen as it had the best friction properties for both wet and dry hands. EPDM was not sticky to the touch with dry hands opposite, unlike silicone. It had still enough friction for a secure grip and did not slip out of wet hands. EPDM is a synthetic rubber and is an alternative to natural rubber. However, it is tougher than natural rubber. It has superior resistance to chemicals, weathering, and heat. EPDM, opposite to natural rubber, are UV resistant (Thompson and Thompson, 2017).



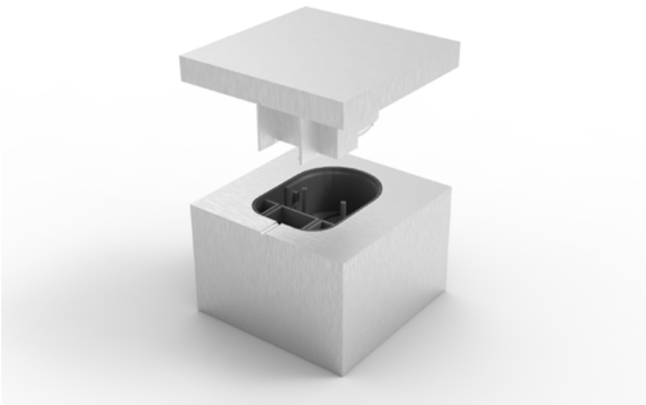
Ill. 121 *Rubber samples*

EPDM, synthetic Rubber gives a secure grip and the needed tactility for the user

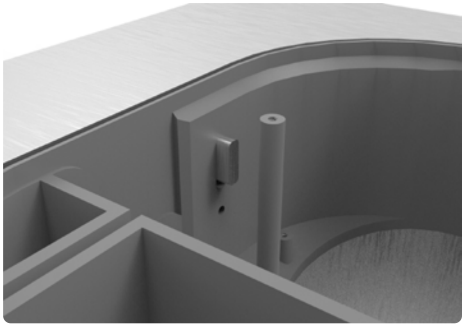
PRODUCTION

Injection Moulding

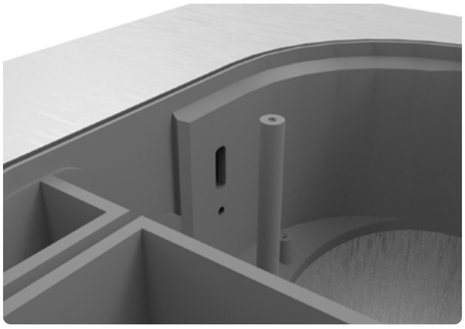
Most of the parts of the product are made of PP. The easiest and cheapest production method for PP parts is injection moulding (ill 122). All the injection moulded parts have been designed for standard guidelines for injection moulding (Protolabs, 2022). All the parts are designed with drafts parallel to drafts on the moulding to help the pull of the part. However, to include all the wanted functions some parts must be injected into a mould with a side pull (ill 123 & 124). This adds some cost to the mould and some movement time of the machine, which increases the cost. However, it is still the cheapest to injection mould these parts.



Ill. 122 *Injection mould*



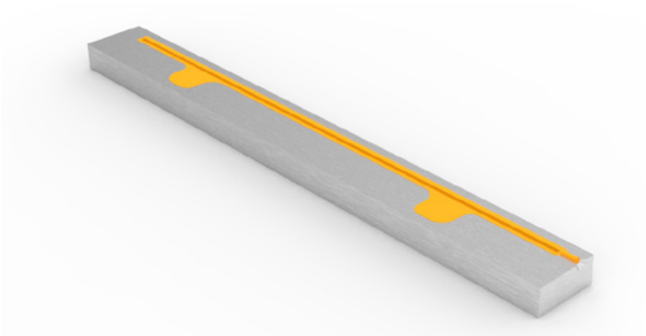
Ill. 123 *Side part of mould out*



Ill. 124 *Side part of mould in*

Rubber Casting

The easiest and cheapest method to produce parts made of synthetic rubber is to cast them in a mould. These parts will after casting have an inlet channel which needs to be removed after casting. As the rubber is a soft material which can be bent without being damaged, they do not need drafts. The rubber band is designed for being cast and is cast laying flat, as it is the cheapest method and because it can be bent after being the casting (ill 126).



Ill. 126 *Cast moulding*

Injection moulded plastic parts	30,81 DKK
Fabric parts	0,15 DKK
Electronic components	103,74 DKK
Assembly costs	0,97 DKK
Total cost	134,70 DKK
Cost per pair	**271,54 DKK**

Ill. 125 *Production price*

Production Price

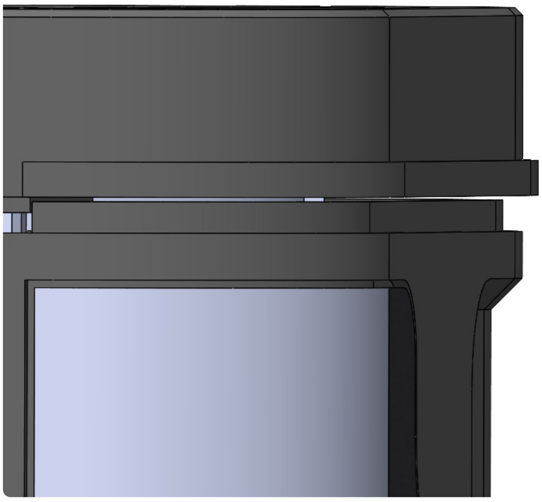
An estimation of the product price has been made from either guestimations or estimations on material cost, factory cost, components cost and assembly time and wage. The estimations on the costs are made from references to similar materials, machines, components, wages or assembling etc. The guestimation is made where it was not possible to do an estimation from something similar. The guestimation is instead made from previous knowledge. The estimation of the production price of one pair of products is 272 DKK (ill 125). The biggest part of the cost is the electronic components, especially the batteries (app. 46).

Assembling

The parts of the product are assembled with different types of assemblies depending on the parts function, form, and production method.

Lid and Bottom

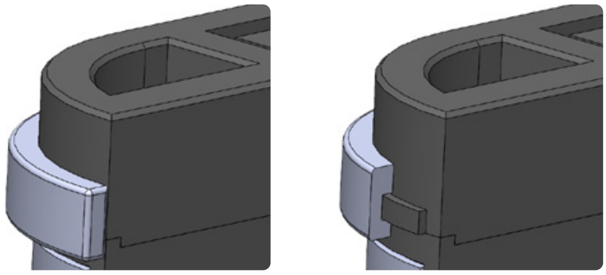
The first intention was to assemble the lid and the bottom by screwing them together. However, this was not possible due to the parts being injection moulded. The parts were designed to being pull out of the mould from the top, though it was not possible to insert the screw from the side without having an expanding mould, which is expensive. It was therefore, decided that the lid and bottom are assembled with glue and a snapping edge (ill 127).



Ill. 127 *Edge assembling between lid and bottom*

Rubber Band

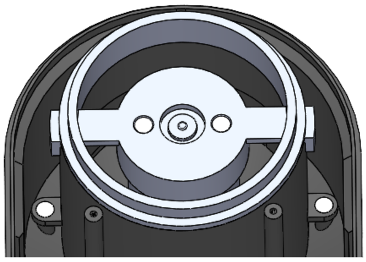
The rubber band is assembled with glue and on an edge on the lid. By using this assembling type the rubber band is pulling on the edge from both sides and together with the glue it is a durable assembling. Furthermore, the rubber band with this assembling can be cast flat, which will only enhance the tension to the edge (ill 128).



Ill. 128 *Edge assembling between lid and rubber band*

Motor

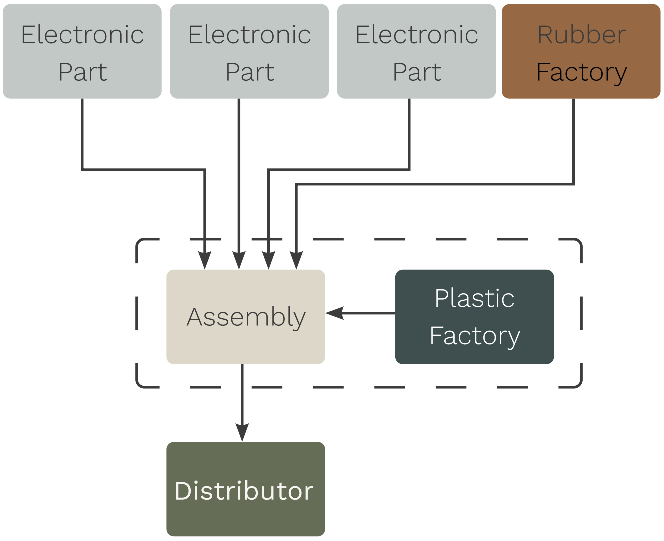
The motor needs to be secured with screws on to the product as it is a rotating part. If the motor were assembled by tension as first though, it could break free or tension from the movement could break the material of other parts. Therefore, the motor is screwed onto a connecting part, which is inserted into the fan tube, and the fan tube is then also screwed onto the bottom (ill 129).



Ill. 129 *Screw assembling of motor*

Supply Chain

The supply chain consists of several companies fabricating different parts of the product and supplying them to one factory which assembly the product. The rubber parts and the injection moulded parts will be produced in different factories, one of these will, if possible, be assembling the product. The electronic components will be produced in other factories, which will supply the assembling factory with the electronic parts (ill 130).



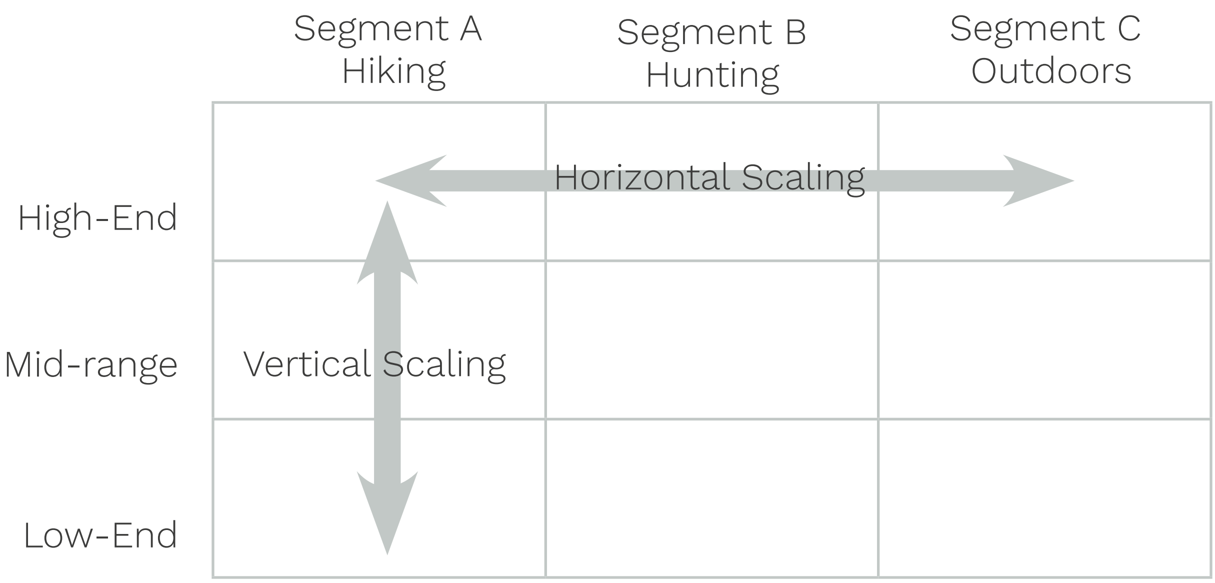
Ill. 130 *Supply chain*

MARKET POTENTIAL

The following section looks at the cost estimation of production as well as variable cost associated with bringing the product to market. The section is divided into three sub sections *market potential, budgeting and lastly launch strategy.*

Market Potential and Scaling

The market potential and market revenue size are based on the US market, as this market has the greatest potential with a total grossing of 198 million USD in 2017. Looking at data and market revenue of hiking gear, approximately 15% of the market grossing 30 million was allocated to the sale of hiking equipment alone (Grand View Research, 2020). With a further market increase projection of 7.0% from 2020 to 2027. The market potential was further supported with 57.81 million Americans participating in hiking in 2020, a 93% increase since 2006 (Statista Research, 2022). Expanding the potential for sales to other industries closely related to that hiking, the US hunting market in 2019 was a 38 billion USD market, with 7.1 billion allocated to the sales of equipment alone (DataM Intelligence, 2022). With a market potential growth of hunting apparel and equipment of 544 million to 4.27 billion USD from 2022-2026 (Technavio, 2021). With a 49% increase in locale sales. This means with including potential customers from other sections allows for a larger scaling of the customer base. This means optimizing market potential could happen by the use of vertical as well as horizontal leveraging as illustrated below (see ill 132).



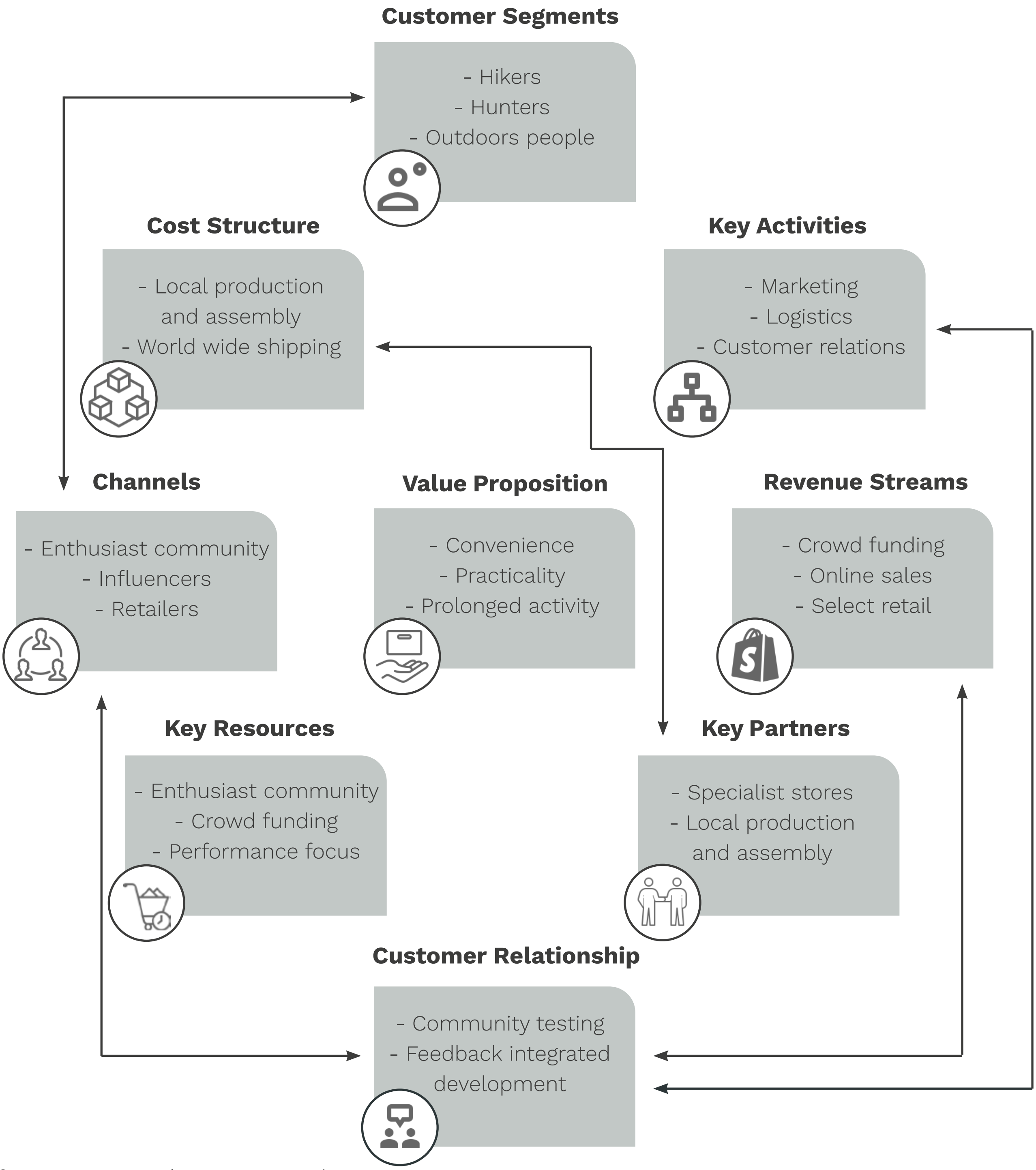
Ill. 131 *Market scaling leverage (Meyer, 1997).*

BUSINESS MODEL

Looking at the market potential of scaling the product both vertically as well as horizontally, creating a business plan for launch requires looking at tools for giving an overview. In this case, a business model canvas can give the necessary overview of going from a product idea to a business.

Business Model Canvas

The business model canvas consists of several segments describing the key points of each aspect of the business (Osterwalder and Pigneur, 2010). The key points highlighted in each aspect are what ties the business together. Integrated into the business model canvas, are vital aspects that could make or break the business when coming up with the launch strategy. Some of these aspects are linkable and relates to each other. Having these connections could strengthen the business case (ill. 133).



Ill. 132 *Canvas Icons (Image: icons8.com)*

COST ESTIMATION AND BUDGETING

Before being able to construct a business plan that eventually will lead to the launch of the product. Cost estimation and budgeting are necessary to understand initial investments and profit margins. With this data a break-even analysis can be made, allowing for future projections of the finances in a given business model. One pair of Wanderlust will be addressed as one unit to simplify calculations.

Unit Cost Estimation

To give a better overview of the cost estimation, the schematics seen to page 76 ill 125, is broken down into categories of elements of the entire construction. The unit cost of 271,54 DKK has been estimated based on large-scale production of 100.000 units. This cost takes into account the initial investment of having to buy the tooling necessary for a production of this scale. Production cost at smaller quantities may therefore affect the overall unit price.

Reaching Break-Even

Looking at Wanderlust as a large-scale production of 100.000 units at a unit cost of 271,54 DKK would yield a profit of 26,1 million DKK. However, this would require an annual sale of 100.000 units within the first year, with a small company size of 10 employees running all of the operations except production. A more realistic estimation of annual sales on a global market would be 10.000 units per year with a company of 3 employees. With an initial investment of 3.42 million DKK for machining and a profit of 295 DKK per unit, it would take 14 months or 11.593 units for the company to break even.

Annual Growth

With an initial production of 10.000 units and annual growth of 5%, it would take the same company size nine years to sell the same quantity of units grossing 9% less in total profit. There is some variable such as inflation that has not been taken into account.

Variable Costs	
Production cost	271,54 dkk
Packaging	5 dkk
Import fees (5%)	15.61 dkk
Import shipping	6,82 dkk
Shipping	40 dkk
Total	**338.97 dkk**

Fixed costs	
Rent	25.000 dkk
Employee salary	285.000 dkk
Marketing	20.000 dkk
Storage	8000 dkk
Utilities	2000 dkk
Total	340.000 dkk * 12 = 4.080.000 dkk

Investment cost	
Design protection	12.500 dkk
Legal fees	2500 dkk
Business Registration	40.000 dkk
Investment	3.370.692 dkk
Total	3.425.692 dkk

Total cost per 100.000 units	
Variable cost	33.897.000 dkk
Operation cost	4.080.000 dkk
Investment costs	3.425.692 dkk
Total	41.402.692 dkk

Revenue	
Price pr unit	900 dkk
Total Revenue	**90.000.000 dkk**

Profits per 100.000 Units	
Total revenue	90.000.000 dkk
VAT (25%)	22.500.000 dkk
Total expenses	38.027.000 dkk
Profit	**26.102.308 dkk**

Ill. 133 *Profit with annual Growth of 10000 units*

Global sales		105%	105%	105%	105%
Budget	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Units sold	10.000,00	10.500,00	11.025,00	11.576,25	12.155,06
Unit price	900	900	900	900	900
Unit cost	271,54	271,54	271,54	271,54	271,54
Expenses	4.545.400,00	4.681.170,00	4.823.728,50	4.973.414,93	5.130.585,67
Revenue	9.000.000,00	9.450.000,00	9.922.500,00	10.418.625,00	10.939.556,25
VAT (25)	2.250.000,00	2.362.500,00	2.480.625,00	2.604.656,25	2.734.889,06
Profit	2.204.600,00	2.406.330,00	2.618.146,50	2.840.553,83	3.074.081,52
Investment	- 3.370.692,00	- 964.362,00			
Remaining	- 1.166.092,00	1.441.968,00	2.618.146,50	2.840.553,83	3.074.081,52

105%	105%	105%	105%		TOTAL
Year 6	**Year 7**	**Year 8**	**Year 9**		9
12.762,82	13.400,96	14.071,00	14.774,55		100.265,64
900	900	900	900		900,00
271,54	271,54	271,54	271,54		271,54
5.295.614,95	5.468.895,70	5.650.840,49	5.841.882,51		46.411.532,75
11.486.534,06	12.060.860,77	12.663.903,80	13.297.098,99		99.239.078,88
2.871.633,52	3.015.215,19	3.165.975,95	3.324.274,75		24.809.769,72
3.319.285,59	3.576.749,87	3.847.087,37	4.130.941,73		28.017.776,40
3.319.285,59	3.576.749,87	3.847.087,37	4.130.941,73		23.682.722,40

Ill. 134 *Global Sales Budget for 9 years*

LAUNCH PLAN

Evaluating the budget in accordance with a unit cost based on 100.000 units. It would require a very large investment of nearly 3.5 million DKK in order to purchase machining capable of producing large quantities. Launching a production at this scale would require using a big supply chain and numerous retailers in order for profits to be optimized. Acquiring the initial investment would also require selling a large part of the company to an external investor. However, there are other alternative launch strategies.

Benefit of Crowd-Funding

Returning to the Business model canvas (p. 79) a benefit of having a customer segment with an enthusiast community is leveraging the activity online as free marketing. As previously mention (p. 16) the target user is actively searching for hiking equipment. Leveraging this in a business model would be using a crowd-funding campaign as the basis for launch. One added benefit of a crowd-funding campaign is the initial investment funded by people supporting the product and campaign before it has even launched. This would lead to higher evaluation of equity, allowing for additional investment to be implemented post-launch to scale up production.

Comparisons to Similar Campaigns

Looking at similar crowd funding campaigns of products in the same category as Wanderlust, *VSSL, Voyager and cook system by Wolf and Grizzly* stand out. All were successfully funded on Kickstarter with about 2000 backers each. These are all specialist or gear enthusiast products. In the interview with Expert 1 from Friluftsland (p. 53), we discovered that products like these are not products a user would look specifically for in the store, and need to be discovered, this further underlines the potential of launching Wanderlust as a crowd funding campaign.

Ill. 135 *VSSL (vsslgear.com)*

2400 Backers
1.9 mil DKK

Ill. 136 *Voyager (Parkitmovement.com)*

2080 Backers
3.4 mil DKK

Ill. 137 *Cook system (wolfandgrizzly.com)*

1745 Backers
2.5 mil DKK

Launch Strategy

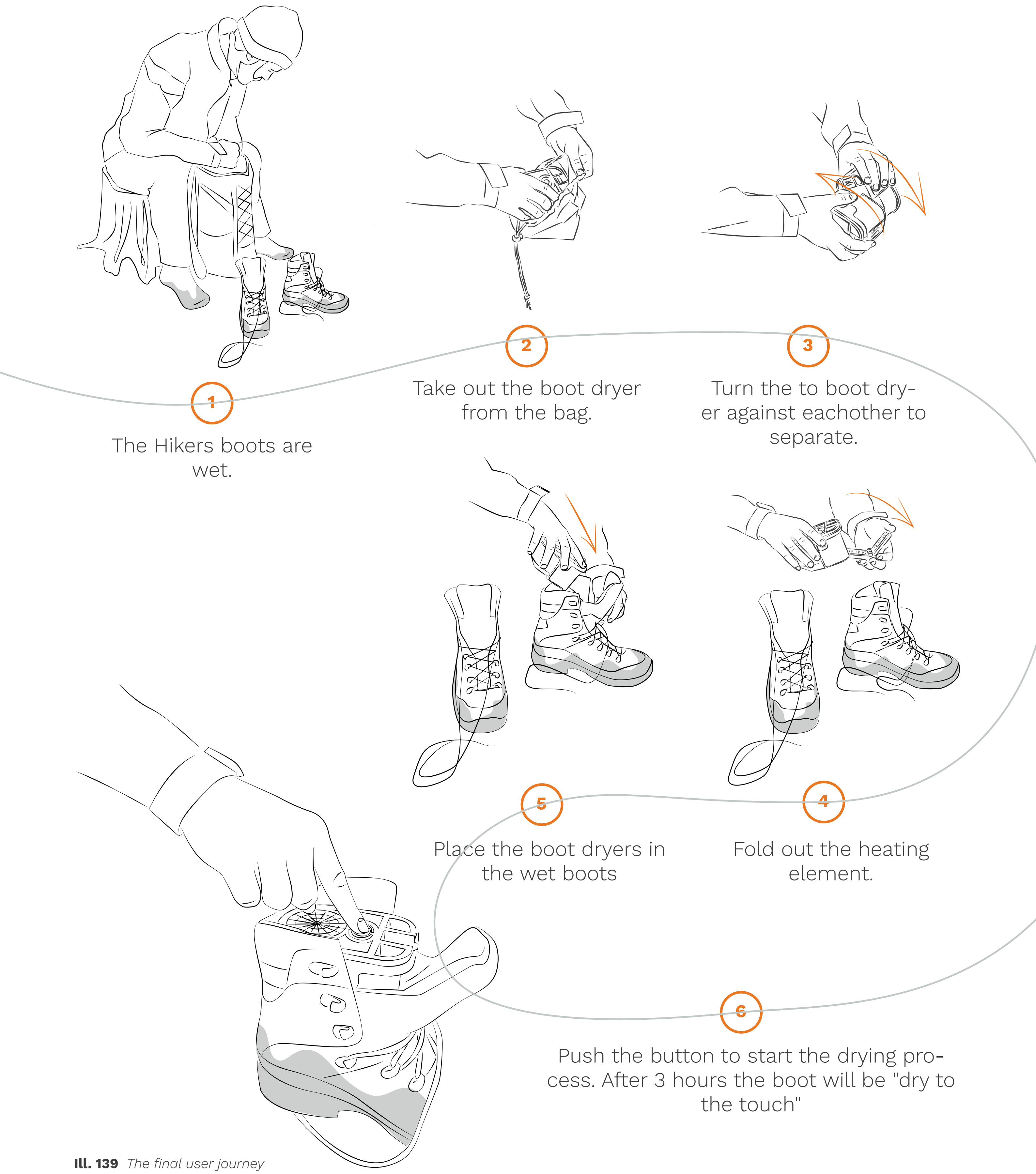
Launching Wanderlust through a crowd funding campaign would tie well with the initial business model, by using a platform for early integration of user feedback into development. With an estimated 2000 backers Wanderlust would gross 1.8 million DKK with a slightly higher unit cost but a lower operational cost and no initial investment cost besides the marketing material and prototypes. With a time to mark of 1 year, Wanderlust would profit 1.189.950 DKK (ill. 139). This would allow for further investment in production as well as online sales channels in the following years.

Profits at 2000 units	
Variable cost	- 679.400 dkk
Operation cost	- 450.000 dkk
Kickstart fee (3% per +3 dkk unit)	- 60.000 dkk
Revenue	+ 1.800.000 dkk
Profit	+610.600 dkk
Total	**1.189.950 dkk**

Ill. 138 *Profits at 2000 Units*

FINAL USER JOURNEY

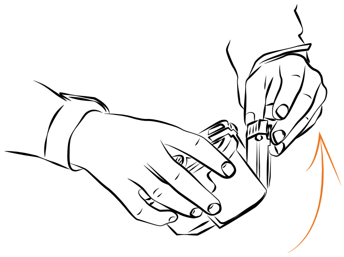
On this page, the final user scenarios are presented before the submission of this project.



Ill. 139 *The final user journey*

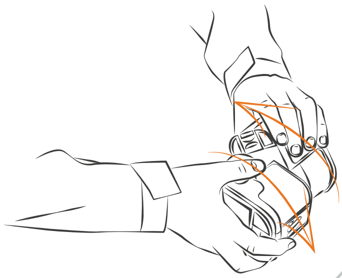
6

Take out the boot dryers



7

Fold the heating element back up.



8

Turn the boot dryers against each other to connect

9

Put the boot dryers in the bag.

10

The boots are dry and ready for a comfortable hike

The final boot dryer weights 289g per unit or 580g in total. The reduction in the weight compared to milestone 3, is due to change of the heating element and reduction of battery.

The final main dimension are 70x116x84mm.

FULFILMENT OF REQUIREMENTS

Below is a table of some of the requirements and wishes to create an overview and show whether the team has managed to meet them. Requirements regarding the drying performance will be assessed based on test result through out the project.

	No.	R	W	Parameter	Page. NO	Fulfilled
Performance		x		Must dry a pair of waterproof or non-waterproof hiking boots	12	Undefined
		x		Must remove water from the toe-area	12	Yes
		x		The solution must not injure the user	13	Yes
		x		The solution must be transportable	15	Yes
		x		Must not fail during a hike	16-17	Undefined
		x		Must make the user boot more comfortable	16-17	Yes
		x		Dry a pair of boots within 4 hour	19 & 38	Yes
			x	Dry a pair of boots within one hour	19	No
		x		The boot must not shrink or expand during the drying process	23	Yes
		x		Must not expose the boot to chemicals and oils	23	Yes
		x		Must reduce the relative humidity between 40%-60%	23	Yes
		x		Must work in Denmark & Norway	25	Undefined
			x	Support the structure of the boot	22	No
		x		Must dry till 65 g water left in boot	38	Yes
			x	Must dry till 45 g water left in boot	38	Yes
Aesthetic		x		Must be high-end product	8	Yes
		x		Must reflect the functions through aesthetics details	36-37	Yes
		x		Must include aesthetics of direction 1	36	Yes
Interaction		x		Must be organizable	37-38	Yes
		x		The Interface surfaces must be accessible when it is in the boot	38	Yes
		x		Must indicate the depth of insertion in the boot	38	Yes
		x		Must make the user feel and look professional	47	Yes
Construction		x		Must be of high quality	8 & 17	Yes
		x		Increase airflow in toe area	12	Undefined
		x		The solution must be durable in nature	16	Undefined
		x		The electronic must be quiet	19	Undefined
		x		Must dry the boot from the inside	29	Yes
		x		Must be rechargeable	40	Yes
		x		Must have an IP rating 54 or higher	57	No
		x		Must not overheat	69	Yes
			x	Have a width of below 80mm	42	No
			x	Have a hight of below 130mm	42	Yes
			x	Have a length of below 120mm	42	Yes

06 | EPILOGUE

The last chapter will include a conclusion of the current solution, reflection of the solution and of the team process.

Ill. 140 *Interaction test with one of the experts*

CONCLUSION

In choosing the topic for the project, the initial intention was to create a product that would impact the everyday life of a user. Moreover, the projects topic had to have a degree of complexity that allowed for a accessible context and a user ground that would be compliant in co-operating with the project so not to set limitations for the possibilities of the final solution. Hence the change from the initial *"Re-design of fire shelters"* and later in the early stage of the process working with hand pain in relations to nursery teachers. The topic of *"Wet hiking boots"* came as a recognition in having an available context, known users and an interest in the topic of outdoor activities. With the initial research it was discovered that despite the apparent lesser complex problem definition, the potential for creating a feasible product for gaping market seemed compelling.

A gap in the market was discovered for a portable and efficient boot dryer for hikers on longer hiking trips. Although it was a product that did not appear to be solving any critical issues, it was discovered through the first interviews with users and experienced hikers, that a products on such would be welcomed for a specific type of hiker. The initial user research unveiled a widespread hiker known as the gear fanatic. The target user became the basis for the final solution, but not limited to, the possibilities of being a relevant product for a number of different hikers - and later discovered other segments such as hunters and military.

In developing the early vision for the product, focusing on the fundamentals of hiking terminology, meant always keeping the following in mind; The product had to be lightweight, efficient, durable and compact. With these guidelines the ideation stage was conducted according to the strict requirements, including the possibility of applying an innovative approach to the traditional drying methods of competitive products. Meanwhile, the basics of drying methods were tested, analysed and evaluated to understand the most optimal integration of methods and technology in order to make a compelling and performance oriented product. With the project's aim set at creating a portable but efficient product, meant running iterative test to determine and established the necessary understanding for improving the already existing solutions.

In testing and prototyping the initial ideas, the difficulty of creating a proof of performance in an early stage meant that the team decided to shift focus, to include the interactive and aesthetics aspects of the solution as well. The team did not only focus on making a proof of concept but a cohesive understanding of the entire project. At this stage in the project a deeper understanding of the target user became imminent and helped propel the understanding of the solution relations to the user. Hereby, an understanding of the needs and requirements of the user and their perception of the capabilities of the solution. This helped elevate some of the aspects in addition to the performance and allowed for further investigation into the importance of the aesthetics and interaction from the users perspective.

Through concept sketching, 3D modelling, interviews and clusterings "Wanderlust" took shape. With the remaining time of the project now set to the development and detailing of Wanderlust, meant that aspects like production, construction and performance could proceed in parallel. With the understanding of production and cost, a predetermined market potential and enthusiasm of the target user towards researching into their next new product - meant that a business strategy could be founded on the basis of a crowd funding campaign. Taking full advantage of the target group, the market size and product complexity meant this could create the foundation for a potential launch strategy of the product and the creation of a startup with potential of future product expansion.

There is potential for further development and improvement to the performance of the solution at a later stage in the project and will be further investigated. However, with Wanderlust the team have created a transportable boot drier for Hikers. It can dry a pair of wet boots within 3 hours. Thereby, Wanderlust have displayed promising results in solving a recognizable problem for the common hiker.

REFLECTION

Process Reflection

As for reflections on the process, the biggest impact on the process progression was the use of *Kolbs Learning Circle*. Working with a large quantity of unknown factors in developing the performance aspect of the solution, meant that everything had to be tested and analysed instead on relying on the theoretical literature associated with the topic. This in terms of time, meant that a large portion of the project was depended on executing hour long tests in order to get results that could then be analysed, reflected on and lastly implemented in a new set of prototype test. Furthermore this meant allocating time to improve the performance, decrease the development in other areas as vice versa. An important notice was, the early integration of target users in the research and ideation phase, which allowed for accessibility to test persons and feedback from the user in developing the identity of the product. Although most of the information was collected through interviews, methods such as shadowing could have been implemented instead of interviewing to deeper understand the use case scenario. However, this would neglect some of the latent needs discovered in interviewing the various users and experts.

In relations to the process progression, the tests performed was that of qualitative nature. This meant that the tests could have a degree of uncertainty but would allow for conclusions and reflections based on a selection of test results and not the need for repetitive testing in order to verify a given hypothesis. An important example in handling test results, is the abstain use of the absorbent material. Even though adding this material resulting in a faster drying time it was deselected, as it was considered to hinder the user in feeling professional not uplifting the quality of the product. The same goes for the abstain use of waste heat recovery in the solution in order to simplify the construction despite might having improved the energy consumption. Furthermore there were errors made in executing the tests, that allowed for an inconsistency in test results, but through analysis could be determined. This includes the means of measuring that required the drying to stop for the duration of measuring the necessary data. As well as the solution only being tested with ambient temperature similar to summer weather. Due to changing seasons during the project it added a layer of complexity to the testing to include both winter and summer temperatures that would disrupt the rate of testing.

Due to the nature of hiking equipment being very focussed on the performance meant that, this was the necessary driving focus on the project from the beginning. However, the team discovered that they were able to improve the users perception of the product by including and improving other aspects of the product. Aspects such as interaction and aesthetics that elevated the product despite its questionable performance throughout the project.

As for the final reflection on the process is in terms of project management. In the final stage of the project the team came to the realization that, if continuing on improving the performance and other aspects of the product the project due to the level of ambition it would not be able to be finished in time - a decision was made to put the development on hold in order to finalize the product and the project as a whole.

Product Reflection

Reflecting on the product and the market potential, it is clear that Wanderlust would be a design push. Despite similar products existing on the market, the teams ability to work on improving the user perception of the product resulted in the potential need for this product in the target user perspective. Furthermore, this gave basis for creating a business surrounding the product that could expand to other customer segments. Working with improving the interaction, aesthetics and the organisational aspects of the product meant the product was stronger as a whole. Despite the improvements needed to the performance based aspects of the design, with the rapid development of the product at the late stage of the project meant that other aspects like the locking mechanism, construction and cohesiveness of the product could be further developed and improved in a later stage as well.

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ILLUSTRATIONS

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INDUSTRIAL DESIGN
SPRING 2022

TECHNICAL DRAWINGS

Wanderlust • Aalborg University • June 2022 • MSc04 ID09

Ill. 01 *image: Freepik.com*

Frederik Kiersgaard Lund • Mette Clausen Nielsen • Mie Charlotte Lundborg

INTRODUCTION

The technical drawings folder is a collection of assembly drawings and production drawings of Wanderlust. It includes drawings of nonstandard components, thus it does not include drawings of standard components, such as screws, O-rings etc. Furthermore, it does not include drawings of the electronic parts of the product. Because of the complexity of the product, it is not feasible to show measurements which are 100% correct on all 2D drawings. Therefore, it is decided to show how a proper technical drawing would be with only one part. The part showing the proper measurement and technical drawing technique is the lid of the product at drawing no 6.1 and 6.2. The rest of the parts are shown with measurements of width, length, height, radius of holes and wall thickness. All parts are designed with a tolerance of the measurements of ± 0.25 mm and all measurements are in mm. All the drawings are conducted by Mette Clausen Nielsen and verified by Frederik Kiersgaard Lund.

ill 01 - https://www.freepik.com/photos/trekking

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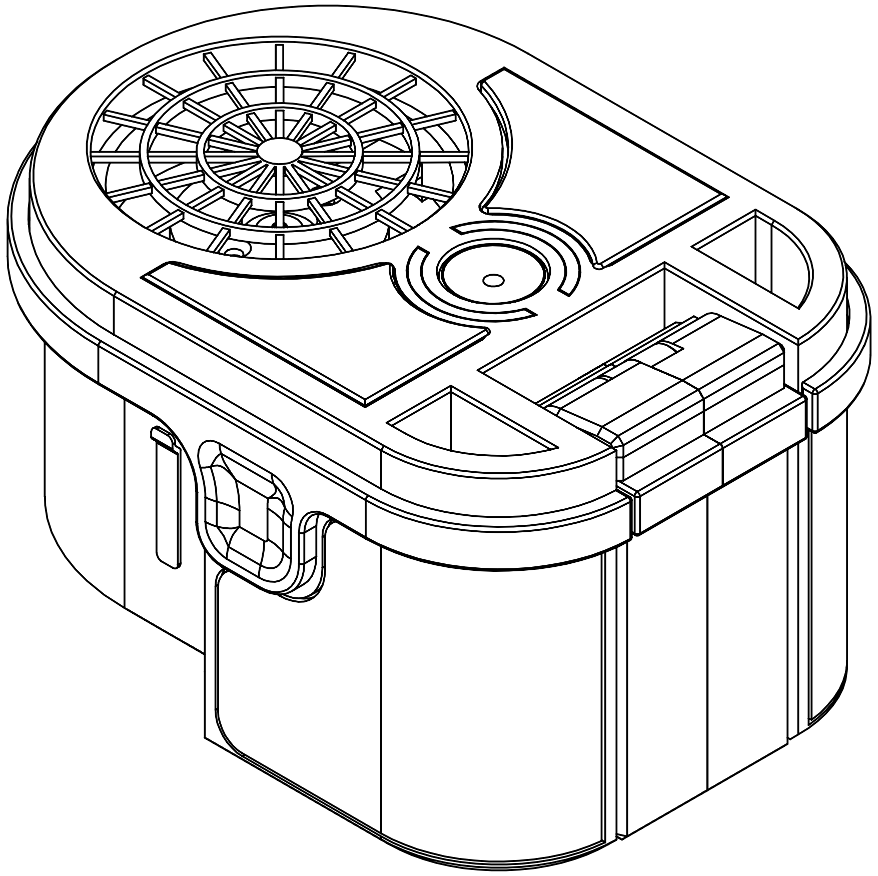
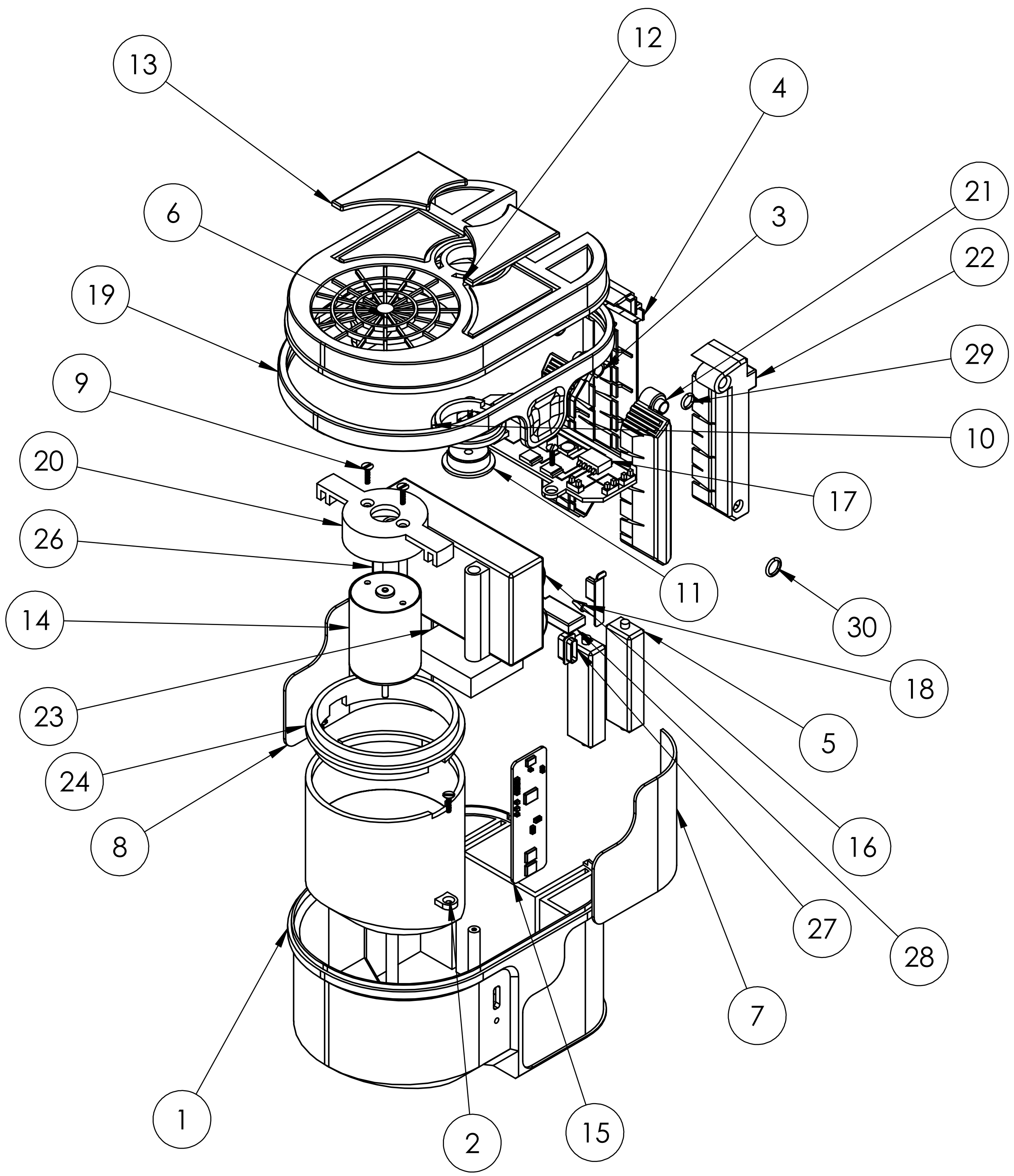


DO NOT SCALE DRAWING	REVISION
TITLE: Wanderlust	
DWG NO. 1.1	A3
SCALE: 1:2	SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.



No	QTY	Item	Material
1	1	Bottom	Polypropylene (PP)
2	1	Fan Tube	Polypropylene (PP)
3	1	Heating Box BR	Polypropylene (PP)
4	1	Heating Box FR	Polypropylene (PP)
5	2	Ceramic Heating Element	-
6	1	Lid	Polypropylene (PP)
7	1	Fabric L	Cotton
8	1	Fabric R	Cotton
9	6	Screw M2X6	-
10	1	Light	Polypropylene (PP)
11	1	Rubber Button	Synthetic Rubber (EPDM)
12	1	Rubber TL	Synthetic Rubber (EPDM)
13	1	Rubber TR	Synthetic Rubber (EPDM)
14	1	Motor	-
15	1	BMS	-
16	2	Battery	-
17	1	PCB Board	-
18	1	Rubber Plug	Synthetic Rubber (EPDM)
19	1	Rubber Band	Synthetic Rubber (EPDM)
20	1	Fan Connector	Polypropylene (PP)
21	1	Heating Box BL	Polypropylene (PP)
22	1	Heating Box FL	Polypropylene (PP)
23	1	Membrane	Synthetic Rubber (EPDM)
24	1	Fan Membrane	Synthetic Rubber (EPDM)
26	1	Battery Box	Polypropylene (PP)
27	1	USB-C Plug	-
28	1	Thermal Switch	-
29	2	O-ring Ø5	Synthetic Rubber (EPDM)
30	2	O-ring Ø6	Synthetic Rubber (EPDM)

DO NOT SCALE DRAWING

REVISION

TITLE:

Exploded View

DWG NO.

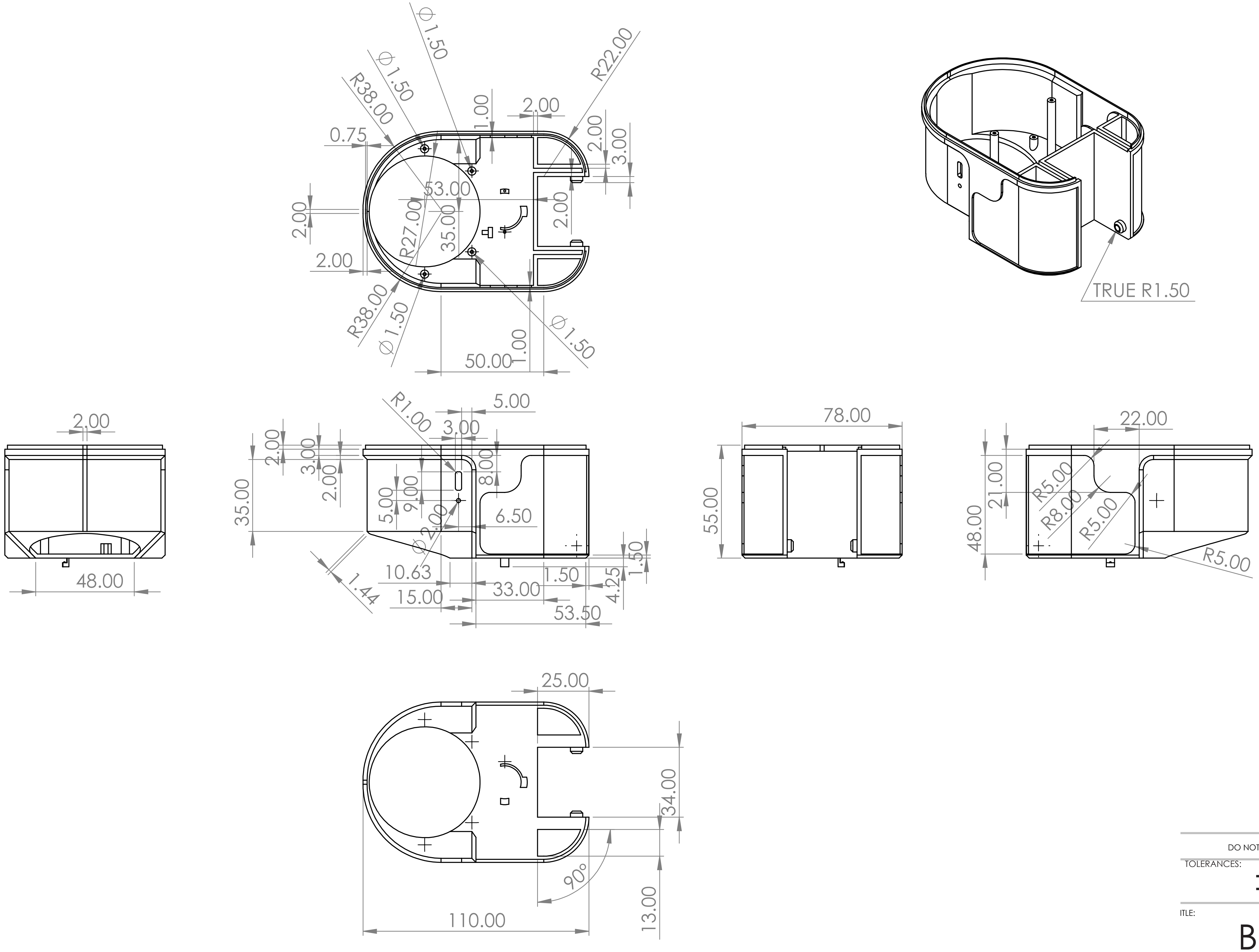
1.2

A3

SCALE: 1:2

SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.



DO NOT SCALE DRAWING

REVISION

TOLERANCES: ± 0.25 mm

TITLE: Bottom

MATERIAL: PP

DWG NO. 2

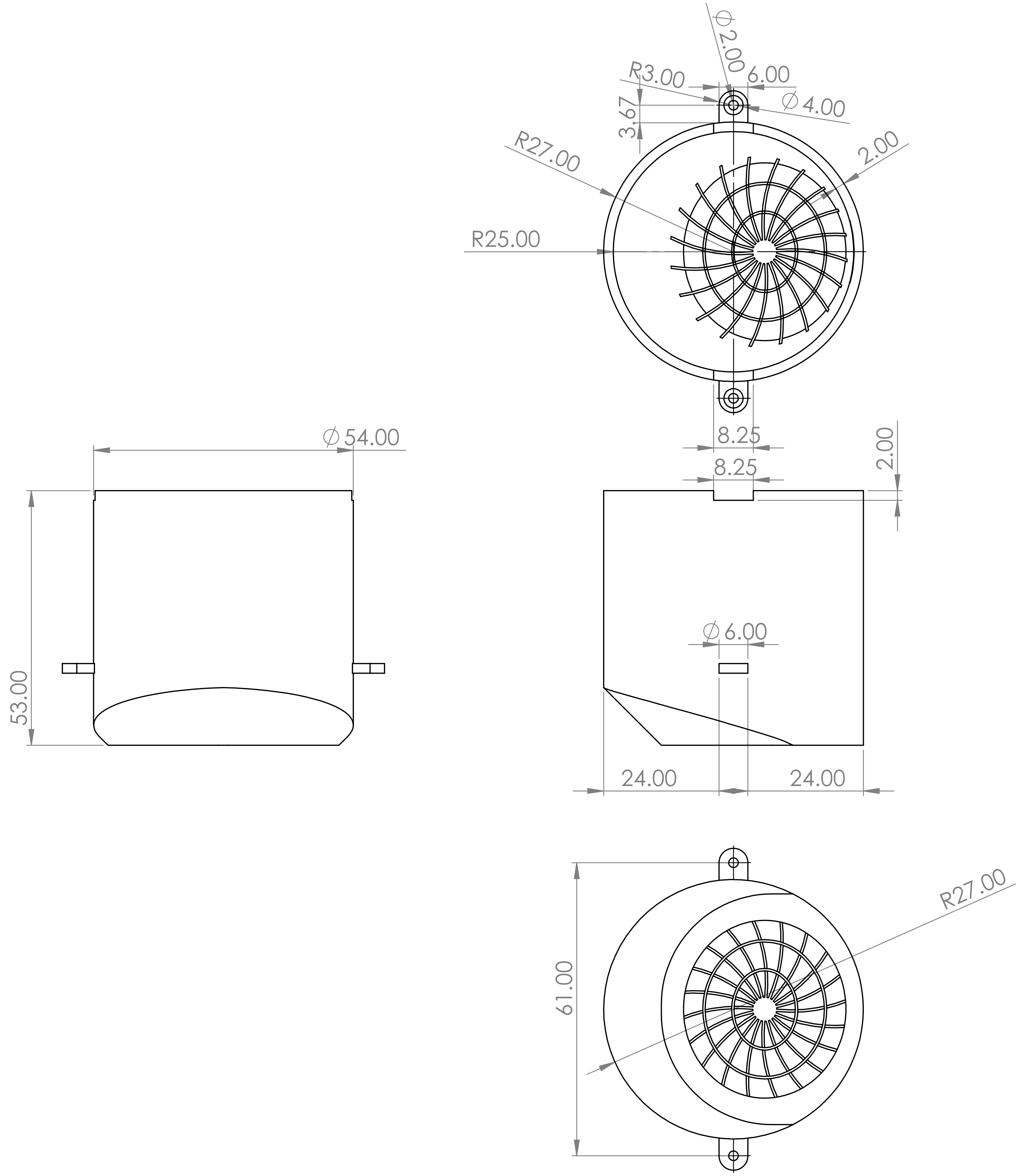
A3

WEIGHT: 53.05 g

SCALE:1:1 1:2

SHEET 1 OF 1

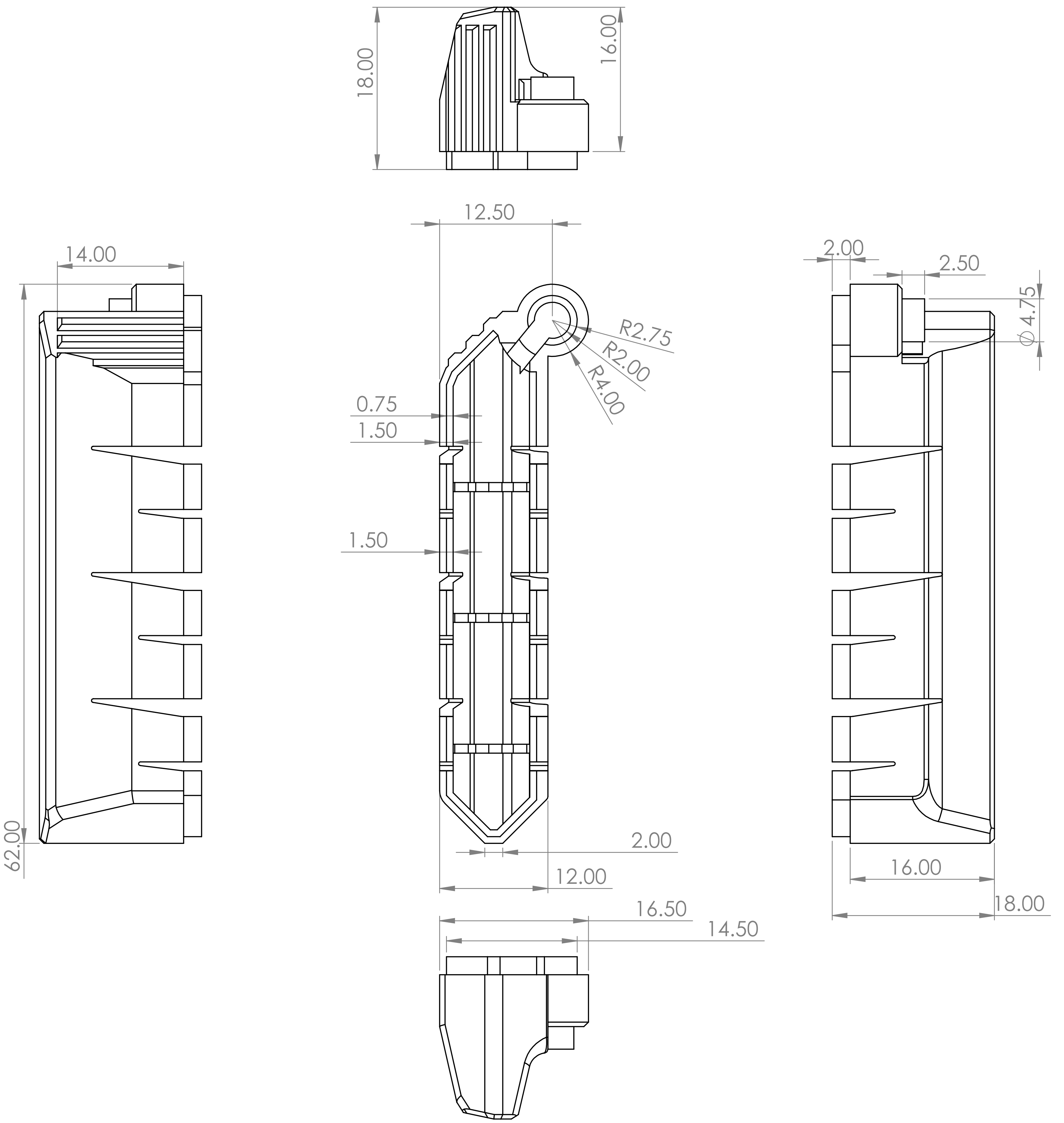
SOLIDWORKS Educational Product. For Instructional Use Only.



DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Fan Tube	

MATERIAL: PP	DWG NO. 3	A3
WEIGHT: 26.06 g	SCALE:1:1	SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.



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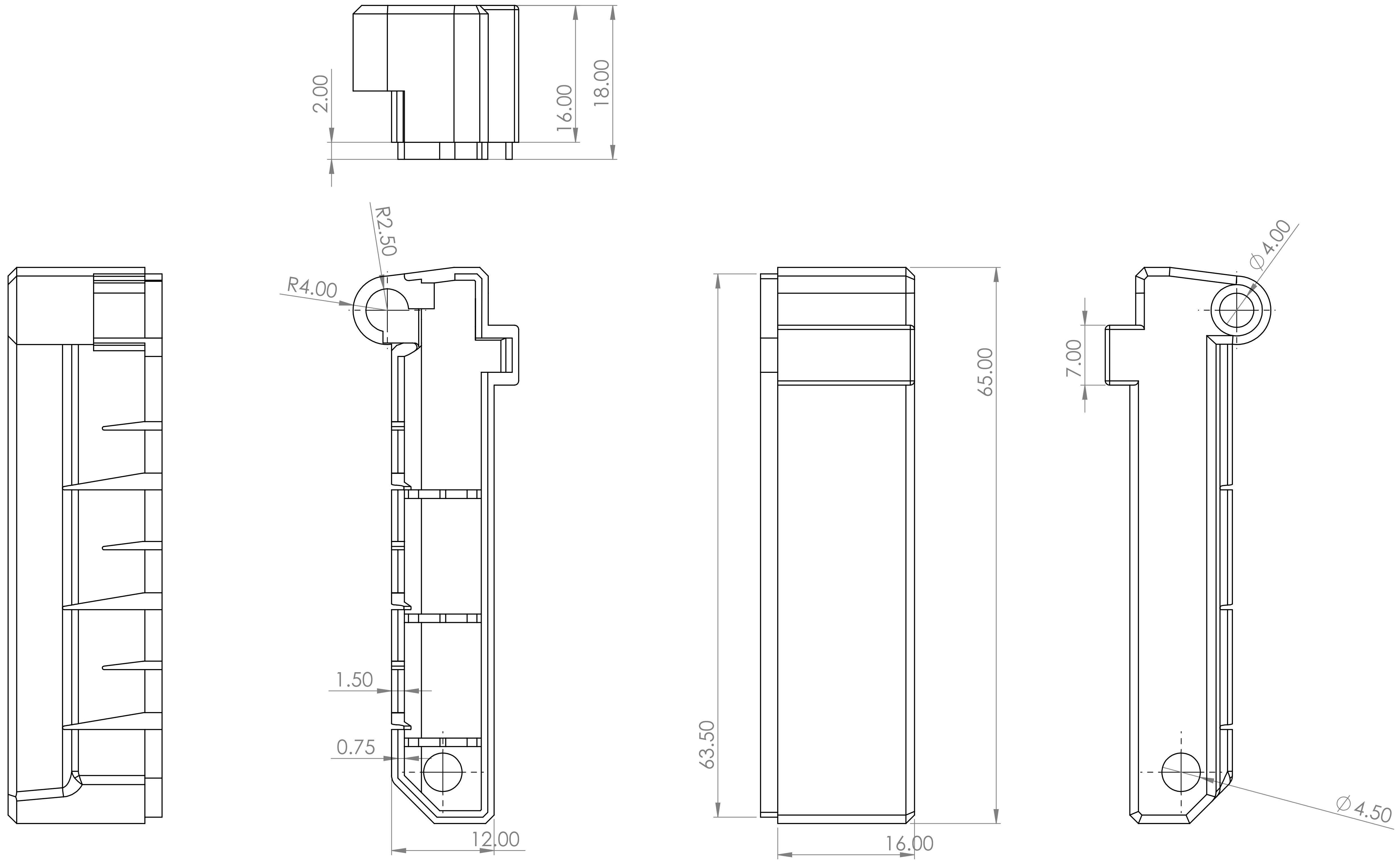
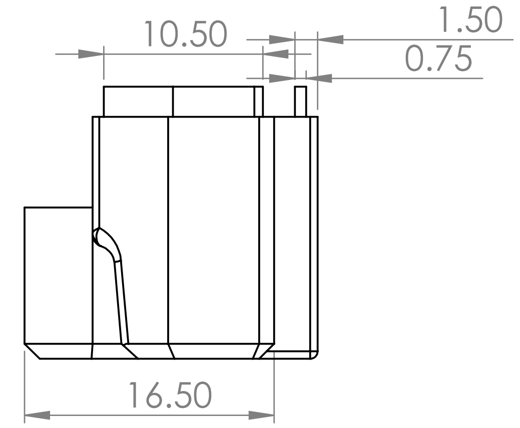
TOLERANCES: ± 0.25 mm	
TITLE: Heating Box BR	
MATERIAL: PP	DWG NO. 4 — A3
WEIGHT: 3.57 g	SCALE:2:1 — SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.





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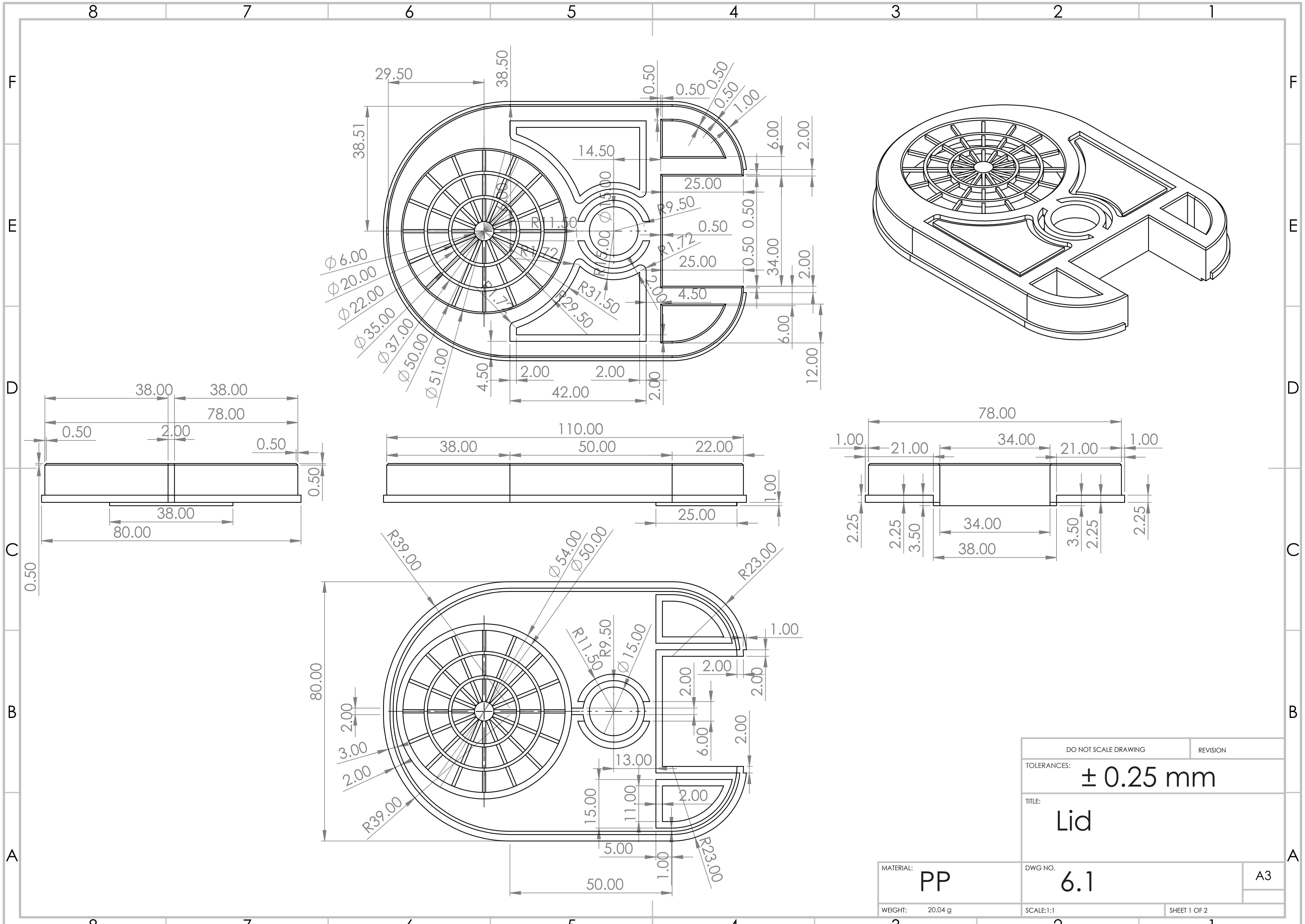
TOLERANCES: ± 0.25 mm	
TITLE: Heating Box FR	

MATERIAL: PP	DWG NO. 5	A3
WEIGHT: 3.99 g	SCALE:1:1	SHEET 1 OF 1

SOLIDWORKS Educational Product. For Instructional Use Only.



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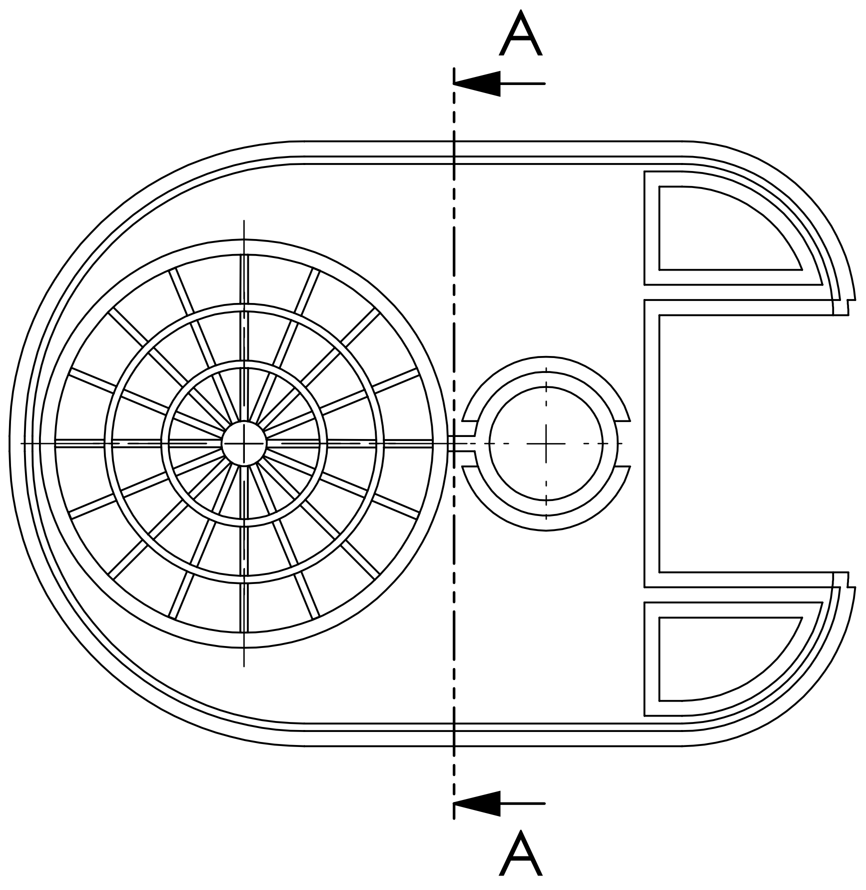
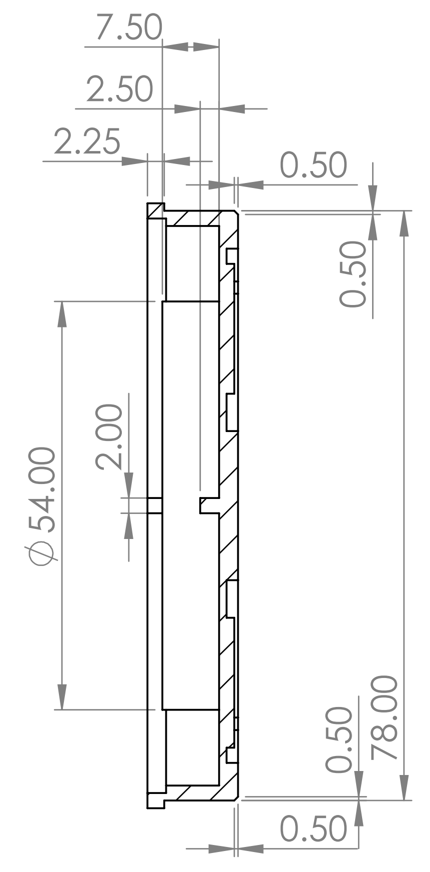
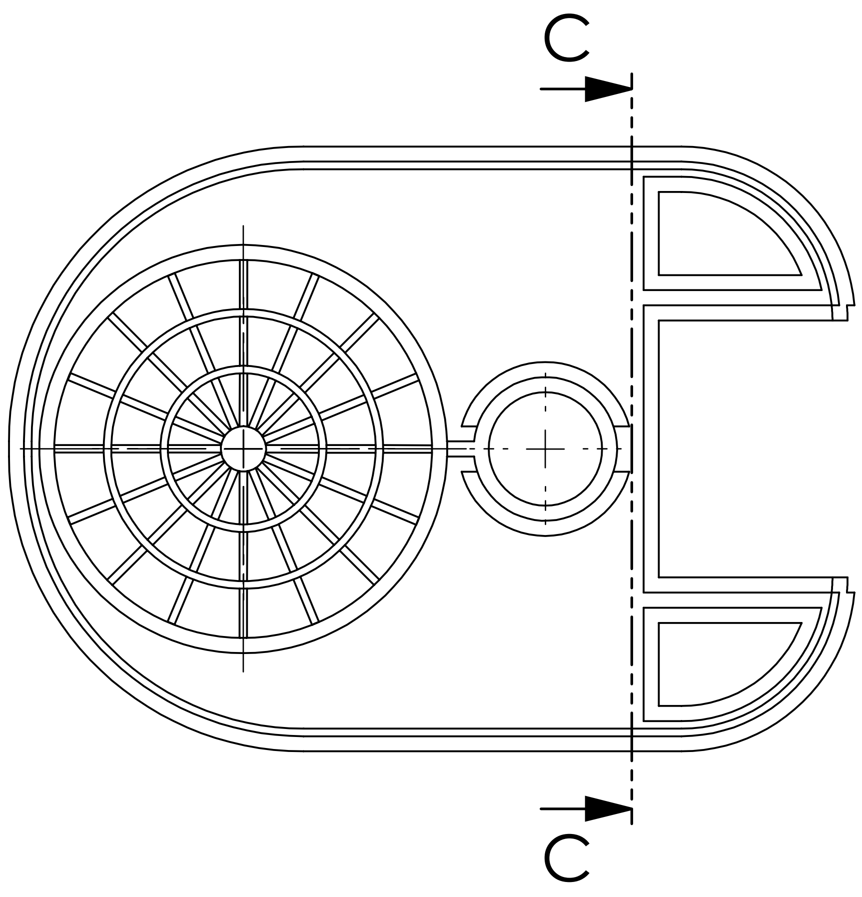
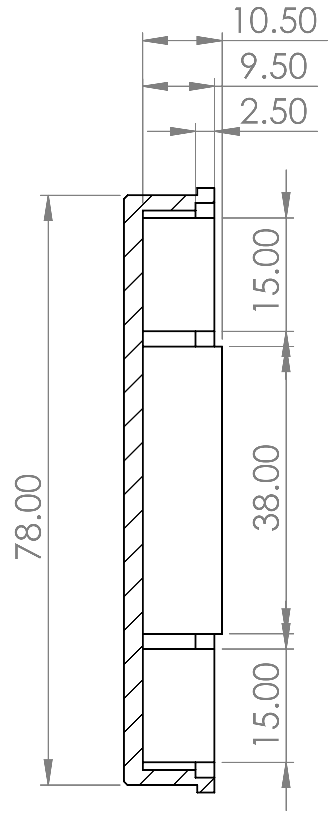




SECTION A-A





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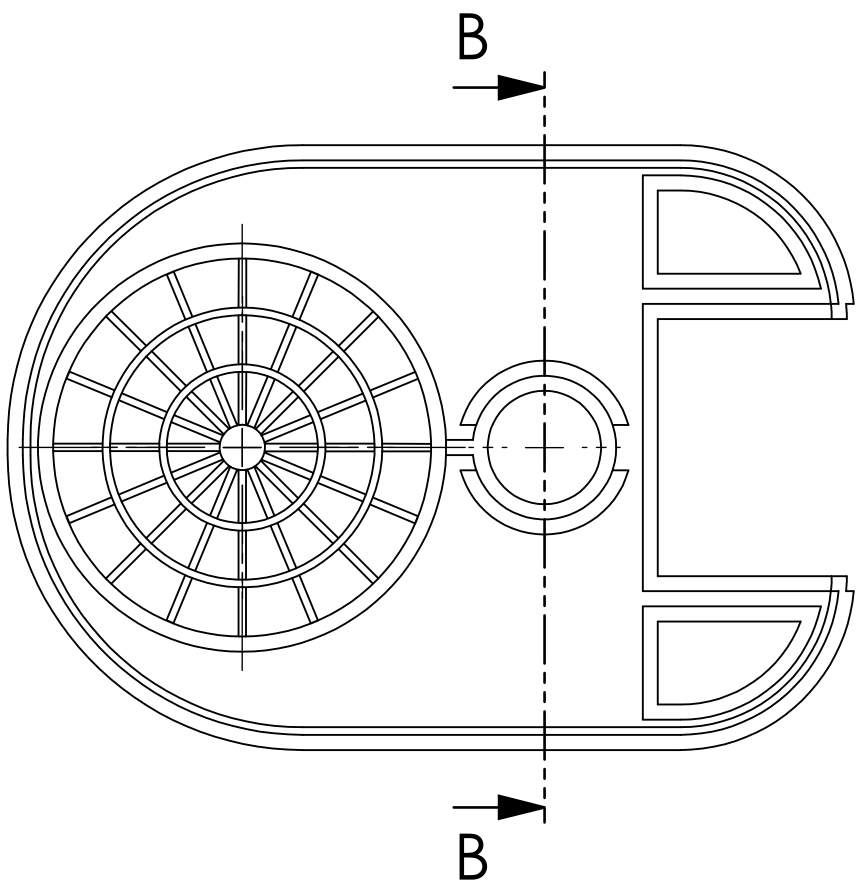
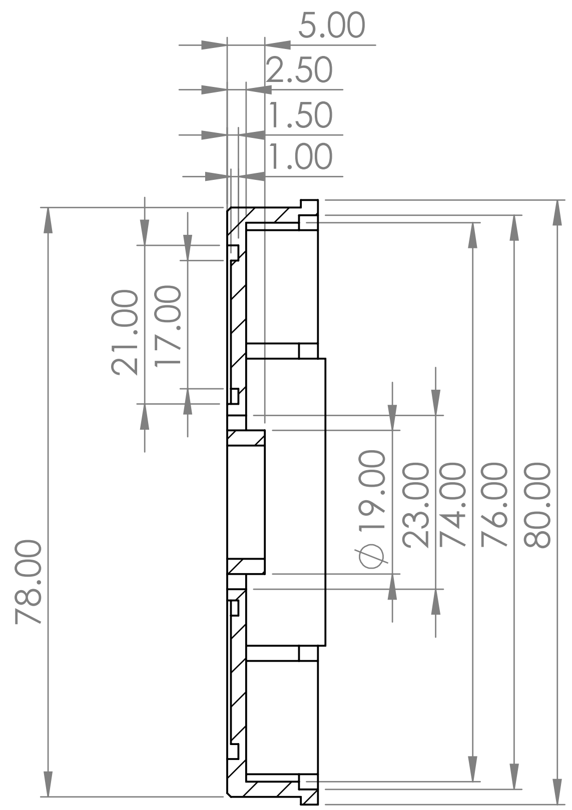
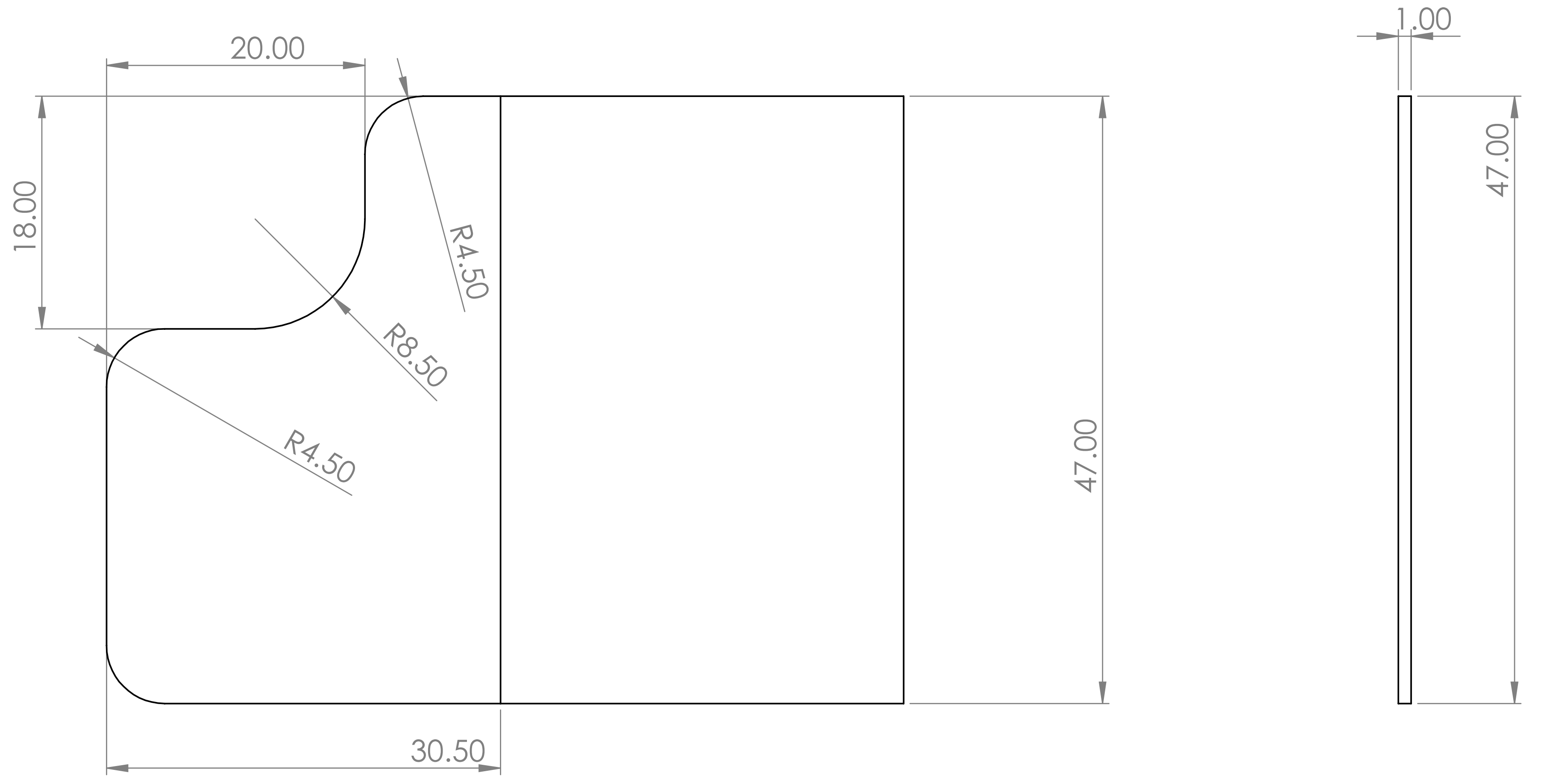




SECTION B-B

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Lid	
MATERIAL: PP	DWG NO. 6.2 — A3
WEIGHT: 20.04 g	SCALE:1:1 — SHEET 2 OF 2

SOLIDWORKS Educational Product. For Instructional Use Only.



DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Fabric L	
MATERIAL: Cotton	DWG NO. 7 A3
WEIGHT:	SCALE:2:1 SHEET 1 OF 1

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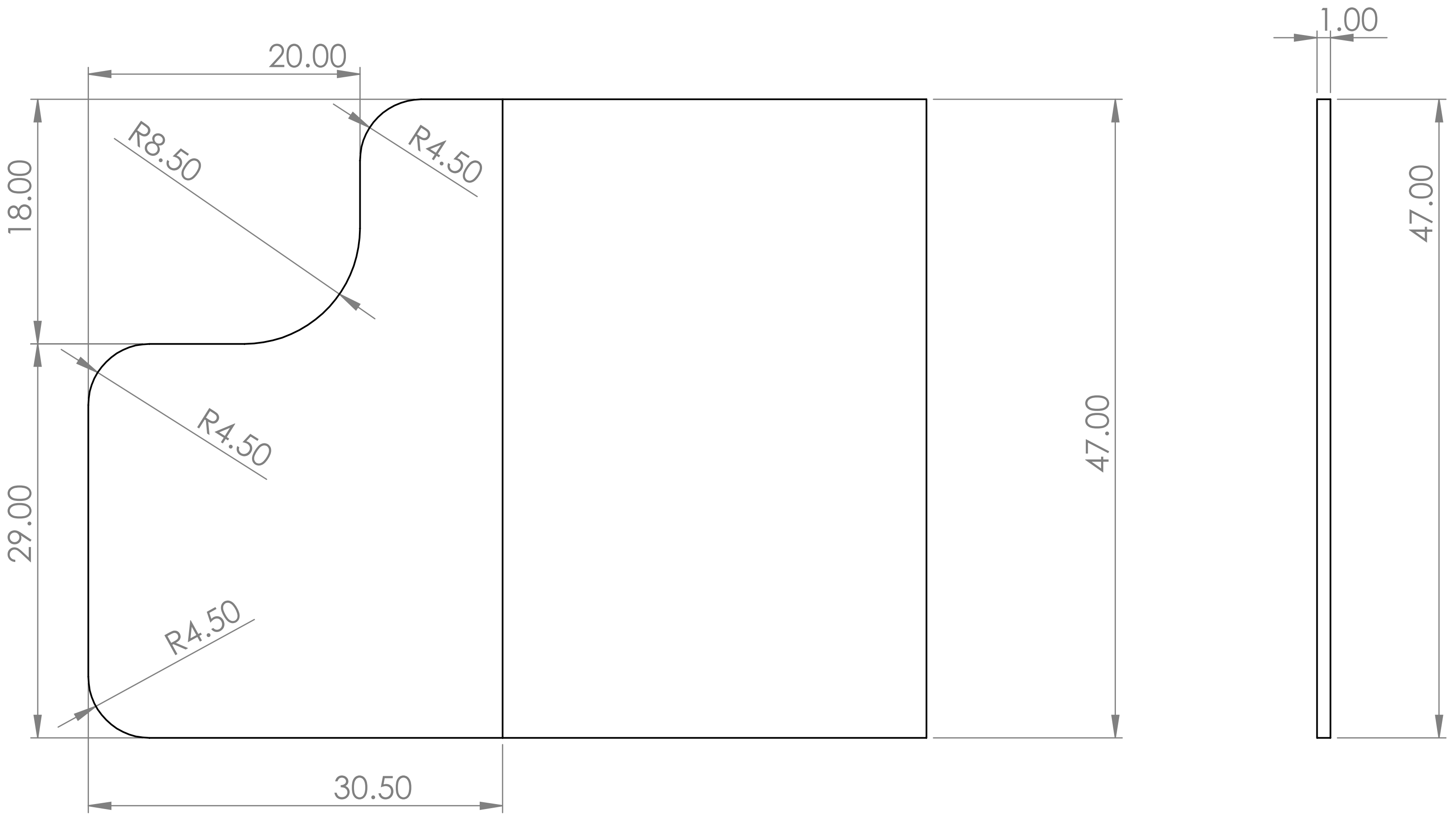

DO NOT SCALE DRAWING

REVISION

TOLERANCES: ± 0.25 mm

TITLE: Fabric R

MATERIAL: Cotton

DWG NO. 8

A3

WEIGHT:

SCALE:2:1

SHEET 1 OF 1

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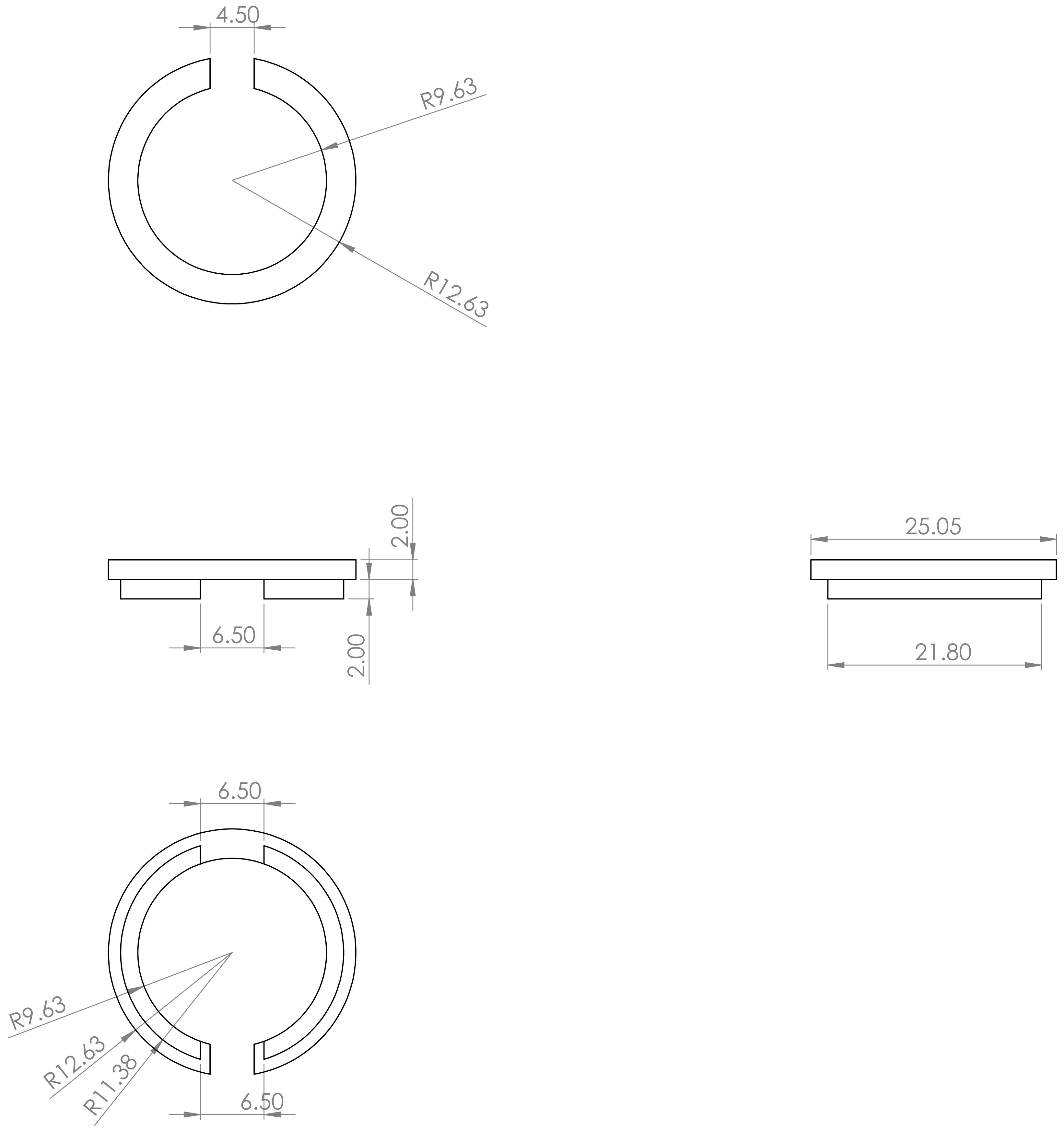

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Light	
MATERIAL: PP	DWG NO. 9 — A3
WEIGHT: 0.51 g	SCALE:2:1 — SHEET 1 OF 1

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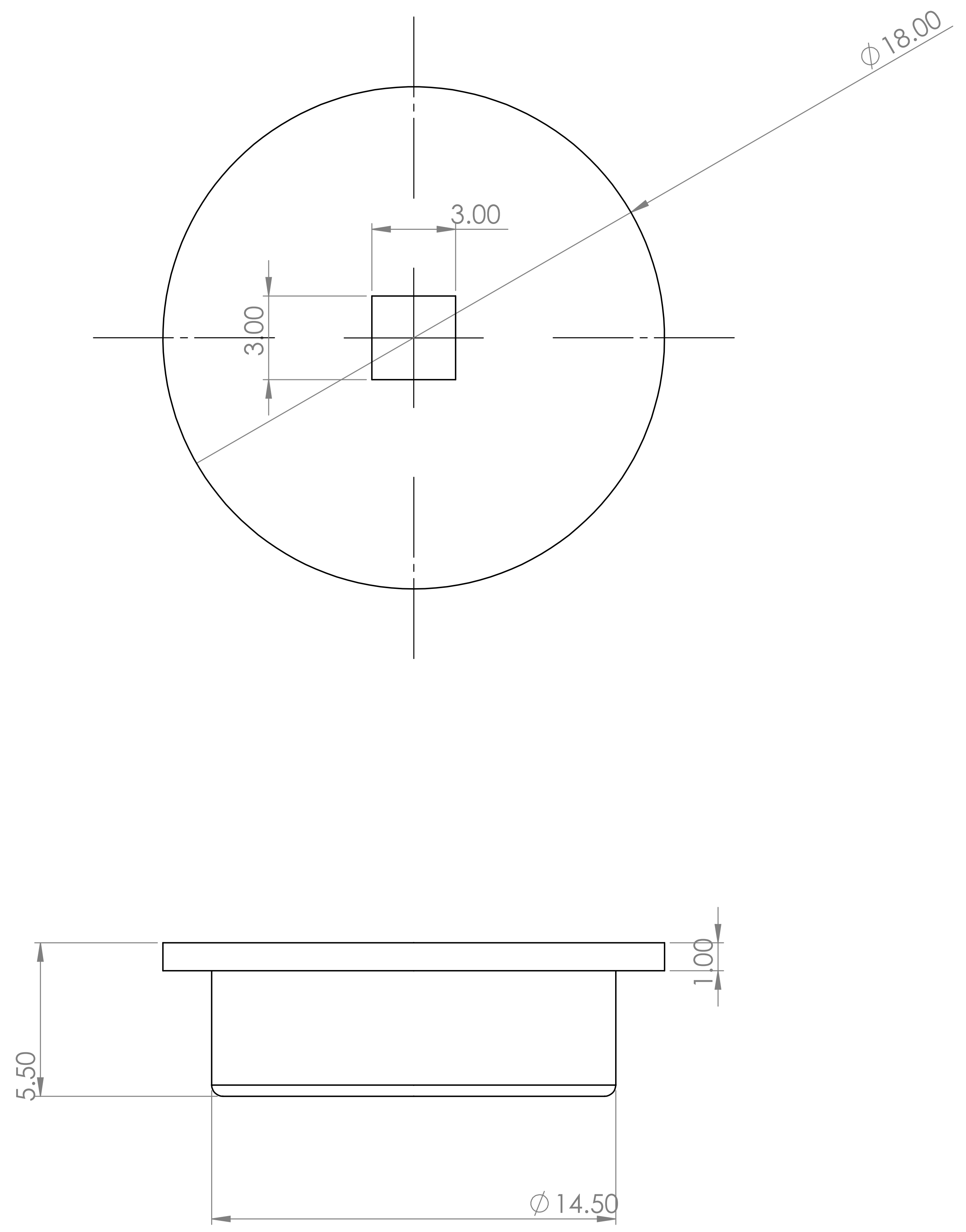

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Rubber Button	
MATERIAL: EPDM	DWG NO. 10 — A3
WEIGHT: 0.85 g	SCALE:5:1 — SHEET 1 OF 1

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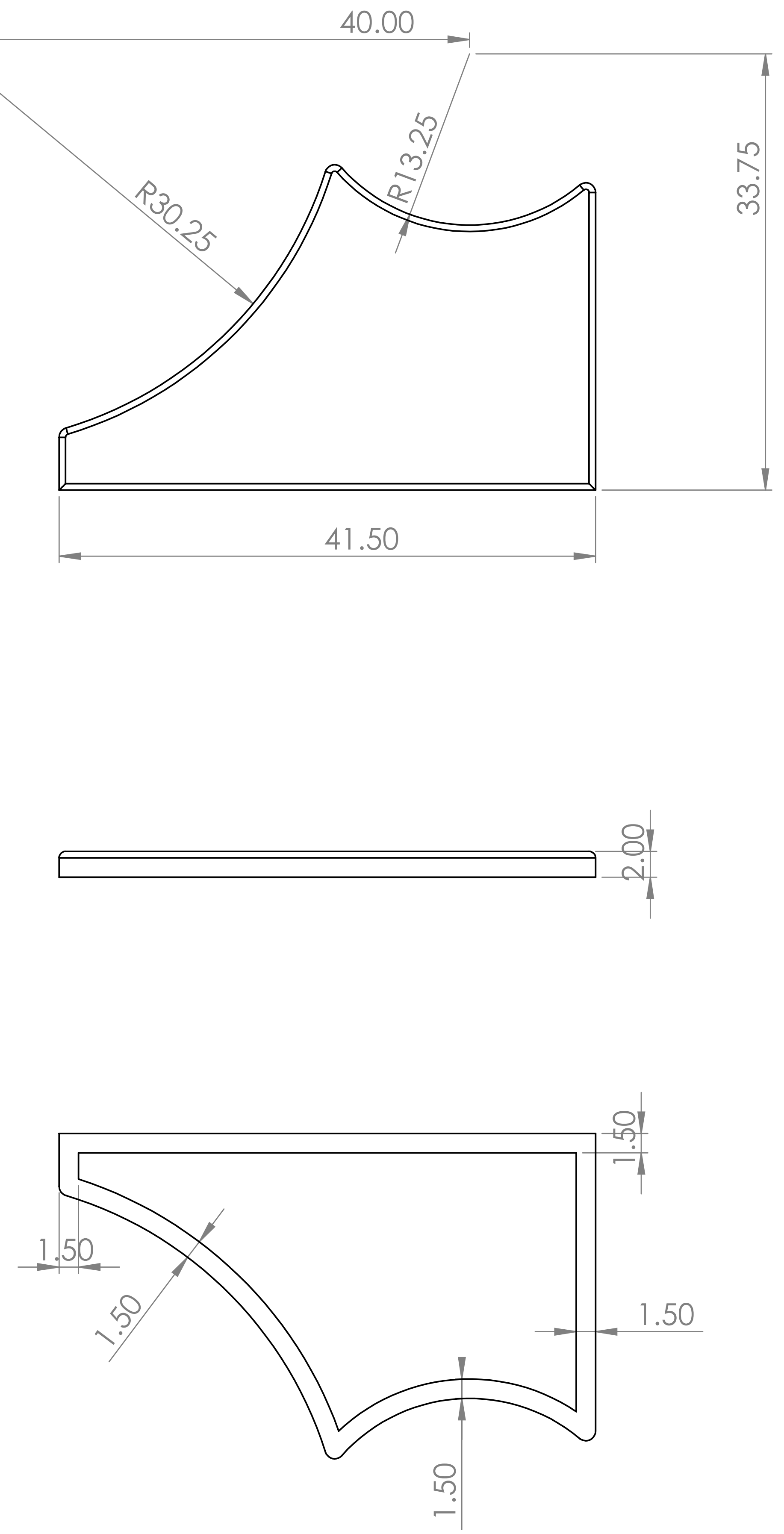

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Rubber TL	
MATERIAL: EPDM	DWG NO. 11 A3
WEIGHT: 0.83 g	SCALE:2:1 SHEET 1 OF 1

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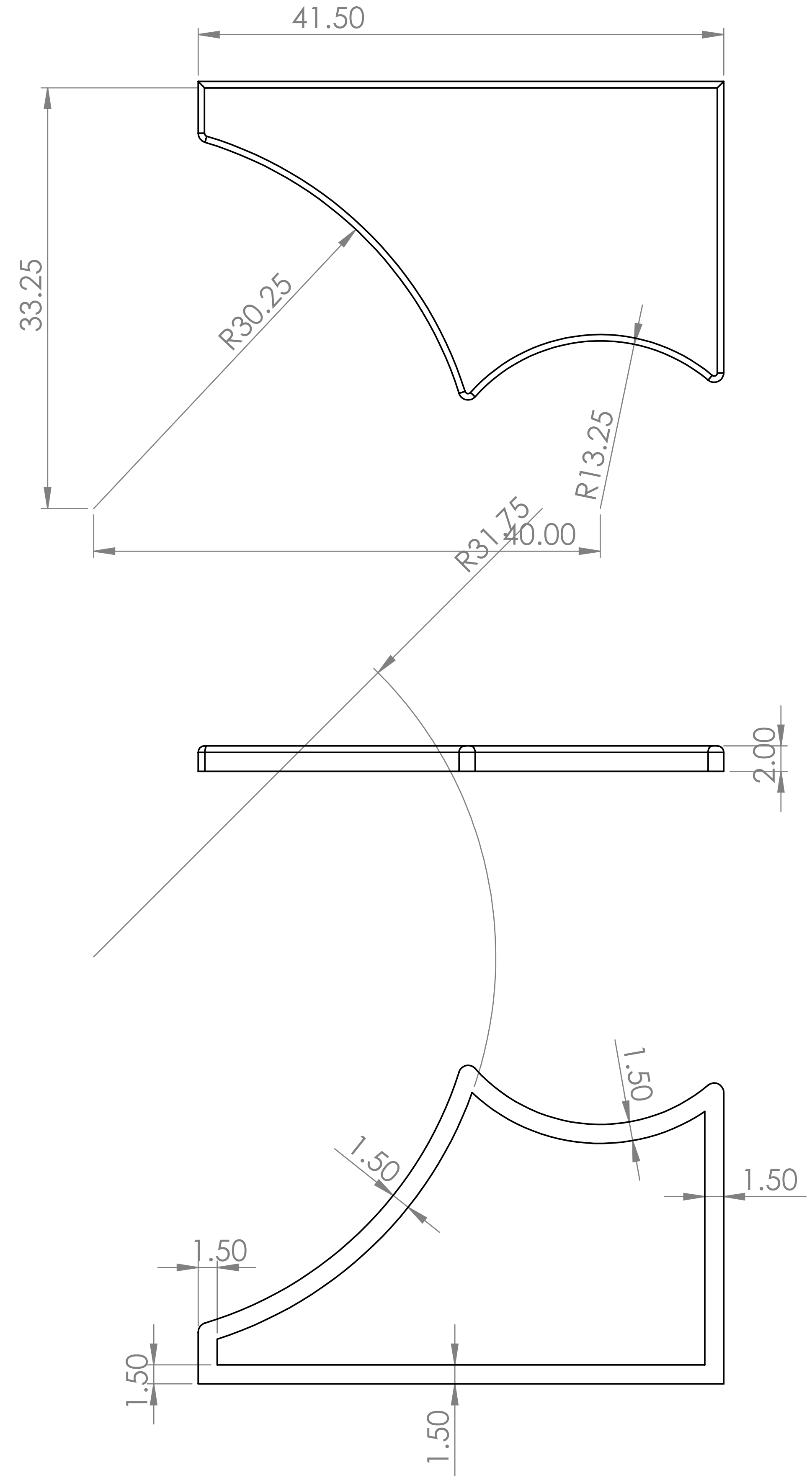

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Rubber TR	
MATERIAL: EPDM	DWG NO. 12 — A3
WEIGHT: 0.83 g	SCALE:2:1 — SHEET 1 OF 1

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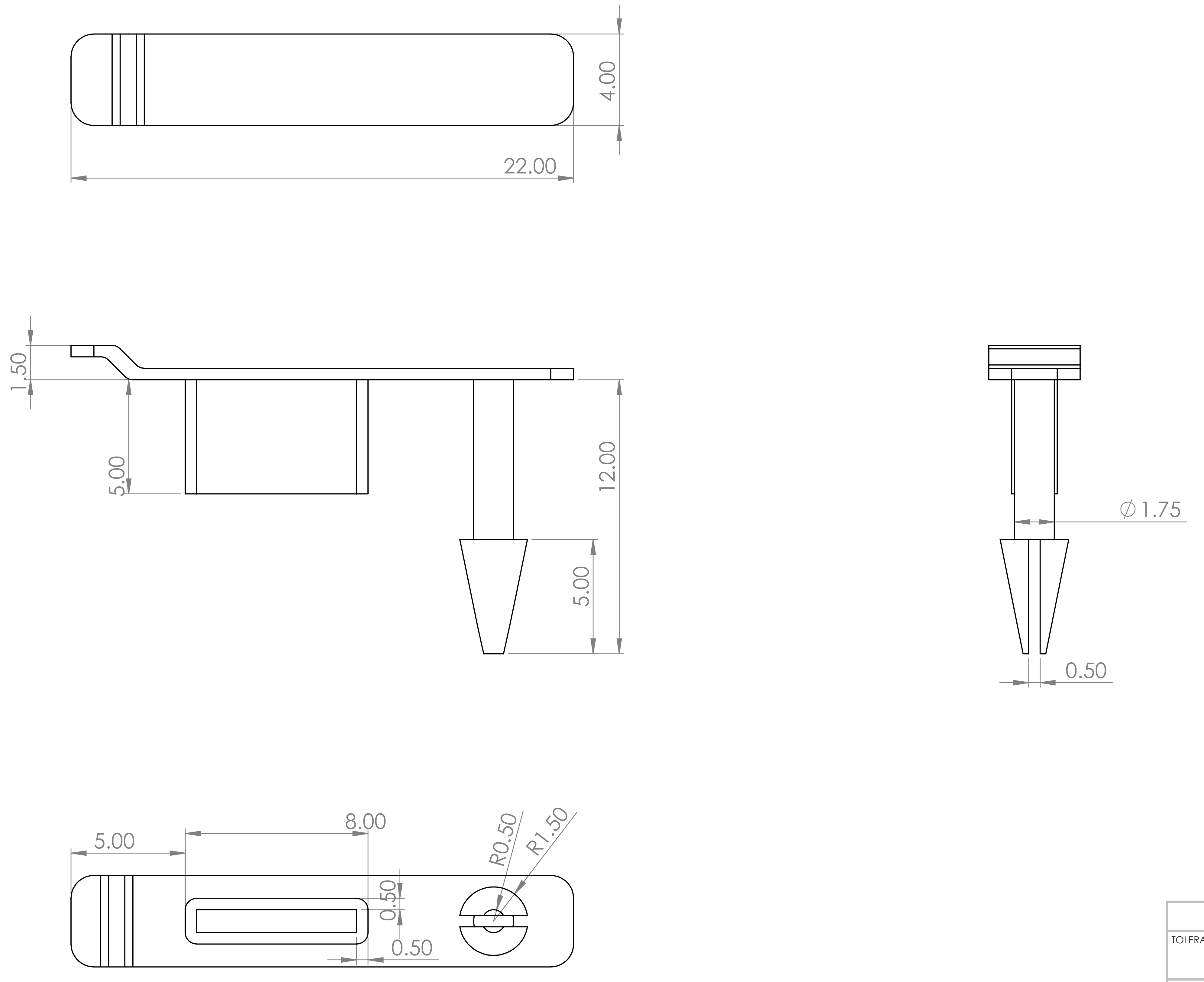

	DO NOT SCALE DRAWING		REVISION
	TOLERANCES: ± 0.25 mm		
	TITLE: Rubber Plug		
MATERIAL: EPDM	DWG NO. 13		A3
WEIGHT: 0.11 g	SCALE:5:1	SHEET 1 OF 1	

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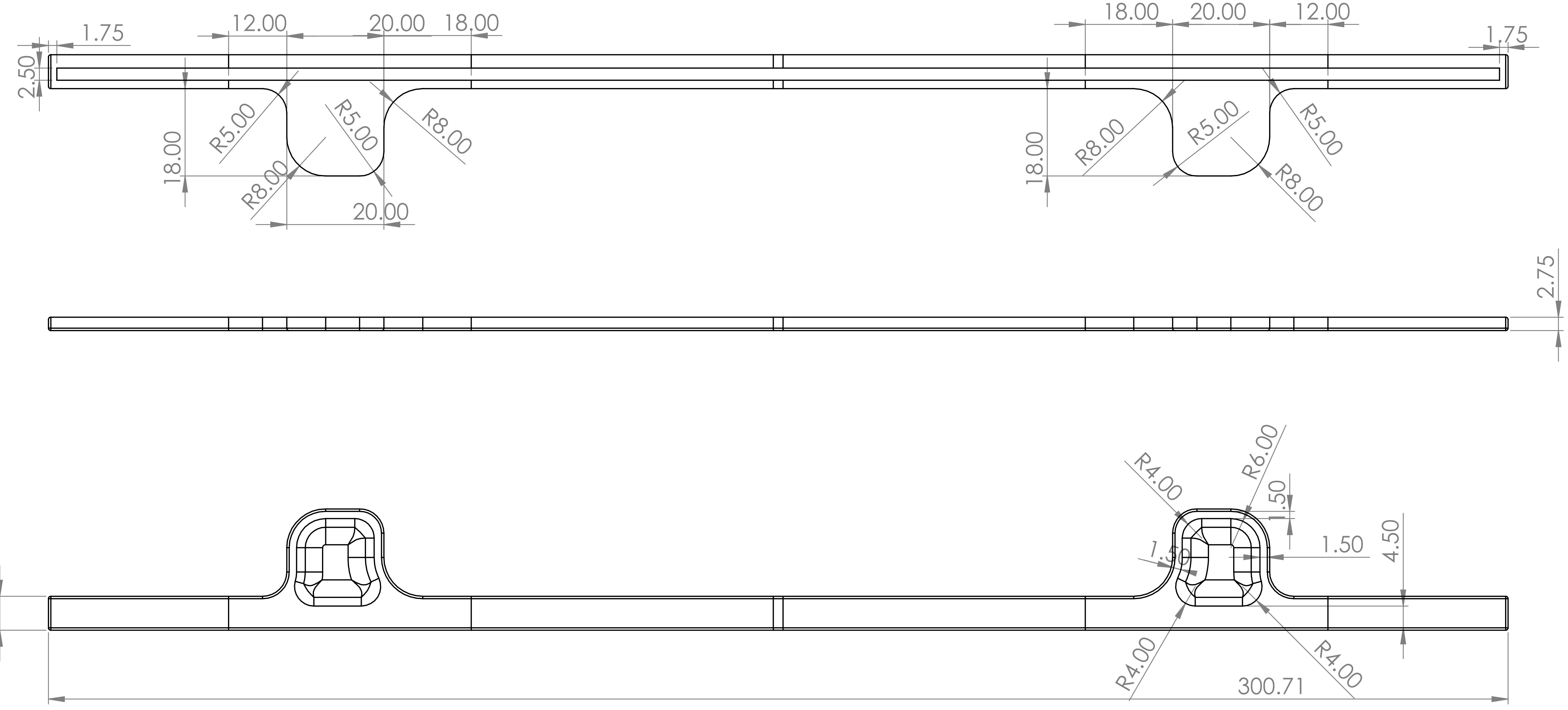

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Rubber Band	
MATERIAL: EPDM	DWG NO. 14 A3
WEIGHT: 6.25 g	SCALE: 1:1 SHEET 1 OF 1

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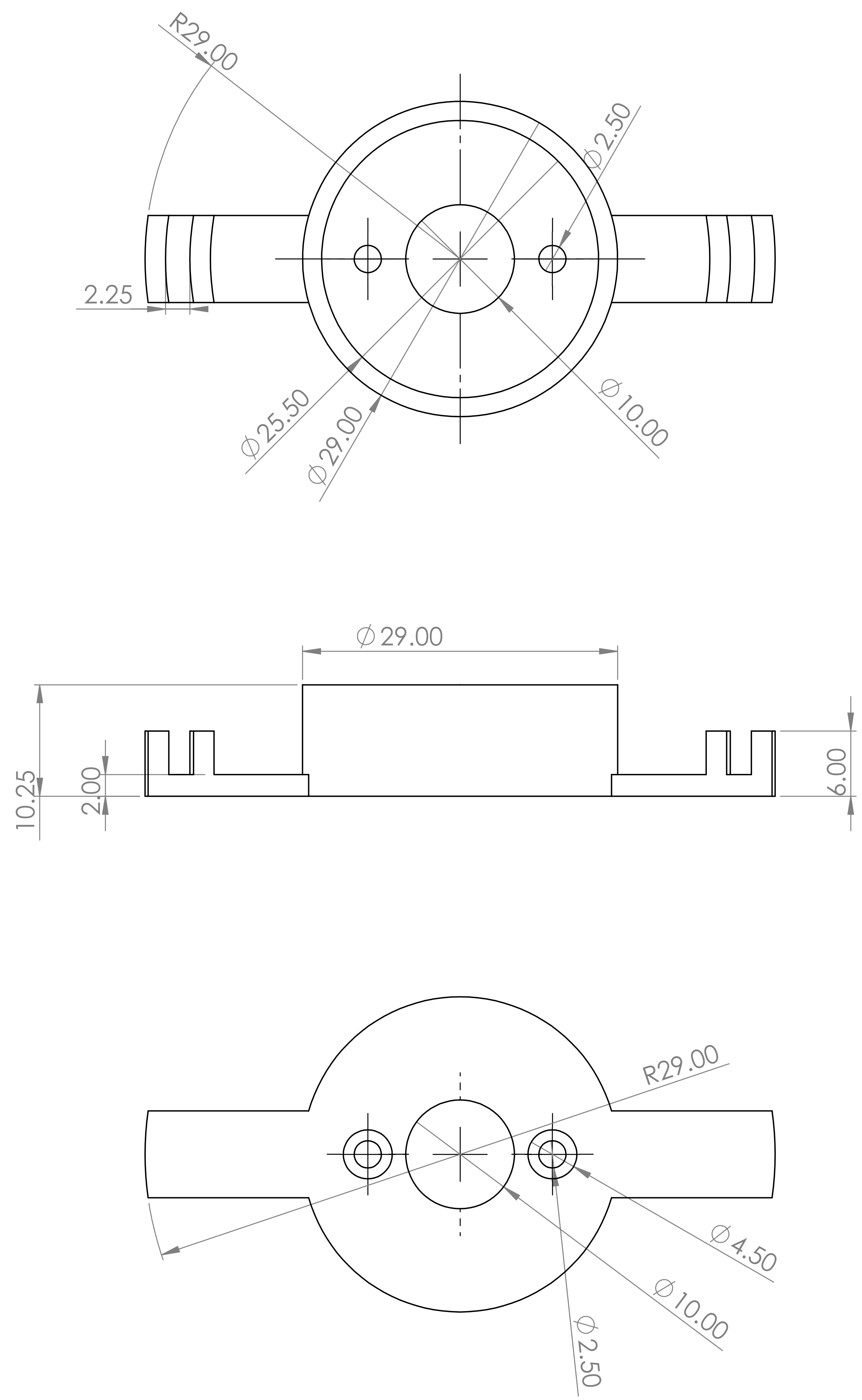

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Fan Connector	
MATERIAL: PP	DWG NO. 15 — A3
WEIGHT: 2.74 g	SCALE:2:1 — SHEET 1 OF 1

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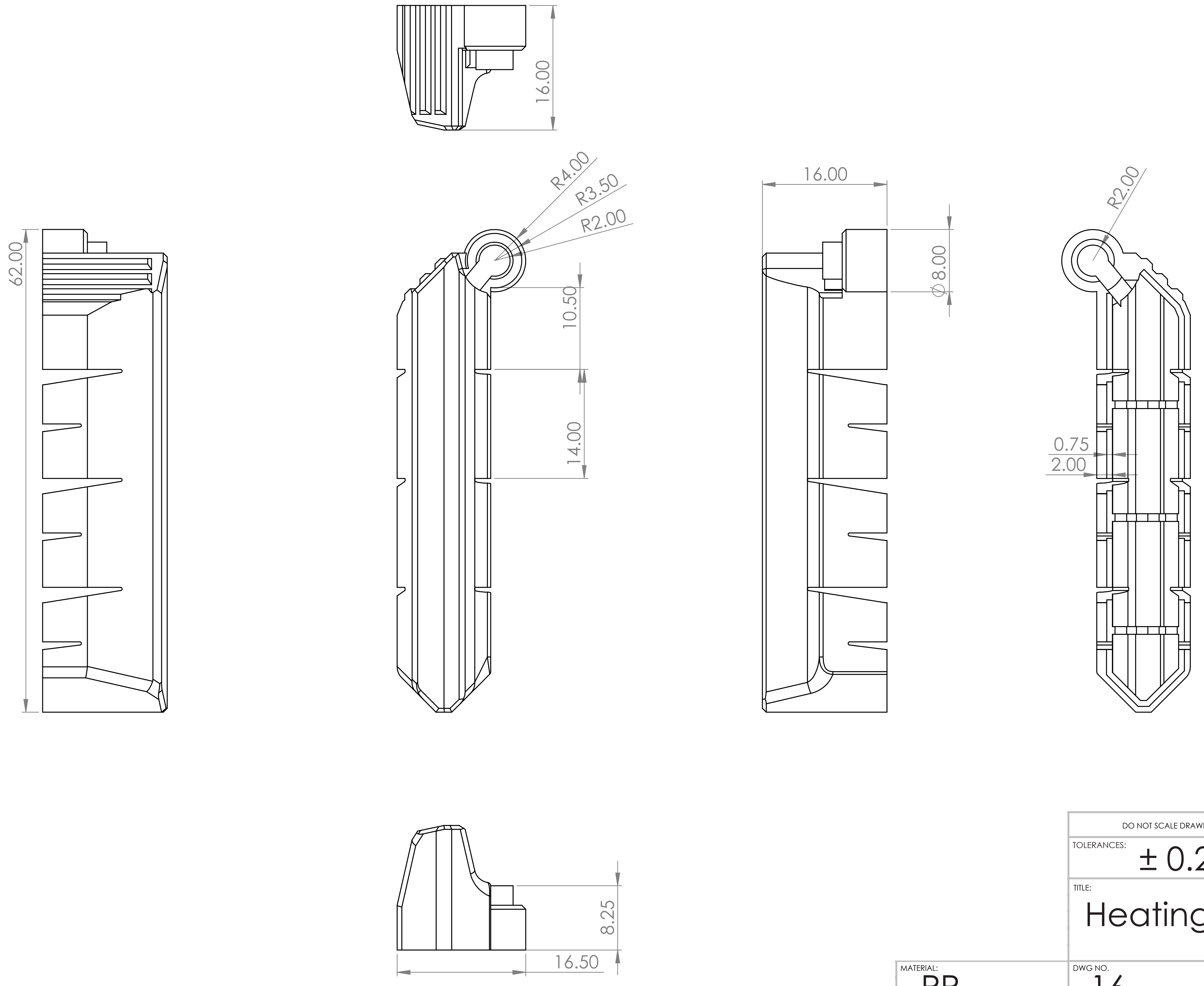

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Heating Box BL	
MATERIAL: PP	DWG NO. 16 — A3
WEIGHT: 3.24 g	SCALE:2:1 — SHEET 1 OF 1

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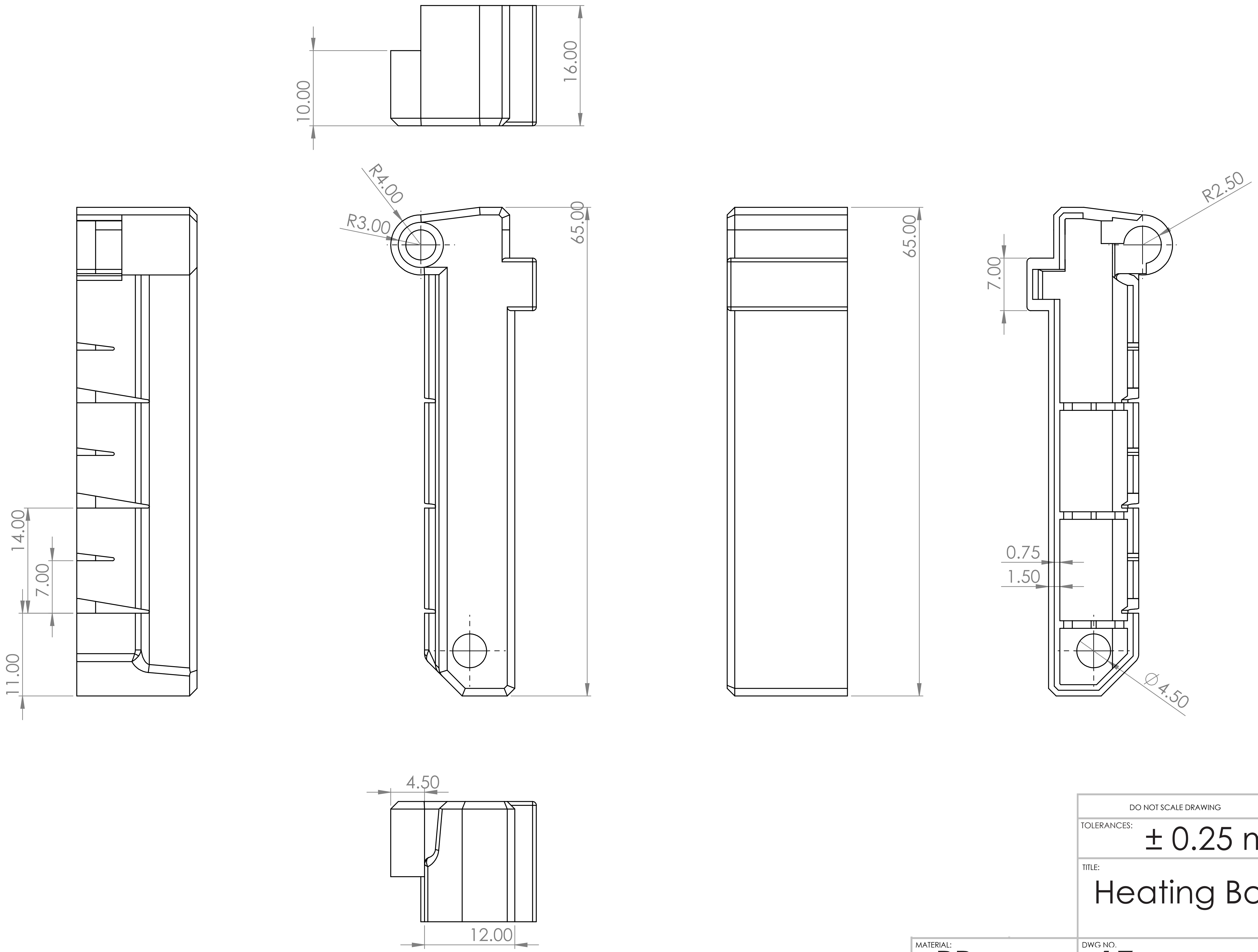

DO NOT SCALE DRAWING	REVISION
TOLERANCES: ± 0.25 mm	
TITLE: Heating Box FL	
MATERIAL: PP	DWG NO. 17 — A3
WEIGHT: 3.63 g	SCALE:2:1 — SHEET 1 OF 1

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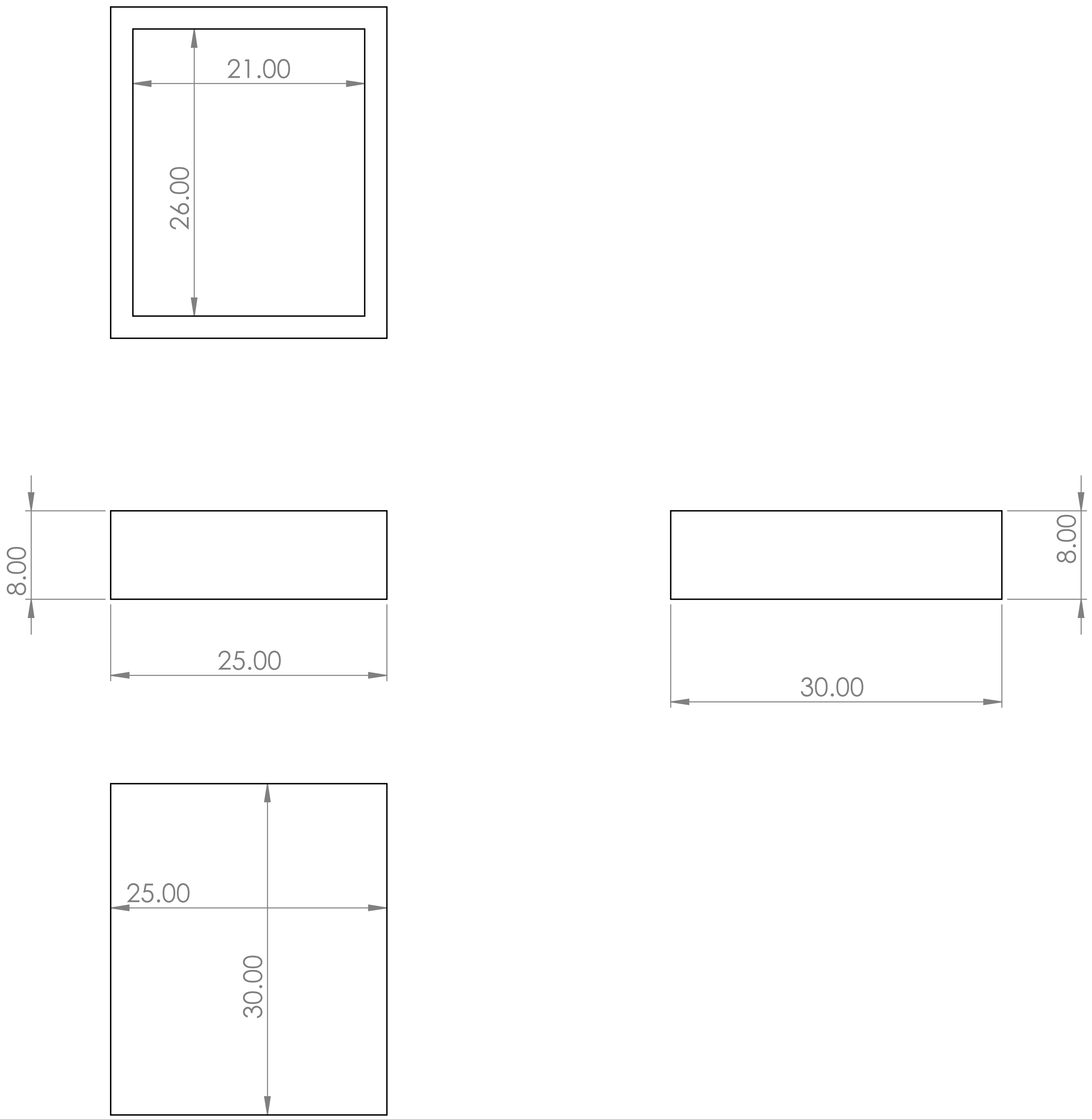

DO NOT SCALE DRAWING
REVISION
TOLERANCES: ± 0.25 mm
TITLE: Membrane
MATERIAL: EPDM
DWG NO. 18
A3
WEIGHT: 2.62 g
SCALE:2:1
SHEET 1 OF 1

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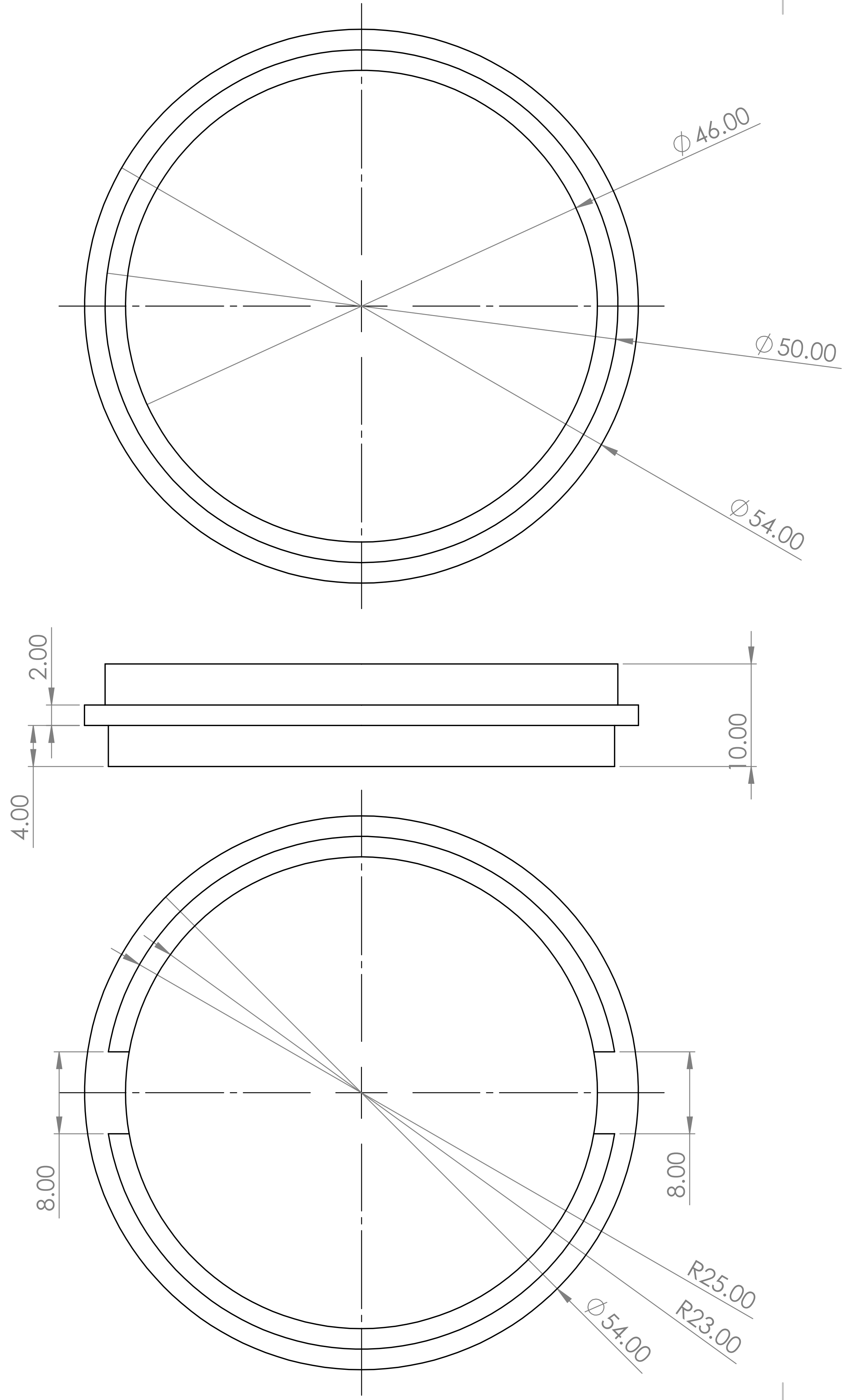

DO NOT SCALE DRAWING	REVISION	
TOLERANCES: ± 0.25 mm		
TITLE: Fan Membrane		
MATERIAL: EPDM	DWG NO. 19	A3
WEIGHT: 3.4 g	SCALE:2:1	SHEET 1 OF 1

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