Nu-Shu

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MOTIVATION

Reasoning

During thepandemic due to the rural nature of where i live I started walking a lot more, this evetually led to me needing to replace my walking boots as they were begining to leak. One of the things that i began to notice both when i was out for walks and then subsequently shopping for boots was the incresead number of people doing both. I was also dissapointed when irealised that the part of my boot that had failed was so integrated into the structure that there wa no way of me removing it to reapir it. It was these thoughts and considerations that motivated me to look into this project concept

Problem

Over the duration of the pandemic, there was an increase in the interest in Hiking and walking around the UK up to approximately 23% of the adult population [1]. As a result of this, there are more people purchasing walking boots however when this is contrasted with the amount of annual waste generated in the footwear industry in the UK This could cause a problem.

Every year approximately 300 million pairs of shoes are disposed of in the UK, with a large portion of these going directly to landfill. Some of the longest-lasting impact of a pair of shoes in landfill is in the sole, once it reaches landfill it can take up to 1000 years to completely break down [2].

Oppertunity

The objective of this project was to design a Walking boot that would be completely repairable during its lifespan and then could be totally broken down and recycled or reused at the end of its lifespan as a product. The aim of this was to achieve this through an improvement in the materials used so that the impact of the boot on the environment during its construction, use and deconstruction is minimised.

What: A modular hiking boot made with eco firendly circular design compainbal materials

Where: Sold online and used throughout the UK in wet and dry environments

Who: Keen adult hikiers of any age or Gender

When: Any time the user is looking to go hiking

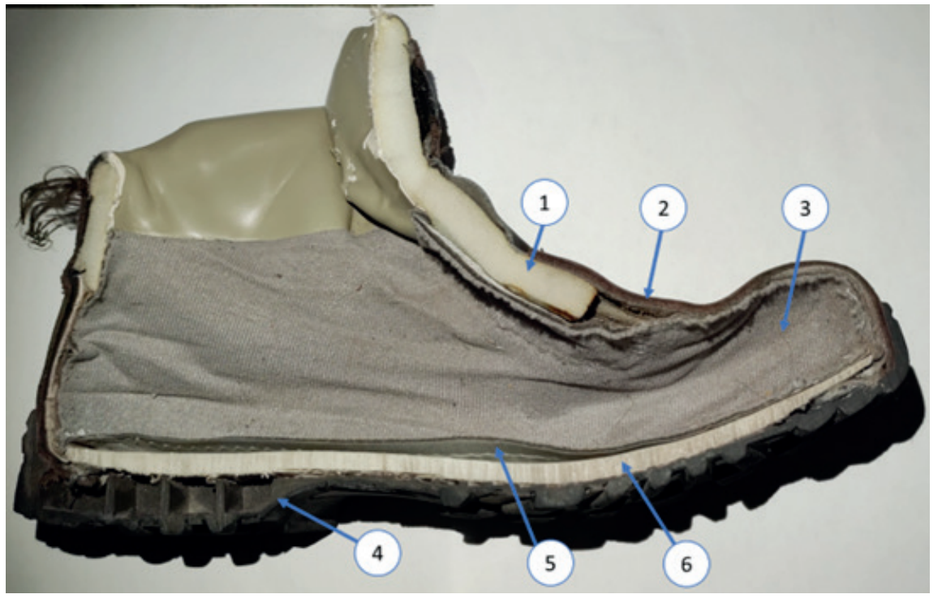
Why: To increase the ustainable nature of the global footwear market by reducing the amount of shoes being sent to lanfill

How: Using a combination of novel design elements and strategies, and materials.

CURRENT LANDSCAPE AND INITIAL RESEARCH

Initial research was conducted by looking itno the construction of current hiking boots and also into the offerings within the circular boot space

In order to get a better look into the current construction of a pair of hiking boots, an old pair was cut in half so that all the individual elemenets could be identified



Current Boot Components

1. EVA expanded foam – Synthetic foam used for padding
2. Leather upper – Chrome tanned leather upper
3. Fleece lining – For warmth and to protect the waterproof liner
4. PU Rubber Sole
5. Inner waterproof liner
6. Semi-Rigid Plastic Shank - Used for providing support and to hold the shape of the boot

Jack Wolfskin

Jack Wolfskins' offering within this space achieves something that neither of the others do is a waterproof boot[4]. However, the main issue here that is while they are providing a sustainable boot, not something offered by many other manufacturers, it is not actually a circular boot. This is unfortunately unsurprising given the use of entirely synthetic materials. While some of the materials used in the boot's construction are produced using recycled materials, such as the lining or insole or in the case of the waterproof liner a combination of 100% recycled waterproof material bonded to a zero-waste waterproof membrane that is manufactured using membrane offcuts from the production of other products.[10]

Timberlands

Timberlands offering in their Timberloop series while very attractive aesthetically with reasonable design choices, run into a few issues with material choice. The main one in this scope is the choice of leather used while they are claiming to be eco-consciously sourced, but this is only true to a point as they source from silver-rated LWG (Leather Working Group) tanneries.[6]
The LWG[7] is an independent auditing company that will investigate an individual tannery and give them a rating based on the traceability and substances used in the tanneries manufacturing process[8]
The main issue however is the highly selective choices that Timberland is making in only choosing top grain nubuck leather[3].
The other main design issue from an ecological standpoint is the use of EVA foam in both the boot midsole and insole, for which no claims of recyclability are made at either end of the product's life cycle.
However, the main innovation that timberland has made in the design of this boot isn't the use of a removable inner manufactured from ReBotl fabric[9], a 100% recycled plastic fabric. The use of this allows for easy breakdown of the boot at the end of its life through the return to Timberland in exchange for a discount on future products. It seems that this discount practice is the decided upon the reason for consumer engagement with this system.

EREM

The third and most progressive of the players in the circular economy hiking boot space is EREM[5]. EREM are a new US-based company producing a range of circular boots for use in hiking in the desert

As part of the research of this project, an interview was arranged with EREM's Director of Operations. This conversation allowed for a more detailed look into how and why certain design decisions were made. The biggest deviation from standard industry practice was the choice to use reverse grain leather. This means that leather that has tick bites, scratches or other aesthetic imperfections that would normally result in the discarding of that section of hiding can thus be used as these imperfections will never be seen.
The main innovation that EREM[5] have made use of in the construction of their boots is the use of a biodegradation enhancer called EcoPure by BioPro Global[11]. This additive has been tested on multiple polymers: e.g., plastics and synthetic rubber, and has been proven to accelerate the biodegradation of these materials under optimal conditions. From the interview with EREM, they estimate that for the sole this reduces the time to degrade from 1000 years, a commonly quoted figure, down to a much more reasonable 7 to 10 years.

IDEATION

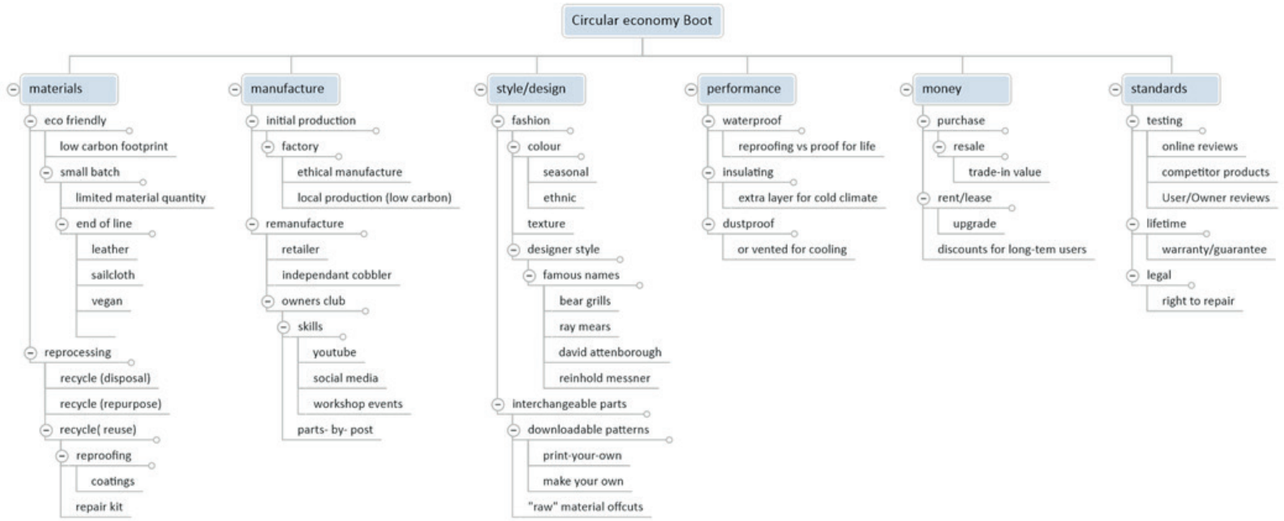
Materials
The first branch of this mind map was to consider the possible ways to go with the material. Some initial concepts were to look into pre-used materials and how they could be restreamed out of landfill and into the production of new footwear. It was also decided at this point that a critical gap in the market as it stands today is the lack of waterproofing.

Manufacture
The second branch of this initial ideation phase identified the opportunity to conceptualise this not just as a product but as a continuous service.
This aspect would be performed through teaching people how to either repair their boots by themselves or if this was not something they were comfortable with at the very least how a professional would be going about repairing them. Hopefully, this level of transparency would help to engage the general public with this product concept and create a culture and community around this concept.

Design and Style
This idea followed through into the preliminary design and style considerations. A driving factor to bring this concept into the public eye would be engaging with celebrities that are well known throughout the outdoors community.

It was at this point that the idea of interchangeable parts was also considered. Due to the time constraints of this project, it was decided that one complete design would be created with the open concept created so that modularity would be baked into the design from the ground up. In order for customers to have as easy a job as possible in engaging with this aspect of the product part of the package that the customer would receive when buying a pair of these boots would be a technical drawing and measurements of the cutting list for each of the panels and parts used in the construction of the boot in the size they purchased. This open-source-style platform would allow for customizability on the users' part.

The modular style here proposed also helps consumer keep their boots up to date as they wouldn't have to buy a whole new boot depending on different seasons as the inner liner could just be replaced. It would also allow for the purchase of new parts as opposed to new boots should there be innovations within the materials science space that concerns the material being used in hiking boots.



The next step of this project was to define the important parameters of the product and begin investigation into how these objectives could be achieved.

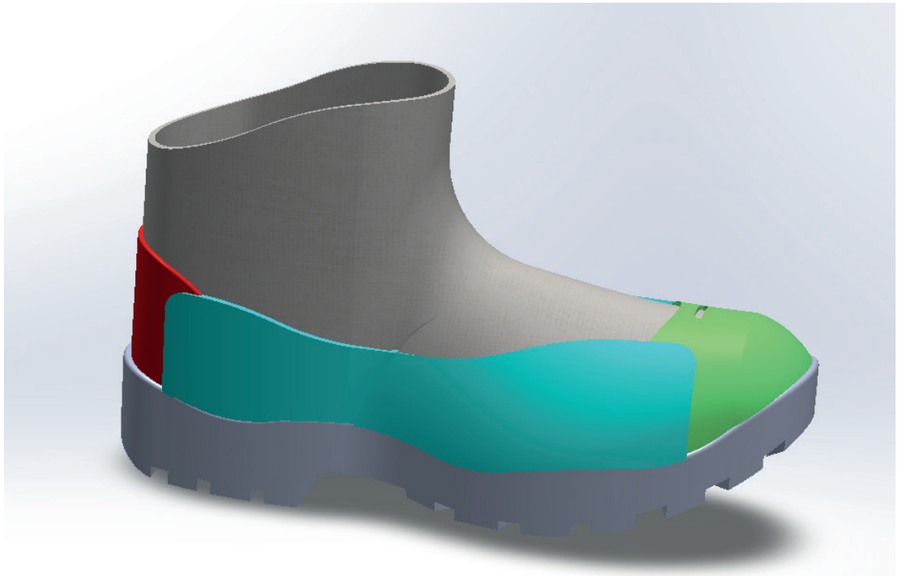
Performance
The performance aspect of this product comes down to a few key factors waterproofing and dust-proofing and comfortable usage temperature. For the most part waterproofing and dust proofing go hand in hand, so long as the boot is waterproof it will also probably be dustproof and there are 2 main ways to consider how you want to achieve waterproofing, either through a waterproof liner with the hope of waterproofing it once and for life or waterproof it through the use of a coating and rely on regular reproofing in order to keep the water out.

Suitable usage temperature is also a big consideration as the ideal amount of insulation for usage in cold winters is obviously going to cause the boot to be too hot for use in the summer and the opposite is true in terms of a light summer boot not being a good selection for use in winter. This further supports the initial concept of making the boot modular as this allows for the tuning of the main platform with different inserts to suit the environment it is being used in. It also has the advantage that if you are traveling with the boots then essentially boots suitable for may scenarios can be packed in a lot less space than would be required for multiple pairs of shoes.

Money
The cost of pair of boots is a big consideration as obviously all the best innovations could be made and included into a pair of boots but if this causes the boots to be proceed in such a way that they are not a financially accessible purchase to anyone but those with large amounts of disposable income or a worthwhile investment anyone except but those that do a large enough amount hill walking. For this reason the best way to go about making them accessible without restricting the technologies and materials used is implementing a trade in scheme with used boots to encourage a more eco conscious choice for those replacing their boots or operate on a rent to buy style scheme for those looking to own the boots outright or a leasing model that would include the cost of any repairs or upgrades that the customer wight want to do over the lifespan of the boots

Standards
One of the most important factors to be considered is the public opinion of the product as this will obviously dictate how many people would even consider purchasing you product. Therefore strict quality standards need to be set in order
A small survey that was conducted with a local hiking group determined that as people were willing to spend more money on a pair of boots they spent more time researching online for good pairs of boot before even going into a store to try anything on. This means that a positive online presence would be critical to getting the public to engage with the product and consider it a viable option in comparison to the rest of the market especially if the was priced at a slightly higher price point.

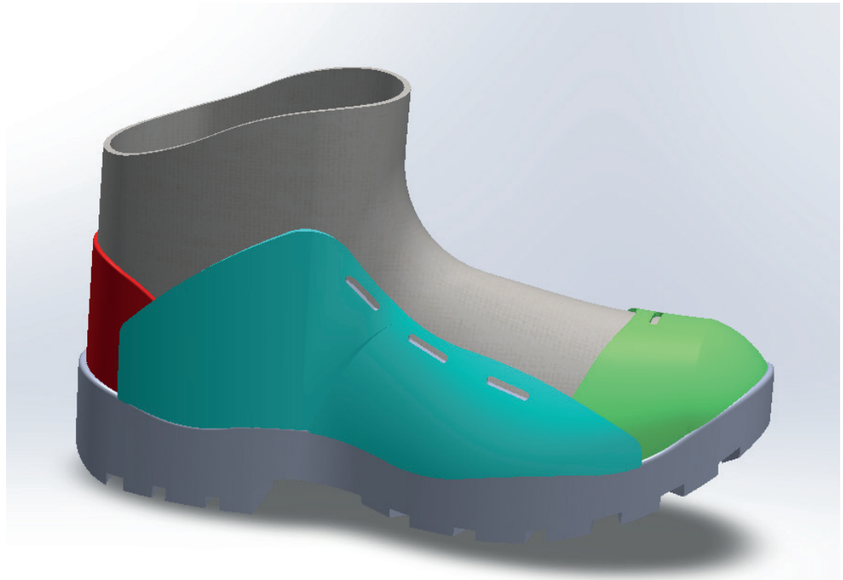
PRODUCT GEOMETRY AND EVOLUTION

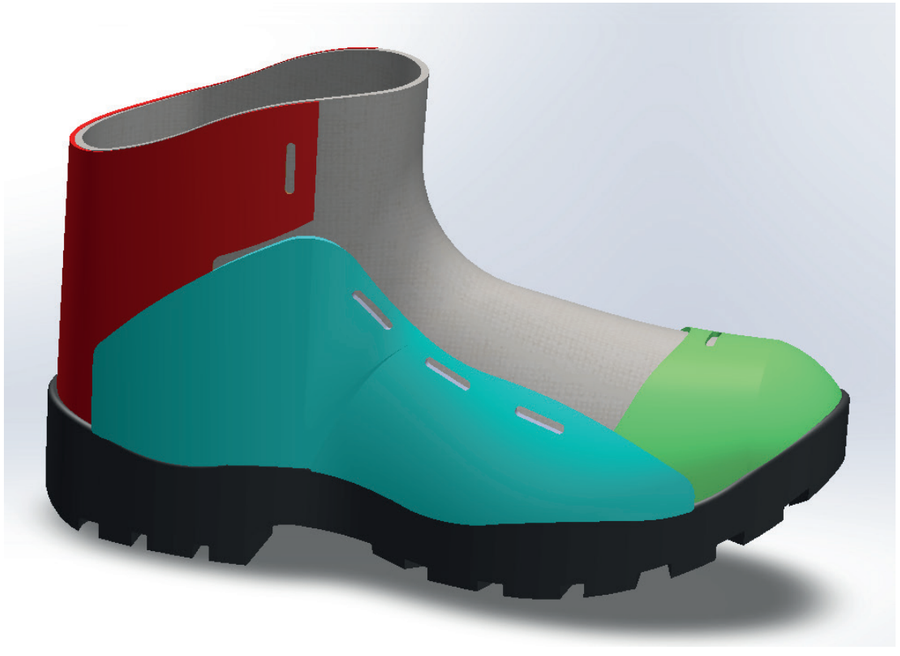


Inital design concept

The first proposed design concept was to simply enclose the lower third of the boot inorder to protect this part of the foot from scrapes and bumbs against terain.
This was comprised of a heel box (red), a toe box (green) and a side rand (blue) to protect the inner liner

The second concept start to adress the fact that there needed to be a way to lace the boot so raised the side walls





This further progressed as it was reasiled that one of the crtital resons for choosing a hiking boot over any other style of shoe was ankle support and therefore the heel box (Red) was raised with attachment points for the lacing added to make this support more effective

The method of securing the boot was then decided upon. This design uses strapping as opposed to laces so that another material type would not have to be sourced and also so that any paternign scraps from producing the inner could be utilised

PRODUCT CONSTRUCTION

Components List	Material Used
1- Heel Box	Leather
2 - Inner Boot Liner	Canvas
3 - Inside Rand	Leather
4 - Straps	Canvas and Velcro
5 - Toe Box	Leather
6 - Sole	Rubber with Injection moulded Shank
7 - Outside Rand	Leather

Material Choices

The materials selected for each of the componenet parts were research meticulously in order to make use of the most eco firendly materials that would integrate into a circular product cyle in the best way possibl while staying within a reasonable price point

Leather

For the outer body componets leather was chosen. The amin reson for this is its tough and abrasive resistant nature when tanned. Tanned leather is achoved though either the use of Chrome tannign orvegtable tanning. For this projec tvegtable tannignwas selected as even though it takes significatly longer to produce its enviromental impact is much lower and can be easily biodegraded without leaching toxic chemicals. The pannels would also be consturted using a revers grain leather. This means that the traditional smooth face that we normally see on a pair of boot sould be facign inwards this is done for the main reason that any imperfections such as tick bites or scrathes to the leather surface are bnot visible and thus reduce the amount of leather waste produced.

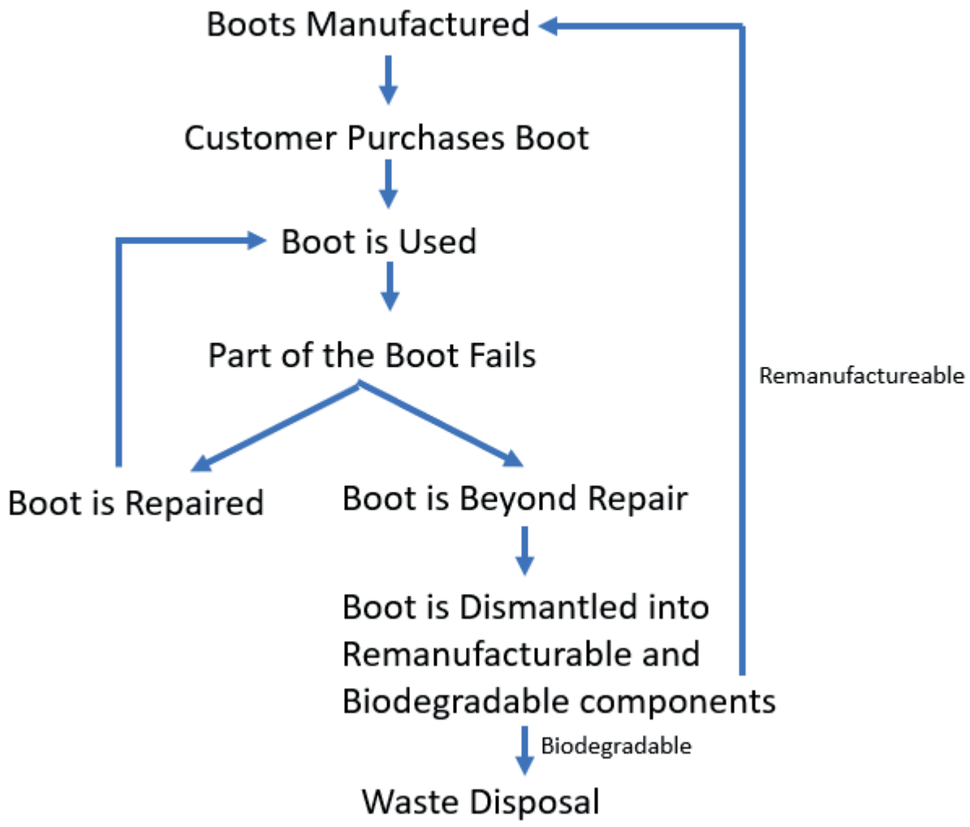
Canvas

Both of the canvas parts would be manufactured using a type of proccessed cotton fiber called CLARUS, this type of fiber increases the moisture wicking and drying time of the fabric allowing for more breathable materials to be produced with it. The idea with utilising this procees would be then weaving the fibers into a canvas style materail that coudlbe layerd with a cousiion fiber in the required places and waxed in order to waterproof it

Rubber Sole

The rubber sole of the product would be created using a vulcanised natural rubber with a biodergradation acccelerant called Eco Pure, though converstaion with manufactures that currenty use this it was reasoned that this could reduce the time to degrade to aproximately 10 years. In order to provide adequite stiffnes then the sole would have an integradted plastic shank. The propsed material for this would be PLA as it is already considered to be biodegradble which could only nbe helped through the use of the biodegradability accelerant.

PRODUCT LIFE CYCLE AND SERVICE



Product Service

One of the most important aspects of this product is the support network that would suround it in order to Remanufature or recycle worn out components. This would be done by Establishing a repair network with cobblers and stores carrying the boots alongside a mailing system so that these parts could be returned to the company

The modular style proposed also helps consumer keep their boots up to date as they wouldn't have to buy a whole new boot depending on different seasons as the inner liner could just be replaced. It would also allow for the purchase of new parts as opposed to new boots should there be innovations within the materials science space that concerns the material being used in hiking boots

Given that the interview with EREM had pointed quite obviously to the fact that as you go in the direction of less used, more eco-conscious materials then the price can increase quite quickly for this reason it seemed that making it as easy as possible for the consumer to engage in repair and customizability of the product would help compensate for the initial higher cost of entry. people with access to a laser cutter or CNC fabric cutter either personally or through local maker spaces could easily produce new parts

FUTURE WORK AND REFLECTION

Future Work

If this project was to continue one of the primary areas of research would be with the materials. This is mainly down to the fact that given the lack of project funding purchasing and testing the various considered materials was not financially viable.
This testing would comprise of 4 separate tests. The first would be breathability, in accordance with ISO standard 2528. Breathability is a key aspect ibn making sure that it the fabric uses can keep up with drawing away any excess heat and moisture generated through usage of the boot away from the body.
The next test that would be carried out would be used to determine how waterproof the boot was under full construction. This would be done using a hydrostatic head test, a test that measures how much water would be required to compromise any given material.
The balancing act is of course that as breathability increases then waterproofing tends to decrease and vice versa. It is also difficult to fully test the waterproofing of a product until it is fully constructed as opposed to just testing the individual component materials
The 3rd test would be abrasion resistance as this is a key metric that can be sued in order to evaluate how well the product will last in daily usage without different parts of the construction, be that fabric panels or stitching to wear through.
The fourth test conducted would be a lot more subjective as this would require custom making prototype shoes so that a range of users could be surveyed as to ease of use, aesthetic pleasure and comfort.

Once full scale prototypes had been produced this would also allow for investigation into the effectiveness of the attachment mechanism between the inner liner and outer leather shell. One of the considerations in order to alter this should I be an issue would be a pair of anchoring bolts that would pass from a plate stitched to the inner liner and though the soe of the boot to have a fattener fixed on the underside of the boot, however given that this could impact the structural integrity of the sole and this would also require finding a way round a possible hole being made in the waterproof liner then this would be something that would only be considered after extensive testing.

The other key piece of further design work that would be carried out would be an improvement to the panels used in the side of the leather outer panelling so that this design could be used in a modular fashion. If design correctly then the same toe box and side panels could be used in conjunction with an alternate heel box on the same rubber sole in order to create a pair of hiking shoes, and any waste or worn out panelling could be repurposed into panelling for a walking sandal that could in similar fashion to the hiking shoe be built from the same base rubber sole platform

Reflection

I am very happy with the final state of the project. However it think the major improments that could be made would be in the final prototyping stage. Due to the difficult and expensive nature of aquireing the materials that it woudl be ideal to be working with to create an acurate prototype of this project but doing so would have drastically improved how eay it would be to demonstrate how the product works to other people.

I am hoever very please with the CAD model that I created as I was working with a very awkward geometry to try and get a model that wasnt blocky and would look like it would reasilistally and comfotably fit on someone foot. I think the challenege tha this presented allowed me to advance my 3D modeling skills significantly. I alslearnt a lot about researching the product space and how to find a gap in the market inw hich to design for.

I also feel that working on a project that holds personal interest is critial for keeping myself engadged and is defintiely something i should keep in mind moving forward.

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