tides

MSc Graduation Thesis **Merlijn Lewerissa**

Design of a softtop surfboard for a circular business model

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Delft University of Technology

Faculty of Industrial Design Engineering

Landbergstraat 15
2628CE Delft
The Netherlands

Graduate Student

Merlijn Lewerissa

MSc Student Integrated Product Design
TU Delft, Industrial Design Engineering

Project Chair

Conny Bakker

Professor Design for Sustainability and Circular Economy
TU Delft, Industrial Design Engineering

Project Mentor

Israel Carrete

PhD Researcher Design for Sustainability
TU Delft, Industrial Design Engineering

Company Mentor

Antoine Stöhr

Co-founder
Good, Thanks Surfboards

Preface

My name is Merlijn Lewerissa, and I'm a product designer and surfer.

The start of this project founded itself from an idea, which started growing a while ago. When I was 18 years old and had just finished high school, I decided I didn't want a job washing dishes in a restaurant, but decided to look for something closer to what I love. I ended up getting a job at a local surfboard factory, where I worked on repairing boards, while learning the skill of making boards myself. Although I really liked making surfboards, I couldn't help but notice how wasteful and toxic the process of doing so was. Out of safety reasons, wearing masks all day and having to cover your skin over your entire body while working was part of the job.
At the same time, I also noticed how the climate is changing our world. When I started studying at the Technical University of Delft, I became more and more aware of the fact that we all carry a responsibility of making the right decisions on how we use the materials available on our planet. But I also saw this as an opportunity. I think designers, more than anyone else, carry the tools to think of creative ways to diminish the impact of the processes that are harming our planet.

These things led to this small idea evolving into my graduation project, and I am happy to say that I got to work on something I both love and believe in. I could say a lot more about what motivates me, but most of it will become clear throughout the content of this report.

Partners

This project is executed in cooperation with Good, Thanks Surfboards, a surfboard production company based in Rotterdam. This partnership came from the fact that we have a common goal: making the surfing industry less wasteful.

Antoine and Jurriaan, the two founders of Good Thanks, have recently acquired a license to use a new production technology developed by Verdure, a company from New Zealand. This technology allows them to manufacture boards using wood, cork and hemp using a more automated process. Their ultimate goal is to make fully bio-based surfboards, that surf just as good (if not better) as the traditional fibreglass boards.

Executive summary

This graduation thesis proposes *Tides*: a product-service system for softtop surfboards. It consists of a redesign of the current softtop construction and a service system through which the boards can be accessed within a circular business model. The goal of this project is to minimize the evironmental footprint of the surfing industry, and help preserve what all surfers love most: the ocean.

A wasteful sport

Softtop surfboards have become very popular over the past decades, especially within surf schools. This is because they are beginner-friendly, and aren't damaged as easily as traditional fibreglass composite boards. However, the design and materials used in these boards make end-of-life strategies very limiting, resulting in a product that is generating a significant amount of waste. The effective lifetime of these boards is only two years, and most surf schools burn through approximately 70 boards during this period. To turn this linear lifecycle around, *Tides* introduces a circular business model for softtops.

Softtops-as-a-service

Through co-creation with different Dutch surf schools, a subscription-based service model is developed. It takes ownership over the boards away from users, and provides them with the guarantee of always having quality softtops. The system makes use of the seasonality in surfing, in which the low season is used to take the boards back and restore them professionally. After materials have gone through multiple iterations of reuse, the boards go into a second lifecycle by leasing them to individual surfers. These use the boards on a less intensive scale, anddemand less of the quality.

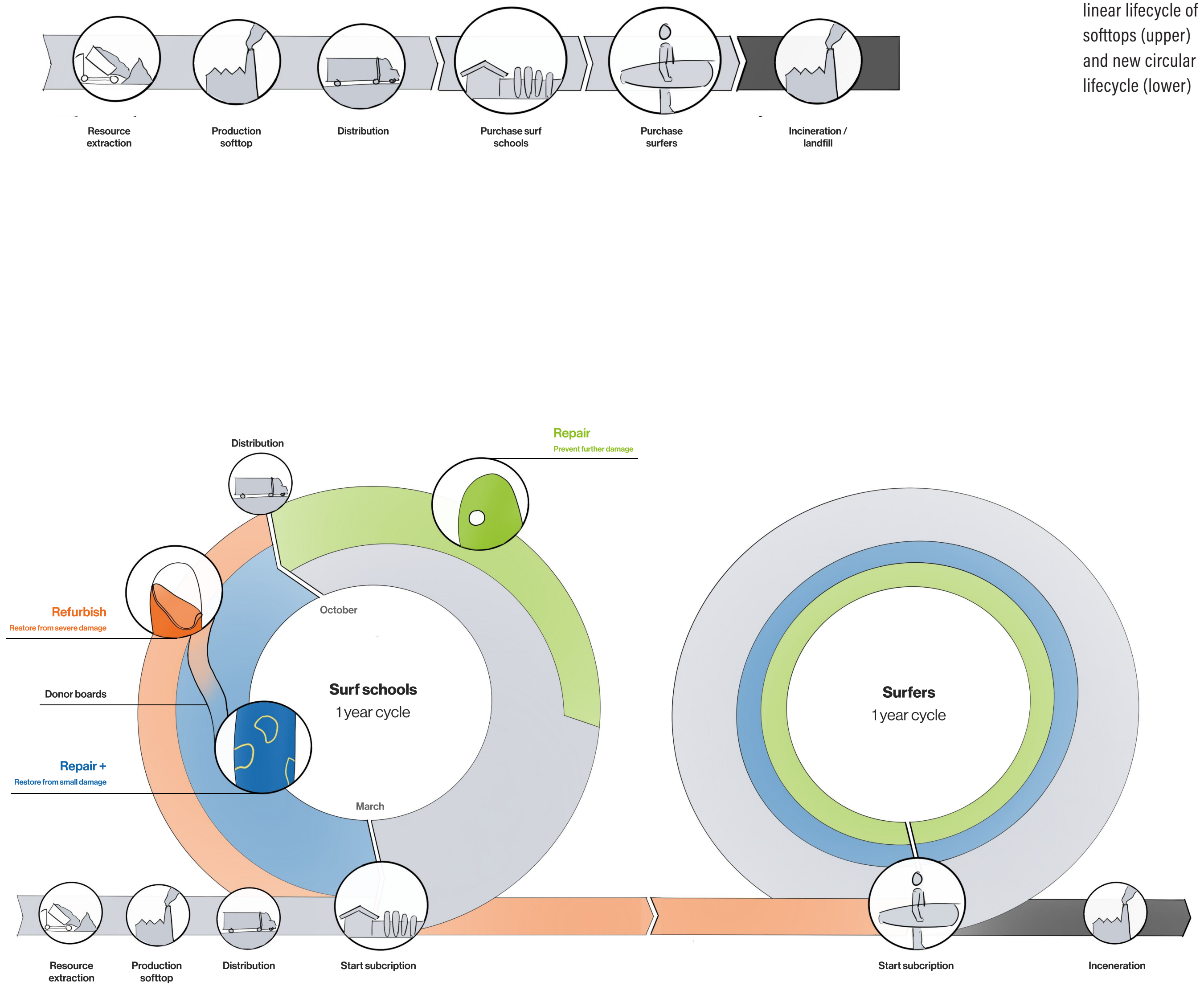


Figure 1 - Current linear lifecycle of softtops (upper) and new circular lifecycle (lower)

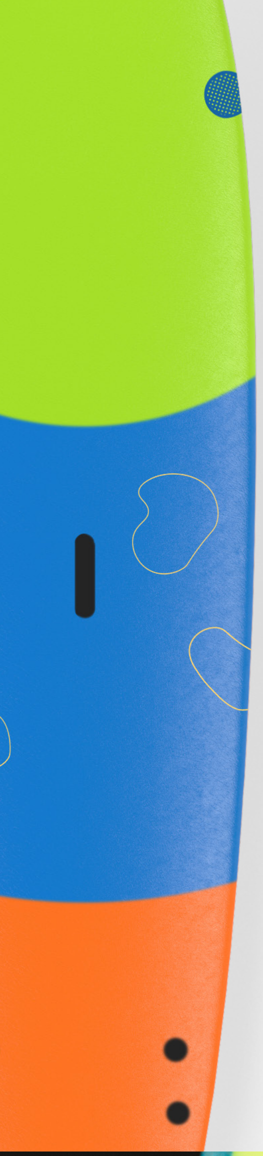


Figure 2 - Levels of intervention of the three recovery strategies

Three recovery strategies

Restoring the boards is done through three different recovery strategies, which are a result of a thorough analysis of the failing mechanisms of current softtops. Each strategy has its own touchpoints within the lifecycle of the boards.

The first one, *Repair*, is used to temporarily fix boards untill the end of the high-season. Through a quick and easy process, surf schools and surfers can remove damaged foam and reseal the boards using pre-manufactured repair patches. The second one, *Repair+*, is done periodically at the end of the season. It removes excess water from the core of the boards, andreplaces all the damaged foam in a professional manner. *Refurbish*, the final strategy, is done when the boards can't be repaired anymore without seriously hurting performance. The boards are reskinned, after which they enter their second lifecycle and old intact foam is reused in the Repair+ process.

The Repair strategy was developed into a technical proof of concept, as this is the first step towards realising a viable circular business model. The patches were prototyped, tested on waterproofness, and evaluated on user friendliness with surf schools.

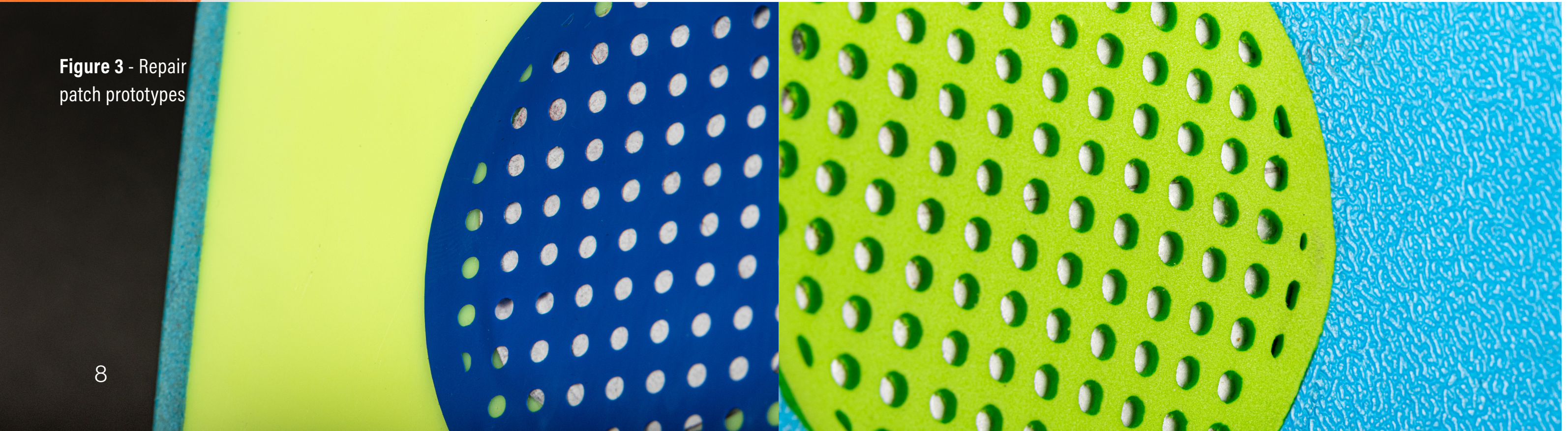
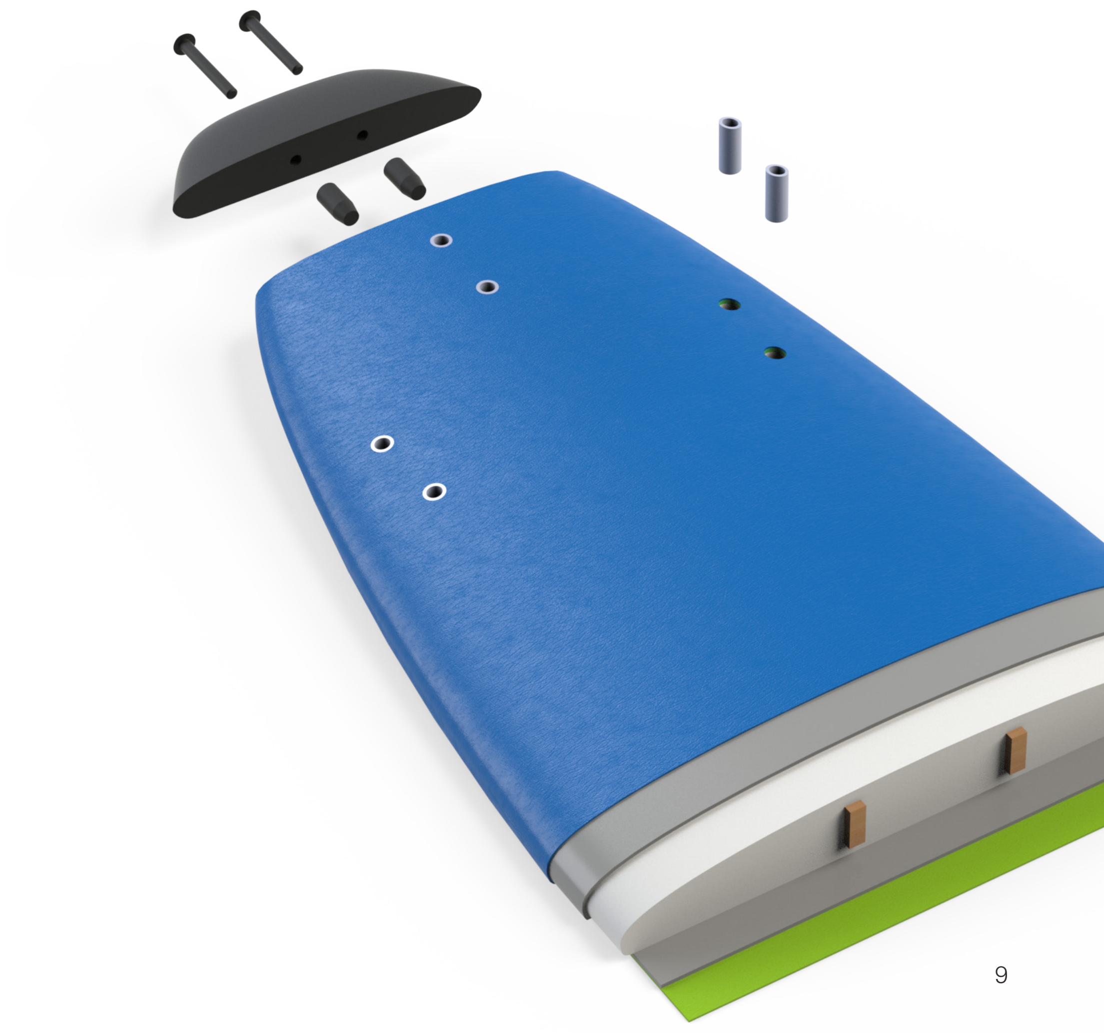


Figure 3 - Repair patch prototypes

A new construction design

The recovery strategies resulted in a new construction design concept. The construction allows for easier implementation of the three recovery strategies, and introduces a few new features to improve the durability of the boards. It includes a modular tail block, through which absorbed water can be removed from the core, as well as a double foam layer that enables an easier repair process. This concept will be developed further, as I plan to continue working on this project.

Figure 4 - New construction design



Surfer Slang (terminology)

Much like what happens within a lot of subcultures, surfing has developed its own language. Surfers have reinvented many words to be able to express themselves to other surfers. Many of them are technical terms describing certain aspects of board design, but others are just ways to describe a certain feeling. There is no official surfing dictionary, so this list contains the unofficial definitions of many terms that are often used. It will not only help you understand this report better, but hopefully also make you climb into the skin of a surfer a little bit before you continue reading.

Barrel The hollow, curling part of a wave, where most surfers strive to be when surfing.

Bottom Underside of the surfboard.

Concave Used to describe the curves in the bottom of the board, which has a big influence on how it behaves in the water.

Deck Top of the surfboard.

Ding Any damage to a surfboard.

Fins Parts attached to the end of the bottom, used for balance and steering .

Gnarly Awesome.

Kook Beginning surfer, who generally doesn't know what they're doing.

Line-up Spot where surfers line up to catch waves, just behind the zone where the waves break

Leash Rope that attaches your leg to the board.

Nose The front of the board.

Peak Spot in the ocean where the waves first start breaking.

Quiver Collection of surfboards owned by a surfer.

Rail The edge of the board.

Rocker The curvature through the spine of the board.

Shred To surf a wave to the fullest.

Single fin Fin setup with one centred fin.

Snake Person that repeatedly paddles around the line-up to get right of way on the wave.

Stringer Piece of material that runs through the spine of the board to create extra strength and stiffness throughout the length. Usually wood is used, but smaller boards sometimes use carbon fibres to reduce weight.

Stoked Extremely happy, excited.

Tail Back of the board.

Thruster Most-used fin setup, with one centred fin and two side fins.

Twin fin Setup with two side fins.

Wax Used to create sticky bumps on the deck of the board for more grip

Content

WELCOME!

You are now looking at a visual summary of this graduation project. It serves as a graphic overview of the design process, and can be used as a tool to guide you through the content of this report. Below this text is a quick tutorial on how to read this overview.

0

Subchapter

This text describes the content of each subchapter briefly.

Page number

Key milestone - These contain important questions, decisions and conclusions from the design process.

Chapter

PROBLEM

1 The linear economy

The way we humans currently make and consume products is generating vast amounts of waste. Most of the material sources we depend on to make these products are not infinite, which is why we need to rethink our consumption model into something more sustainable.

Page 27

SOLUTION

2 The circular economy

An answer to this problem lies in the Circular Economy, which is based on three principles: eliminating waste, circulating materials at their highest value, and regenerating nature. This is done through processes like reuse, refurbishment, remanufacturing, recycling, and composting.

Page 27

FOCUS

3 The surfers paradox

Surfing is a sport with a high environmental footprint. At the same time, the ability to practice it is highly dependent on nature. This phenomenon is called the *surfers paradox*.

Page 28

DESIGN FRAME

4 A circular surfboard

The surfers paradox calls for a different approach to surfboard manufacturing. This project uses the Circular Product Design framework to minimize the environmental footprint of surfers.

Page 31

Design goal - Design, prototype and evaluate a new surfboard construction for a service-based circular business model, minimizing waste and CO_2 emissions.

5 Research questions

The project can be subdivided into two research areas: the circular business model, and the construction design. Within the project, are explored and embodied.

Page 32

RQ1 - What could be a potentially viable target group within the surfing community, and what form of circular business model would fit their needs and behaviour?

RQ2 - How can the traditional construction of the surfboard be modified to minimize waste and CO_2 footprint, and better fit the circular business model?

RQ3 - How can the construction design and business model be integrated into a system that enhances user experience?

Introduction

CONTEXTUAL ANALYSIS

The first part of the analysis is focussed on the context of surfing, and looks for a scope to answer RQ1 with. What are the different types of surfers, and is there a particular one that can be identified as viable target group?

1 The past

The history of surfing and surfboard design is explored through the Circuit of Culture model. This historical analysis helps determine a direction for the future.

Page 37

Analysis

PRODUCT ANALYSIS

This part of the analysis zooms in on the most commonly used softtop among Dutch surf schools, and forms a basis for finding an answer to RQ2. What does its life cycle look like, and why are they currently not suitable for a circular business model?

Scope - A circular *softtop surfboard* for *surf schools.*

2 The present

There are different types of surfers, with preferences for different kinds of surfboards. An analysis of the current market and what's already happening to make surfboards more sustainable will help distinguish these types - and shape a vision for the future.

Page 44

3 The future

The scope for the project is determined based on the findings from the contextual analysis.

Page 47

Finding 1 - Surfboard performance requirements become more demanding as surf experience increases.

Finding 2 - Surfboards for beginners are widely applicable for many (one size fits almost all).

Finding 3 - Surf schools go through up to 90 surfboards per year, and are actively looking for more sustainable options.

4 The leading softtop in surf schools

The most used softtop in the Netherlands is made by Vision. This part looks into why most surf schools use it.

Page 50

5 Construction analysis

The Vision softtop is constructed using a lot of different materials. This part looks at why this construction is not yet suitable for a circular business model.

Page 53

6 Product journey map

Based on interviews with Dutch surf schools, a product journey map is made, containing insights on how Vision boards are used and how they are performing.

Page 53

8 Value chain map

The failing mechanisms discovered from the interviews are mapped along the value chain, giving an overview of where the opportunities for a circular business model might be.

Page 58

7 Material analysis

Failing mechanisms of the boards are validated by simulating the use context and experimenting with the current materials.

Page 56

PROBLEM DEFINITION

This part summarizes all the findings from the analysis, and translates it into a clear definition of what the problem really is. It then defines the directions that help guide the design process.

9 Key findings

The main insights from the product analysis are summarized in a visual way.

Page 62

10 Design directions

The definition of the problem is translated into three circular design strategies. These directions are a guide to the following chapter of the report.

Page 64

Direction 1 - Design for Durability

Direction 2 - Design for Repair

Direction 3 - Design for Disassembly

Design

DESIGN EXPLORATION

This part explores the potential of each direction through individual design sprints. Can we think of new possibilities and solutions, based on what we now know?

1 Design for Durability

The goal of this direction is to make the boards last longer. It explores different ways of preventing water from coming in, or allowing the board to be dried.

Page 68

2 Design for Repair

The goal of this direction is to make repairs more accessible and easy-to-use for surf schools. It not only looks at a possible new construction, but also at how the current construction could be repaired in a better way.

Page 69

3 Design for Disassembly

This direction explores ways of adding modularity to the board, which opens up possibilities for new end-of-life strategies.

Page 70

BUSINESS MODEL DEVELOPMENT

Through what form of circular business model could softtops be brought to consumers, in a way that suits their needs?

4 A circular business model

The insights from the analysis and design sprints are used to develop a first circular business proposal, through business model archetypes.

Page 73

SYSTEM DESIGN

This part contains a complete overview of the system side of the developed concept. How can the value propositions and personal drivers be developed into a desirable user experience.

PRODUCT DESIGN

This part contains a complete overview of the developed concept in its physical manifestation. How do the recovery strategies work in practice, and what should the construction design look like within the service-model.

5 New value propositions

The circular business model is developed further through co-creation with surf schools. A framework is created, containing all personal drivers of different surf schools.

Page 74

Final Business Model - A softtop subscription service *(Softtops-as-a-service)*

6 The service model

The insights from the co-creation are developed into a clear subscription-based business model, forming a base for the concept design.

Page 80

7 Introducing: Tides

The system through which the service model operates is presented. It introduces three different recovery strategies that are used to enable efficient reuse of materials in softtops.

Page 82

8 Subscriptions

The two different subscription levels of the model are explained in more detail.

Page 87

9 Product journey

The system is shown in more detail, by comparing its old linear lifecycle to the new circular product lifecycle.

Page 88

10 Recovery strategies

The processes and designs behind the different recovery strategies are explained in more detail.

Page 91

11 Design criteria

A program of requirements is made, based on the new product-service system. It includes existing performance requirements, and requirements based on the design interventions.

Page 95

12 Construction

With the design of the system and following design criteria, a proposal for a new construction design is made.

Page 98

13 Repair

Repair, the highest level of recovery intervention is designed and prototyped into detail. The prototype is tested on water tightness by doing water absorption tests with the Repair patches.

Page 101

14 Cost price calculation

The costs for the Repair concept are calculated, and an estimation of the total costs of the product service-system is made. This can later be used as a reference when testing the viability with surf schools.

Page 108

CONCEPT EVALUATION

The concept evaluation looks at the quality and ease-of-use of the Repair strategy, by testing and evaluating with users. This is used to determine the desirability and feasibility of the concept.

1 User testing

The Repair concept is tested with users and evaluated on ease-of-use, sense of trustworthiness and aesthetics.

Page 112

2 Seal testing

The seals created by potential users are tested on their water tightness.

Page 119

3 Impact analysis

A rough estimation of the impact of the product-service system on reduction in waste and CO_2 emission is done.

Page 122

Evaluation

CONCLUSION

This part concludes the report, by looking back at the design goal and the research questions. Do the concept and business model meet all the criteria, and what are their limitations? The answers to these questions are translated into recommendations for the future of the project.

3 Conclusion

The results from the concept evaluation are concluded with a summary of the key findings on all the research questions. These are followed by a list of recommendations for future development of this project.

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4 Reflection

I give my personal reflection on the project, both on results and the things I've learned throughout the process.

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Appendices

1. **Analysis interviews** *Page 138*
2. **Value proposition canvas** *Page 146*
3. **Co-creation** *Page 147*
4. **Morphological chart** *Page 154*
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6. **Repair+ conceptualising** *Page 157*
7. **Construction conceptualising** *Page 158*
8. **Waterproof seal testing** *Page 159*
9. **Cost price estimation** *Page 162*
10. **Repair evaluation** *Page 166*
11. **Surf schools in the Netherlands** *Page 172*

Introduction

1.1 Climate change and the Linear Economy

The world we live in today is a world of rapid change, and one development that has undeniably taken up a big part of the stage is climate change. Our goal of limiting the global temperature rise is currently set at 1.5˚C in 2100, but a report by UNEP has shown that we are still not close to being on track to achieve this (2018).

This problem is incredibly complex, but a big part of it can be explained by our current 'take-make-waste' consumption model. By now, we have learned that the way we use the materials accessible on our planet has a big impact on environmental change. A research report from Circle Economy claims that 70% of all emitted greenhouse gases are directly linked to material handling and use (2021), and extraction and use are responsible for about 90% of all biodiversity loss and water stress (IRP, 2019).
Waste has especially become a problem since the big plastic revolution. The amount of globally generated plastic waste has more than doubled, from 156 Megatons in 2000 to 353 in 2019. Of this amount, 69% was incinerated or landfilled, 22% was disposed of informally, and only 9% was effectively recycled (OECD, 2022).

These problems are forcing us to critically rethink the way we currently make and use products. Our linear economy is not a sustainable one, as the materials we currently rely on are not infinitely available on our planet, and will eventually run out. Urgent action will be needed to stop these developments. Systemic change in our energy systems, land management, but also in the way our products are made and used, is needed to get our economy on track to limit global warming to 1.5˚C with no or limited overshoot (Ellen Macarthur Foundation, 2019).

1.2 The Circular Economy

The problematic nature of this linear consumption model has become evident over the years, which has pushed us to think of a solution. It has led to the introduction of a variety of alternative models that encourage the sustainable use of materials. Of these models, the one that has attracted the most attention is the Circular Economy.
In a research report, the Ellen Macarthur Foundation explained its fundamentals through the following definition (2013):

> A **circular economy** is an industrial system that is restorative or regenerative by intention and design (see Figure 6 in Chapter 2). It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.

The circular economy relies on three main principles: eliminating waste and pollution, circulating products and materials at their highest value, and regenerating nature. At the core, these three principles are driven by design, and underpinned by a transition to renewable energy. The ultimate aim of the Circular Economy is to build a resilient system that is good for business, people, and the environment.

Despite its surge in popularity over the past years, the implementation of the circular economy still has its challenges. The amount of discussion, debates and articles addressing the topic have almost tripled over the past five years, indicating an increasing interest in circularity. However, circularity itself has been in decline. The majority of materials entering the economy are virgin, and the amount of used secondary material has decreased from 9.1% in 2018 to 7.2% in 2023 (Circle Economy, 2024). This shows that, despite the talk and popularity, the amount of practical implementation and measurable impact is still low.

This project aims to look beyond the product itself, to see what other factors make the realisation of the circular economy such a challenge.

1.3 The Surfers Paradox

Surfing is one of the most popular water sports globally. An estimated 35 million people surf regularly on our planet. The equipment you need is an important aspect of surfing, which is why in total the global surf industry has an annual revenue of about 22 billion dollars (International Surfing Association, 2021).

The larger part of this surf industry is taken up by the production of surfboards, which is a toxic and wasteful process (Schultz, 2009). The use of epoxy and polyester resins, in combination with an intensive manual manufacturing process make for quite a harsh work environment. The materials used in surfboards not only make them very difficult to recover using the principles of the circular economy, but also result in health complications among surfboard makers (Borne & Ponting, 2017, pp. 50-53). Add to this the constant transport of boards across the globe (shipping and surf travel), and you see why the sport is quite unfriendly to our environment.
At the same time, surfing is heavily reliant on nature. Besides the equipment, its only real requirement is the presence of good waves, and the effects of climate change are posing a threat to the sport. Research showed that the effects of climate change (and especially responses to climate change, such as coastal armouring) are harming surf spots worldwide (Sadrpour & Reineman, 2023).

These conflicting aspects of surfing are also called the **Surfers Paradox**. Every surfer wants to help preserve the ocean, but surfboards are as polluting as sports equipment can get.

Design Goal

Design, prototype and evaluate a new **surfboard construction** for a **service-based circular business model**, minimizing **waste** and **CO2 emissions**

1.4 The circular surfboard

This problem calls for a different approach to surfboard manufacturing. The goal of this project is to help minimize the environmental footprint of surfers, while still offering them the surfing experience they want. This is done through the principles of the circular economy, and the framework proposed in the book *Products That Last* (Bakker et al., 2020). This framework emphasises the importance of business models in achieving circularity. It presents circular business model archetypes, and relates product design strategies to them that enhance the viability of these models. The symbiosis between the two is what gives circular product design the opportunity to thrive.

The project focuses on two things: a **circular business model** through which surfers can access surfboards, and a redesign of the current **construction** to make the boards suitable for the business model.
The circular business model is developed by co-creating new value propositions with surfers. Ultimately, the goal of this is to create a system that not only offers a viable platform for the circular construction, but also enables a desirable user experience. This is a factor that is often overlooked, but is an important part in transitioning the consumer mindset to a circular one.
The redesign of the board is based on the proposed business model, and a thorough analysis of current construction techniques, use scenarios and failing mechanisms. This is used to design and develop a concept into a prototype, which is evaluated through user testing at the end of the report.

The deliverables included in this report contain the following:

1. **Analysis** report, breaking down the current use and construction of surfboards
2. **Circular business model** proposal, developed into a system enhancing user experience
3. **Product design** concept, based on the analysis of the current construction and business model
4. **Prototype** that is evaluated through user testing

1.5 Research questions

In order to make the shift from the current linear approach to a circular one, this project finds a symbiosis between the product design and business model side of the project. The goal is to bring these two together into a system that creates a desirable user experience. The project is subdivided into three research questions, to help structure the process.

	Research question		Sub question	Chapter
1	**What could be a potentially viable target group within the surfing community, and what form of circular business model would fit their needs and behaviour?**	1	What meaning have surfboards had to surfers over the history of the sport?	2.1
		2	What are the different types of surfers?	2.2
		3	How do these types of surfers currently use surfboards?	2.2 2.6
		4	What type of surfer and surfboard is a suitable scope for this project?	2.3
		5	What does the value chain of surfboards currently look like?	2.8
		6	What and where are the different forms of value loss currently existent in the value chain?	2.8
		7	What personal drivers motivate potential users to choose for a certain surfboard?	3.5
		8	What kind of new value propositions can be introduced in the business model?	3.6
2	**How can the traditional construction of the surfboard be modified to minimize waste and CO2 footprint, and better fit the circular business model?**	1	What is the most used board within the chosen scope, and why is this the case?	2.4
		2	What barriers are there that prevent the current construction from being suitable for a circular business model?	2.5 2.6 2.7
		3	What product design strategies are most applicable for the circular business model?	2.10
		4	What requirements do boards have to fulfil to fit the circular business model?	3.11
		5	What could be an alternative construction that fits these requirements?	3.12
3	**How can the construction design and business model be integrated into a system that enhances user experience?**	1	How can the personal drivers of the target group be used to create a desirable system around the boards?	3.7
		2	In what ways is the desired system manifested?	3.10 3.13
		3	How much CO2 and waste could be saved with the implementation of the system?	4.2

Table 1 - Research questions

Analysis

Contextual Analysis

The first part of this report will take a deep dive into the context of surfing and surfboard production. Why do people surf and where does it come from? What does it mean to be a surfer now? What is already happening in surfboard manufacturing to minimize the environmental footprint of surfers? These are all questions that will help shape a vision and pick a suitable target group for the design process.

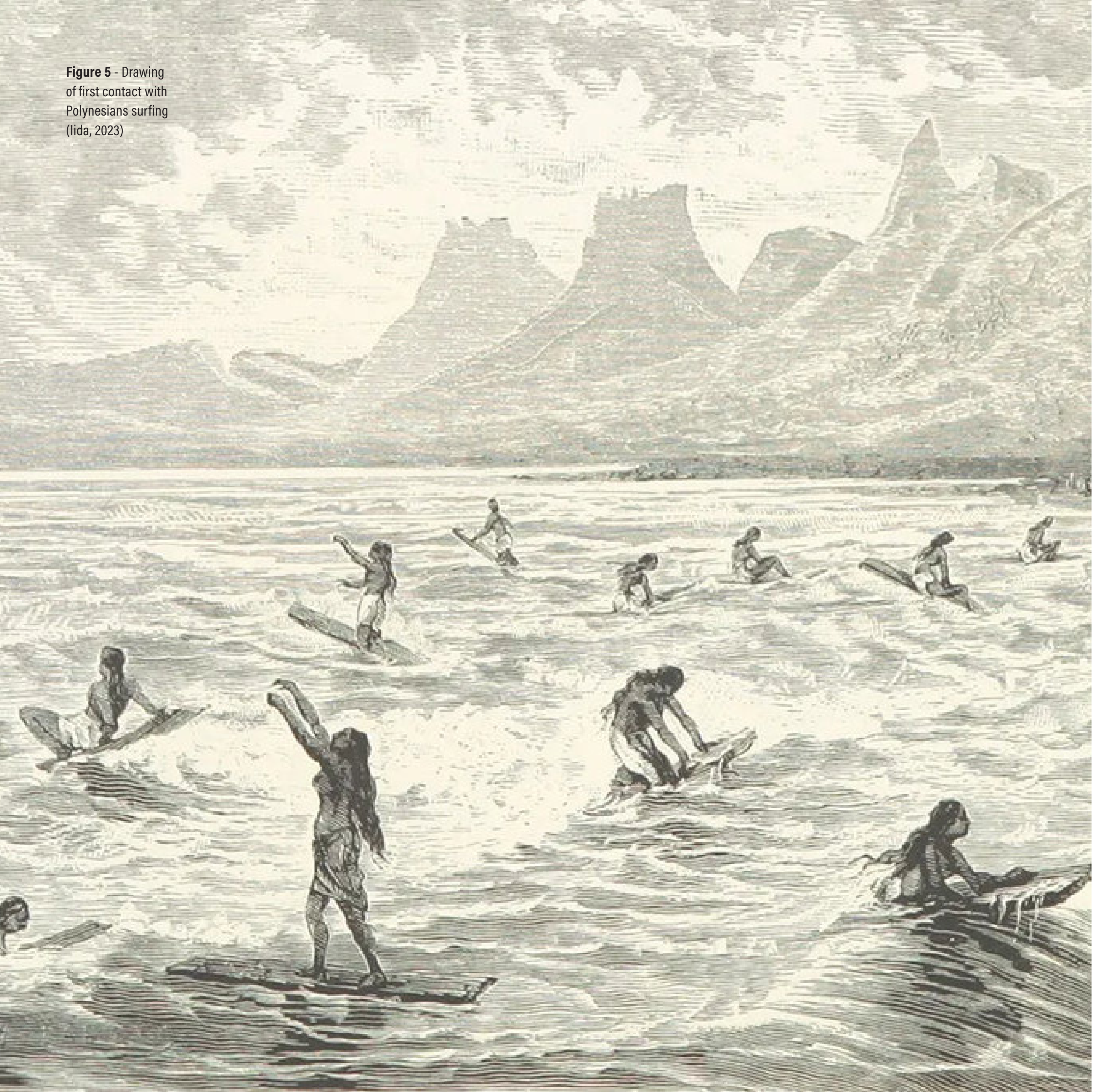


Figure 5 - Drawing of first contact with Polynesians surfing (Iida, 2023)

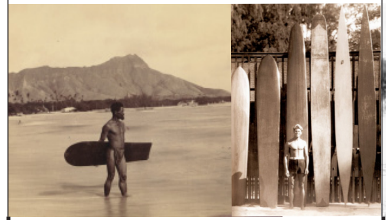
2.1.1 The past

RQ 1.1
What **meaning** have surfboards had to surfers over the **history** of the sport?

The first step in understanding where the future should go, is to learn where we come from. This part looks at a brief history of the meaning of surfing through the lens of the Circuit of Culture model (Hall et. al., 1997). It looks at how production, representation, regulation and identity around surfboards has developed throughout its time.

Production
For many surfers, surfboard manufacturing is considered a form of art. This is mostly the reason why, since the shift from wood to plastic materials, there haven't been many developments in surfboard production. Industrialization has introduced ways of producing mass-manufactured surfboards using plastic moulds, but surfers have generally never embraced this way of production (Feldmann, 2019). Within the worldwide surf community there is still a big focus on local craftmanship. Especially between more experienced surfers, industrial board manufacturing is overshadowed by the preference for quality, handcrafted surfboards (Warren & Gibson, 2015). However, despite this focus on craftsmanship, there have been some changes in the last few decades. The introduction of CAD modelling has moved the shaping process from the physical shaping room to the computer. CNC-shaped boards have become accepted, but boards are still mostly laminated by hand (Feldmann, 2019).
In addition to this, softtop surfboards have also become very popular over the past few decades. These boards, which are mostly targeted to beginners, are very buoyant, softer (which is safer), and more durable than traditional fibreglass boards. Many surfers have come to the consensus that surfing should not always be about performance, but about having fun. This development has been named 'The Softtop Revolution', and has replaced a big share of the hand crafted fibreglass surfboards with boards made in large Chinese and Taiwanese factories (Pierson, 2019).

Around 300AD, Polynesians migrated to the Hawaiian islands, where they introduced a culture of riding waves. The first surfboards recorded during this period were all straight planks cut out of solid pieces of wood. There were three categories, based on size: the **Olo** (12 ft+), the **Alaia** (6-12 ft) and the **Paipo** (3-6 ft). The Alaia (picture left) was the most versatile and widely used, and is still made nowadays. **[1]**



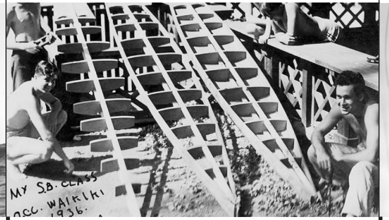
300 AD

As Hawaii was annexed by the United States, surfing gained a boost in popularity and surfers began experimenting with newly introduced types of wood (mainly redwood). This produced **smaller**, **lighter** and more **versatile** versions of the traditional Alaia. **[1]**

1900

1910 Duke Kahanamoku creates famous Swastika/Waikiki plank surfboard, made of redwood

Surfing was revolutionised when Tom Blake developed the first **hollow surfboard**. It consisted of a wooden frame with a skin of plywood, and became the first mass-produced surfboard. At the same time, the introduction of Balsa wood from South America made the construction of solid lightweight boards possible. **[1][2]**



1920

1929 Tom Blake creates first version of his hollow wooden surfboard

1931 Blake's surfboard gets patented, and gets named "The Cigar Box"

1934 The creation of the "Hot Curl Board", a board with much narrower tails and sharper rails that transforms the way of surfing **[3]**

1935 Tom Blake introduces the "Fixed Fin", adding both stability and manoeuvrability to surfboards

WWII saw a huge boost in material innovation and technology. **Plastics, PU foam, PS foam** and **fibreglass** offered surfers new tools to experiment with surfboard design. **[1]**

1940

1946 The first hollow moulded plastic surfboard is made, with outer layer of fibreglass tape

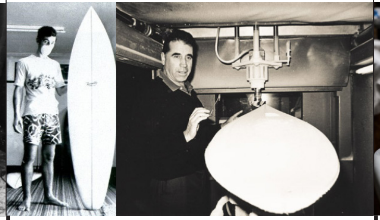
1947 The first polyurethane foam-core surfboard is built, with a shell of thin plywood

1951 Introduction of the removable fin system

1958 Hobie Surfboards develops PU foam mould, and starts building polyester resin boards exclusively

1958 The introduction of the wooden stringer to strengthen PU foam blanks

As manufacturing technology kept evolving in the 60s, various companies began making plastic moulded **"pop-out" surfboards**. These were cheaper to make and therefore more suitable for the beginners market . Experimentation with surfboard design also continued, which resulted in surfboards getting **smaller and smaller.** This change in board size allowed for a quicker style of surfing, opening up a world of new techniques and tricks. This style of surfing has been the most dominant until this day. **[1]**



1960

1967 Year of the 'Shortboard Revolution', during which this new style of surfing started taking over the surfing world

1976 Tom Morey & Mike Doyle make first soft top surfboard in the world

As PU surfboards had almost completely taken over surfboard production, companies also started experimenting with other composite materials. Big manufacturers started making boards with **polystyrene** and **epoxy**, which was more durable and less toxic than PU. However, apart from the materials, the process didn't change. **[1]**

1980

1979 Michel Barland invents the first CNC shaping machine, standardizing the quality of shapes and cutting down on labour costs

1981 Simon Anderson creates the 'Thruster': a three-fin setup, quickly becoming the most popular on the market for shortboards

Surfboard manufacturing techniques had stopped developing after the switch to PU/epoxy composite boards. However, this period saw the rise of the **'softtop'** surfboard: foamy beginner-friendly boards with lots of volume (funboards). Many surfers started realising that surfing isn't always about the performance, but about having fun. Surfers of all levels started showing up to the beach with bright coloured softtop surfboards. **[4]**

2000

2004 Wavestorm creates the first mass-produced softtop surfboard

Developments in the world during the 21st century have shifted the focus in the surfing industry to its environmental impact. Many shapers are trying to minimize the CO2 footprint of their boards by experimenting with their manufacturing methods. Variations mainly focus on replacing the core with **bio-based materials**, but no shaper has yet succeeded in manufacturing surfboards without epoxy / polyester composites on a large scale. **[1]**

2020

[1] (Feldmann, 2019)
[2] (History, 2015)
[3] (The Surfers Journal, 2021)
[4] (Pierson, 2019)

Figure 6 - Historical timeline of surfing

Consumption
The demographic of surfers has changed a lot over time. The sport, originating in Hawaii, has been spread as a result of colonialism. It first travelled to the United States and Australia, then throughout the rest of the continents, and is now practiced almost everywhere in the world. However, because there are big differences in the quality of waves, there is a lot of movement of surfers around the world. Surf tourism is a growing trend (Müller, 2022), and surfers travel to many exotic destinations in search of better waves. This is also contributing to the spreading of the sport, and the diversification of the surfing community (Howard, 2024).

Identity
The identity of surfers and the sport itself has grown with the global spread of surfing. As it originates from places with good weather, palm trees, clear blue water, and white sandy beaches, this was what it was associated with for a long time. However, as it has spread to other places, its identity has also taken new shapes. Surf spots in the Netherlands are the opposite of the places just described, and surfers and brands have embraced this, instead of trying to copy the exotic surfing identity. A brand like New Amsterdam Surf Association celebrates the brown muddy water, windy coastlines, and cold temperatures, and Dutch surfers feel closer to this identity (New Amsterdam Surf Association, n.d.).

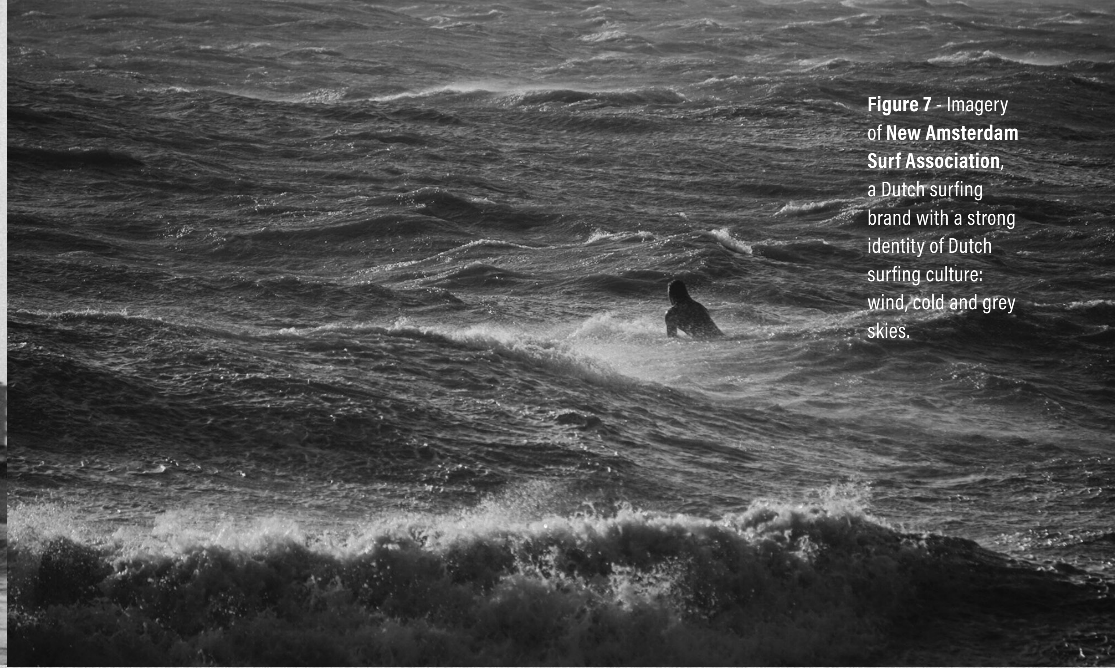


Figure 7 - Imagery of **New Amsterdam Surf Association**, a Dutch surfing brand with a strong identity of Dutch surfing culture: wind, cold and grey skies.

Figure 8 - Image from **The Electric Acid Surfboard Test**, A YouTube show on experimental surfboard design

Representation

This change in surfing identity is correlated with a change in representation. In surf film and photography, famous professional surfers mostly used to go to warm exotic places to explore new unsurfed waves, but are now also traveling to rocky, Arctic coastlines to surf.
This is also because of the increase in media platforms on which surfing content is now shared. New media platforms have accelerated developments in surfboard design. Shapers are now creating content on progressive approaches to the way they shape their surfboards. This is contributing to the development of new surfboard designs, as well as helping to demystify the art of surfboard shaping (Borne & Ponting, 2017, pp. 41-43).

Regulation

One of the big reasons why surfers develop a love for the sport is the freedom. Except for some swimming beaches, there is no official legislation on where you are allowed to surf. However, there are some 'unwritten rules' in surfing. The rules mainly entail who has right of way in the water, and what to do - and not to do - when someone is already on a wave. These are globally known and taught to beginners in surf schools, to prevent accidents and fights in the water (De Alessi, 2009).

> **Conclusion 1.1**
> - Production in surfboards has shifted from natural materials to more petroleum-based **plastics**.
> - Despite the introduction of industrial processes, surfboard making is still considered an **art form**.
> - **Softtop surfboards** have become the exception, as they have become very popular despite distancing themselves from the locally crafted fibreglass boards.

2.2 The present

> **RQ 1.2**
> What different **types of surfers** are there?

> **RQ 1.3**
> How do these types of surfers currently **use** surfboards?

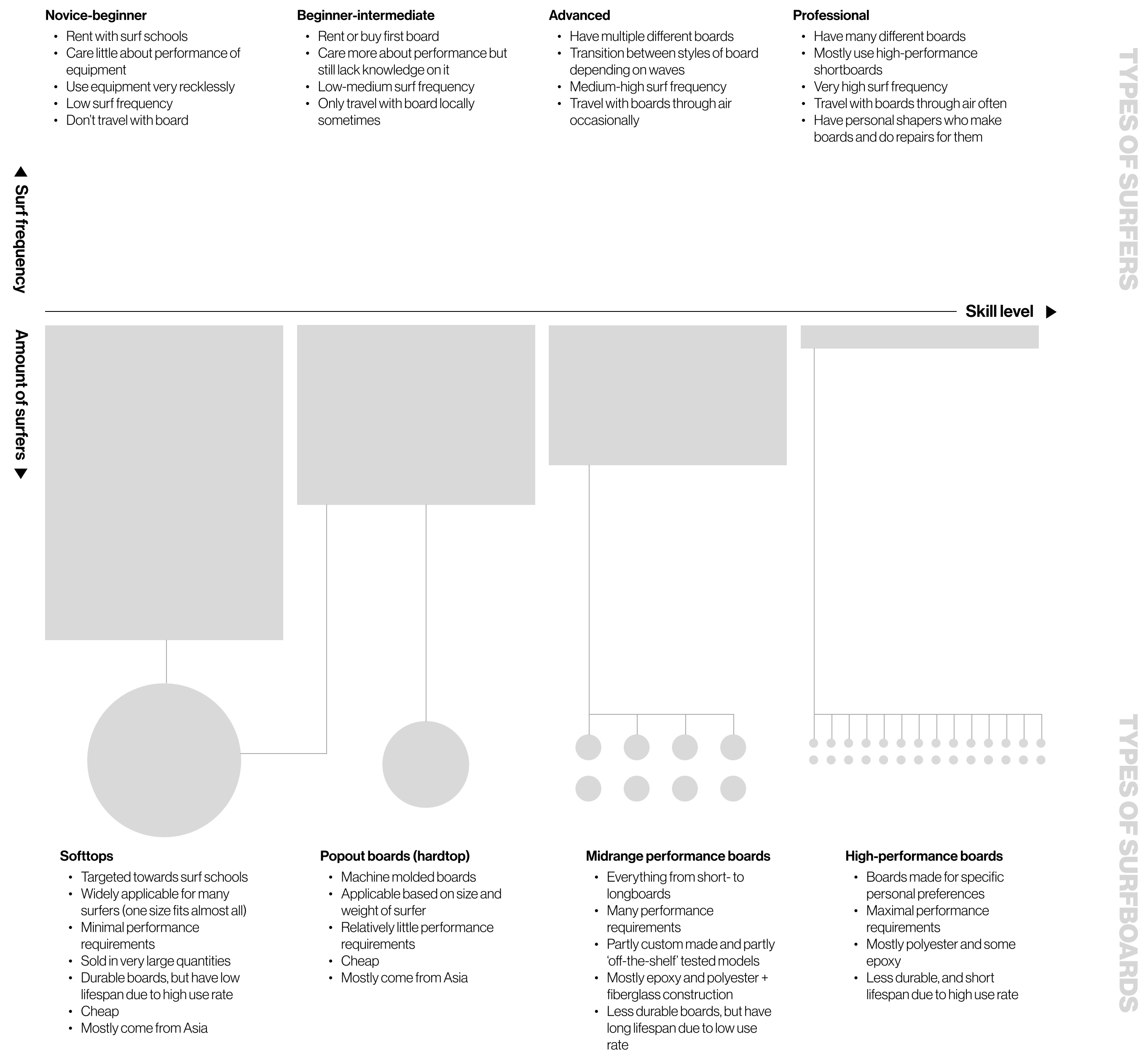
Now that we have an understanding of its history, we can look at the current context of surfing. This part contains an overview of the different types of surfers and the boards they use. It also dives into the market of surfboard manufacturers, and what they are already doing to lower their environmental footprint.

Surfer archetypes
There is not a lot of data on surfers. Apart from research by the International Surfing Association on the demographics of surfers, it is difficult to find literature, due to the informality of the sport. However, several different surfer archetypes were defined during a brainstorm with *Good, Thanks Surfboards*, a company selling custom-made surfboards to surfers in the Netherlands. Their knowledge on the segmentation of the surfboard industry comes partly from marketing sessions they have done with different surfers, but mostly from the practice of making and selling boards. This input was combined with the Tree of Knowledge model, developed by surf school and magazine Surf Simply (2011). This model describes four different skill levels within surfing, that each have their own characteristics.

This distinction between the different archetypes shown in figure 9 is based on skill, surf frequency, and board preferences. These indicators are not scientifically proven, but are an estimation of what separates different market segments, and will be analysed further in the analysis of a specific target group. Most of the characteristics in each segment shown in the figure are defined together with *Good, Thanks*, and do not refer to any scientific literature.

There are quite some differences between these archetypes, and a lot can be learned from them.
First of all, the ownership of surfboards is something that changes as the skill level progresses. Softtop surfboards are rarely owned by surfers, but are mostly bought by surf schools who use them as rentals. It's also clear that softtops have the lowest performance requirements out of all types of boards, because they are targeted towards beginners. The most important criteria for softtops are in their durability, price and safety features for beginners (Vision Softboards, n.d.-a).
Hardtop 'popout' boards mostly function as a transition board between softtops and high-performance boards. In many cases, their lifetime is decided by the amount of time intermediate surfers need before outgrowing the boards. Where softtops are sometimes still used by more experienced surfers because of their 'fun factor', popout boards are usually only used for a short span in a surfers skill progression.
Boards for more experienced surfers become increasingly specific, and have high performance standards. A result of this is also that these surfers own a lot of different boards that are used for specific wave conditions. A study has shown that the average surfer in the United States owns four different surfboards (Surf-First & Surfrider Foundation, 2011). More advanced surfers usually own a lot more than this. These boards therefore have a much lower use rate than softtops, and sometimes don't even reach the end of their lifespan.

Figure 9 - Surfer archetypes



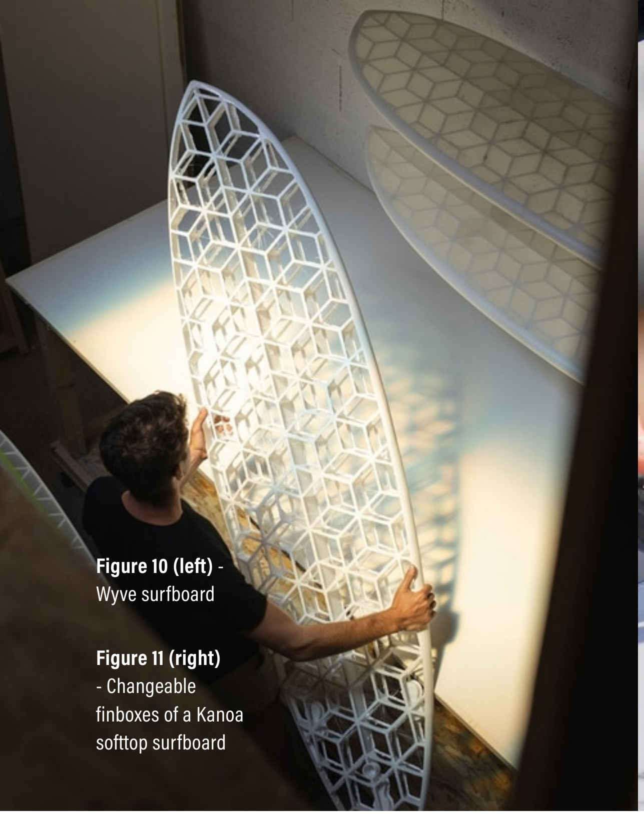


Figure 10 (left) - Wyve surfboard

Figure 11 (right) - Changeable finboxes of a Kanoa softtop surfboard

Current strategies

There are a lot of surfboard manufacturers who are already trying to make their boards less harmful to the environment. As many of them focus on different types of surfers, the approach they have taken also shows some differences.

A common approach among shapers that make boards for experienced surfers is using bio-based materials (Allen, 2021). Verdure Surfboards, a company from New Zealand, has developed a technology that produces high-performance surfboards using wood, cork, hemp and EPS (Verdure Surf, n.d.). Wyve, a different shaper from France, uses 3D printing to make hexagonal structures to replace traditional PU or EPS cores (figure 10). They aim to make boards that are more durable and easily repairable, because they can drain the inside structure in case of a leak (WYVE, n.d.). However, both strategies still can't avoid the need for resin-based composites to create the stiffness needed in high-performance surfboards, which creates challenges. Resins make it difficult to produce a fully bio-based surfboard, and also limit end-of-life possibilities (Gibson & Warren, 2017).

Among softtop manufacturers, the bio-based approach is less popular. These are trying to innovate by making their softtops more durable. Kanoa, another French company, has included some form of modularity in their softtop designs, by making their fin boxes customizable (figure 11) (Kanoa, 2023). However, because of the use of more expensive materials, manufacturers that are making efforts to make more durable boards generally end up with a much higher price than the average softtop (Carpenter, 2022).

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Conclusion 1.2

- Surfers can be divided into **four different categories**, based on their skill level and board preferences. As the skill level progresses, board preferences become increasingly specific, resulting in surfers having a lot of different surfboards.

Conclusion 1.3

- Surfboards on the beginner-end of this spectrum, **softtops**, are very widely applicable. They are mostly used by surf schools and these use a one-size fits all approach, by buying a large amount of the same board in a few different sizes.

2.3 The future

RQ 1.4
What type of surfer and surfboard is a suitable **scope** for this project?

Now that we've done a quick analysis of the past and present of surfing, we can start looking at the future we are designing. The following takeaways from chapters 2.1 and 2.2 form a base for the scope of the project:

Shaping is an art form - Traditional surfboard making is seen as a form of art, in which changing consumer behaviour can be difficult.

The softtop revolution - Softtops have become increasingly popular, as a fun alternative to traditional fibreglass boards.

With skill comes performance - More experienced surfers have increasingly specific demands in surfboards, resulting in many different types of boards.

One softtop fits all - Surf schools use one type of softtop (in a few different sizes) for all beginning surfers.

Through these findings, a choice was made to focus on softtops, as they open op the most opportunities within the project. The primary buyer of softtops, surf schools, is taken as a target group for the development of the business model. These take up a large share of where softtops are actually used.

Conclusion 1.4

- **Softtops** were identified as the most suitable scope for this project, and **surf schools** are used as a target group.

Design Goal + [Scope]

Design, prototype and evaluate a new **[softtop] construction** for a **service-based circular business model** for **[surf schools]**, minimizing **waste** and **CO2 emissions**

Product Analysis

The first part will take a closer look at the softtop surfboard. What softtop surfboard do surf schools generally use, and why? How are these softtops constructed, and why are they currently not suitable for a circular business model?

2.4 The leading softtop in surf schools

> **RQ 2.1**
> What is the **most used board** within the chosen scope, and why is this the case?

To find out what softtops surf schools mostly use, four semi-structured interviews were done with different Dutch surf schools and camps. The goal of these interviews was to get an idea of how softtops are typically used at surf schools, and how surf schools are run in general. So apart from this subchapter, the results of these interviews are also used in a product journey map (2.6) and value chain map (2.7), to create a complete overview of the lifecycle of softtops.
The interviews were done with the following surf schools and camps, on the following dates:

1. **The Hook** - *Hoek van Holland, 01-05-2024*
Surf school, 30 boards
2. **The Shore** - *Scheveningen, 14-05-2024*
Surf school, 76 boards
3. **Ripstar** - *Netherlands, France and Spain, 16-05-2024*
Surf camp, ~360 boards
4. **Surfblend** - *France, Spain and Morocco, 08-05-2024*
Surf camp, ~700 boards

Data was recorded by taking notes and taking photos of the different topics that were discussed. The full question list and transcripts of the interviews are shown in Appendix 1. The following parts will refer to these interviews every now and then, as they serve as the main source of information on the current use of softtops in the Netherlands,

Out of the four, three are using *Vision* softtops and one (Surfblend) is using boards from *Softdog* Surf. The latter one mentioned that Softdog is a company that was branched off from their surf camps, out of financial considerations. The ones using Vision boards said that almost all surf schools in the Netherlands use them, for the following reasons:

> 1. They have a good **price** for their durability (best return on investment)
> 2. They are the most **beginner-friendly**. Other durable softtops (like Softdog) have a layer of fibreglass and epoxy below the soft shell, which still causes too much impact in the case of an accident.
> 3. Vision maintains a good **relationship** with surf schools.

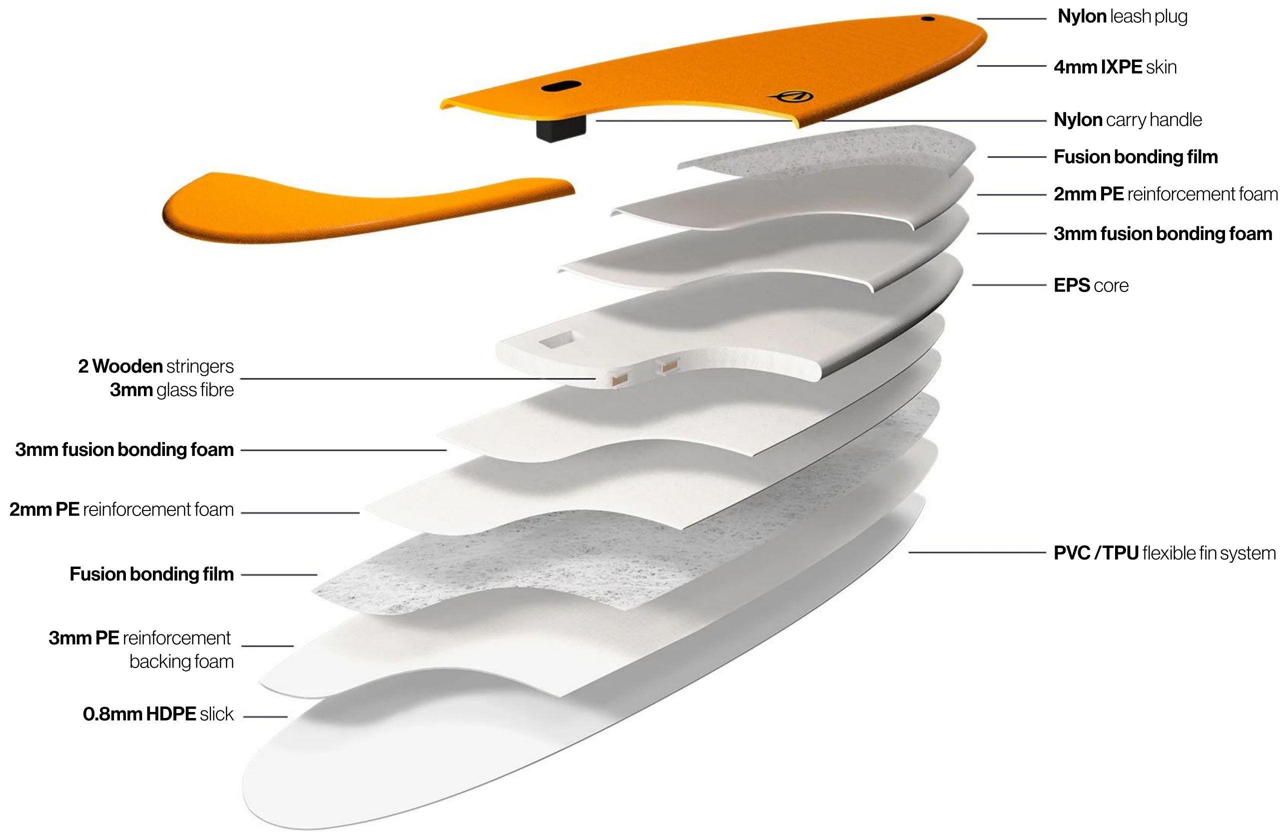
Despite these advantages, surf schools are still actively looking for alternatives to the Vision boards. This is because they still only last about 2-3 years, and most of them get thrown away after use. One surf school mentioned that they order a board from 3 new brands every batch, to see if there are better boards available. Until now they haven't found one.

> **Conclusion 2.1**
> - The most-used softtops within Dutch surf schools is made by **Vision**, because of its price, durability and their client-customer relationship.

Figure 12 - Vision softtop

Figure 13 - Softdog softtop

Figure 14 -
Construction of
a Vision softtop
(Vision Softboards,
n.d.-b)



2.5 Construction analysis

> **RQ 2.2**
> What **barriers** are there that prevent the current construction from being suitable for a circular business model?

A visual of the construction of a Vision softtop is shown in figure 14. The boards contain quite a lot of different materials (PE, cross-linked PE, EPS and Nylon), which are fusion bonded into a solid construction. Fusion bonding is a process that involves heating up materials to above their melting points and applying pressure, after which they form chemical bonds without adding new materials (Harkous et al., 2017). This construction method has a few consequences for the lifecycle of the softtops:

1. The outer shell consists of **IXPE**, which is a cross-linked polyethylene foam. During cross-linking, the material forms strong bonds which make the material behave as a thermoset.
This has a big influence on the repairability and recyclability of the material, as it means the material strongly degrades before melting. (Zéhil & Assaad, 2019)(Bawareth et al., 2022)
2. The **different material streams** mean that they have to be separated for them to be recycled.
3. **Fusion bonding** makes it difficult to recycle materials. It means that the materials have to be shredded and then separated, for instance through sink-float techniques (Bauer et al., 2018).

It's clear how these factors all have an influence on the lifespan of the softtops, and its end-of-life scenario. The choice of materials are at the expense of the ability to repair, or recover value from the boards.

2.6 Product journey map

From the interviews with surf schools, a product roadmap was made. This roadmap is shown in figure 15 on the next two pages It contains a visualisation of the lifecycle of a Vision softtop. Things like the failing mechanisms are shown, and it includes insights on how the design factors from the previous paragraph are reflected in a practical use scenario. These insights will help determine directions for the physical redesign later in this chapter.

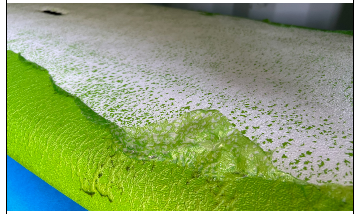
> **Conclusion 2.2**
> - The outside layer of boards breaks, after which the EPS **absorbs water**. Boards get heavier this way, and surf performance decreases.
> - Boards are currently repaired using **permanent adhesives**, limiting other recovery methods even further. Repairs also **lower the visual quality** of boards.
> - Materials and bonding methods currently used in softtop construction make **recycling virtually impossible.**

Figure 15 - Product journey map

The low-season runs from **November-April**

The high-season runs from **May-October**

Production
Production is done in a factory in **Taiwan**



Quality of production is dependent on geopolitical trends in the world. According to multiple surf schools, the quality of softtops decreased heavily during COVID. It resulted in boards with a much shorter lifespan.

Shipping
Shipping from Taiwan to NL, can take up to **45 days**

Shipping is also prone to disruptions. When the Suez canal was blocked off, surf schools had to wait very long and eventually had to buy boards locally for the start of the surf season.

Purchase
Surfschools buy batches of **70-90 new surfboards**, every **2-3 years**

Surf schools get ready for the season by buying and preparing all equipment: boards, leashes, wetsuits and rash vests. On busy days during the high season, boards are rented out about 1-2 times a day.

Boards sometimes break. Things that occur are:

- Holes in the HDPE bottom, or soft shell
- Fin connections start leaking

When the boards get holes, the EPS core starts absorbing water, causing the boards to get heavier over time. Leaks can also go unnoticed for some time, as they are not always very visible.

Surf schools try to do self-repairs, using silicone glue, hot glue or epoxy. One surf school also mentioned they put their boards in the sun when they've absorbed water to let it evaporate, but this also causes the outer layer to delaminate from the heat.

During the off-season, surf schools store their boards in containers. They try to rent out some of their boards to surfers for the entire winter, but this is only a very small fraction of their stock. One surf school also mentioned to have implemented a crowd-sharing platform, where surfers can store their own boards in the containers and use all of them in return.

2nd purchase
A small part of the boards is resold to surfers, but most boards are usually too worn out

Surf schools mostly dispose of their boards when they feel the boards have absorbed too much water and are getting heavier. The centre of gravity in the boards usually shifts when this happens, and this gets very noticeable.

Disposal
Boards are incinerated

The boards that are completely worn out are usually taken to a garbage disposal. Every now and then, surf schools reuse parts of the boards in creative way, as a way of preventing the boards from getting burned.

2.7 Material analysis

The interviews with surf schools have brought up some of the reasons Vision boards fail. However, it is interesting to validate whether these things are actually happening, and to look for the real root of the problem. By conducting material tests we can discover exactly which materials, or parts of the construction are causing the things described by surf schools to happen.

Water absorption

The ultimate reason for why boards get thrown away is that they get heavier. Surf schools mention the reason for that to be that the core (EPS) of the boards absorb water once they start leaking. Studies have also shown that EPS does indeed absorb water through capillary action due to the voids between the closed cells in the foam (Gnip et al., 2006). However, the results from these tests are given in increased volume percentage, and were not done with salt water.

I conducted some material tests myself to see how much the weight of the foam increases from water intake, and to simulate an environment closer to that of the ocean.

Blocks of identical dimensions were cut from EPS with two different densities. For each density, two tests were done by exposing one side of the block to water over a period of 12 days. The tests were done with tap water with a 3.5% salt (weight percentage of salt in seawater), in similarly sized containers.

The results are shown in figure 16. Both densities absorbed the same amount of water, which already stagnated after day 6 of the experiment. For the lighter samples, this meant an increase of 33.3% of its original weight, and for the heavier sample an increase of 15.4%. It's safe to conclude from this test that EPS does indeed absorb water. However, to investigate exactly how much water would be absorbed in a use context, further research would have to be done. Factors that could also play a role are temperature changes (air pressure in foam becoming lower when moved from warm to cold), and pressure on the foam from the outside.

This result has implications for the design of the boards. It means that the core is actually the root of the problem, but there are different approaches to tackling this problem. A core made of a different material could prevent the board from absorbing water. Good repairs by resealing the outer layer in a professional manner, or being able to remove water from the core, are also solutions. These directions will be explored further later in the report.

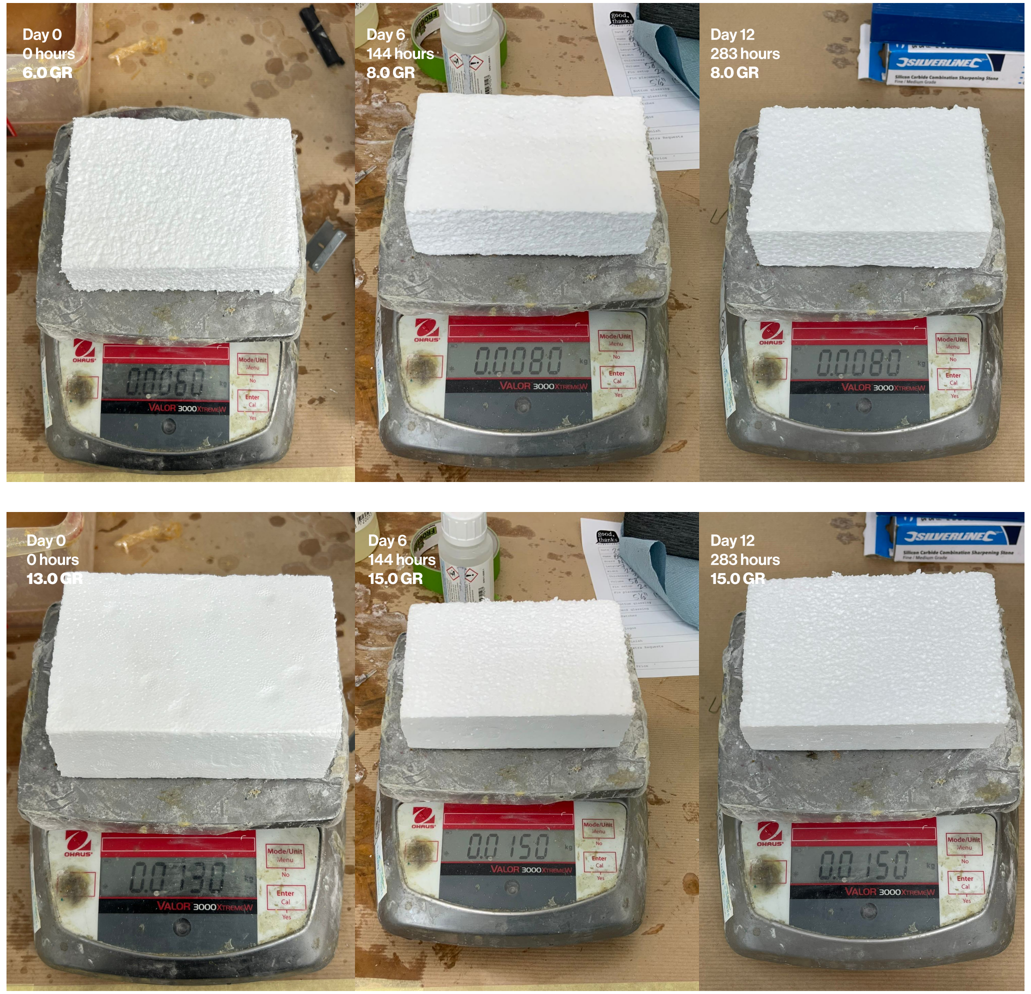
Conclusion 2.2

- The outside layer of boards breaks, after which the EPS **absorbs water**. Boards get heavier this way, and surf performance decreases.
- Boards are currently repaired using **permanent adhesives**, limiting other recovery methods even further. Repairs also **lower the visual quality** of boards.
- Materials and bonding methods currently used in softtop construction make **recycling virtually impossible.**

Figure 16 - EPS material tests

EPS 60
Density - 15 kg/m3

EPS 200/250
Density - 32 kg/m3



2.8 Value chain map

RQ 1.5
What does the **value chain** of surfboards currently look like?

RQ 1.6
What and where are the different forms of **value loss** currently existent in the value chain?

We have now identified some of the mechanisms that cause Vision softtops to fail. For the development of an alternative business model for surf schools, it is also interesting to see where most of these mechanisms take place in the value chain. Figure 17 on the next two pages shows a visual of the current linear value chain of Vision softtops. Shown above the value chain are ways in which value is lost, above the corresponding stage of its lifecycle.
It is quite clear that most value is lost during the use phase of the lifecycle. Boards break during use, and because there are no fitting repair tools, degradation of the boards happens quite quickly. Also, there are not really any recovery strategies in place to save the material value that is still in the boards. A small amount of the boards are resold to beginning surfers, but they often lack the knowledge on how to repair the softtops. These insights can be used as a base for the development of the business model. It shows where the potential for business opportunity lies, which will be explored later in this report.

Conclusion 1.5
- The value chain is currently a linear one. The only circular mechanisms that are currently in place are the repairs surf schools do themselves, and the resale of boards that still have some value left.

Conclusion 1.6
- By far the most value is lost during the use phase of softtops. This is because boards break quickly during this stage, and because of a lack of fitting repair methods.
- The use phase is an interesting place to start exploring circular business models and new value propositions.

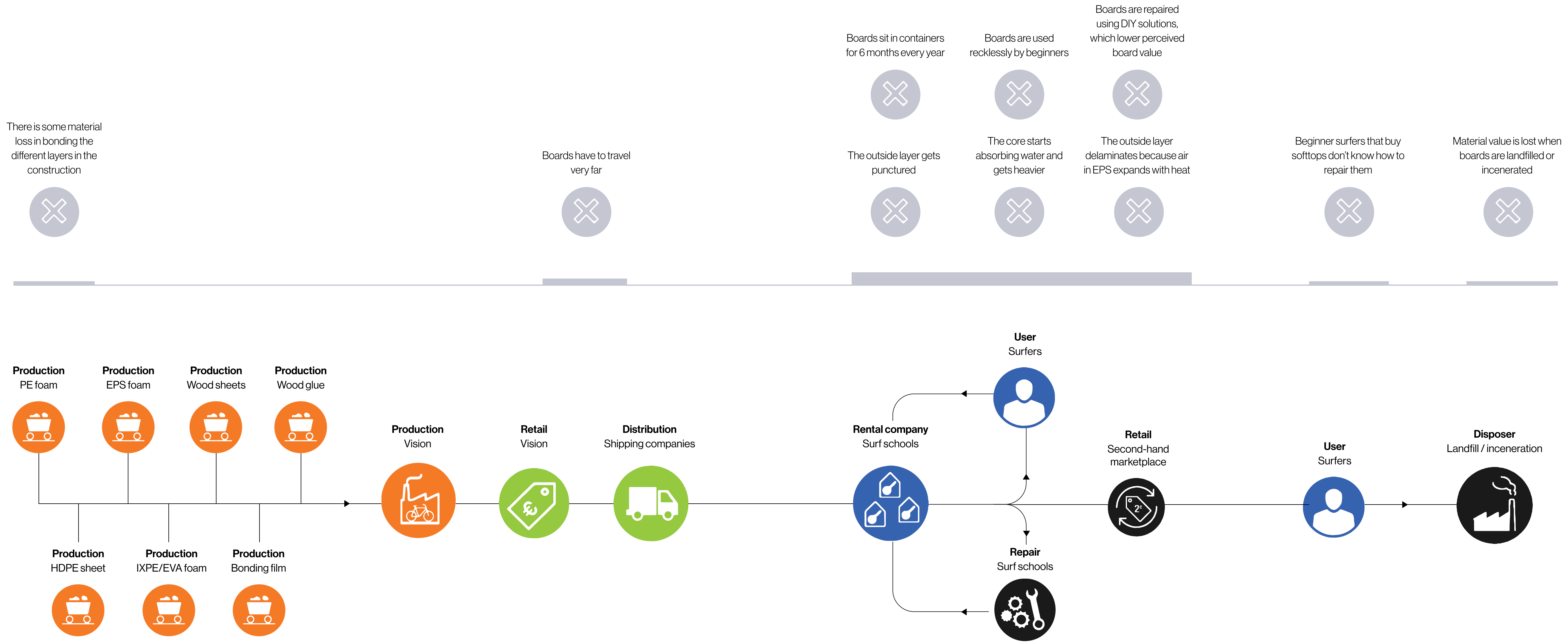
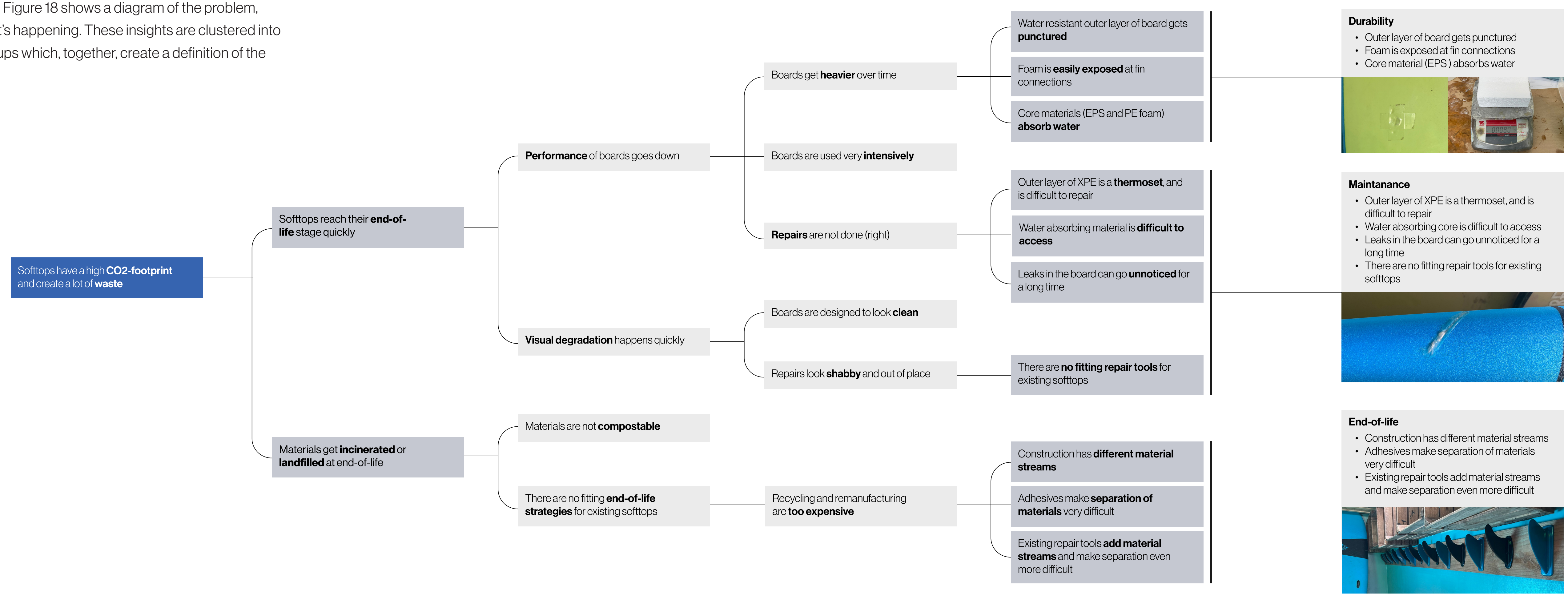


Figure 17 - Value chain map

2.9 Key findings

This chapter took a deep dive into the world of surfboards. Softtops were identified as the most interesting scope for this project, and the construction and performance of the most used softtop were analysed. To create a strong base for the ideation design process, it is important to define the core of the problem, and what is causing it. When we peel off the layers of what is happening, we find out what the real reason is for why softtops are currently not in line with the circular economy. Figure 18 shows a diagram of the problem, and why it's happening. These insights are clustered into three groups which, together, create a definition of the problem.

Figure 18 - Problem definition diagram

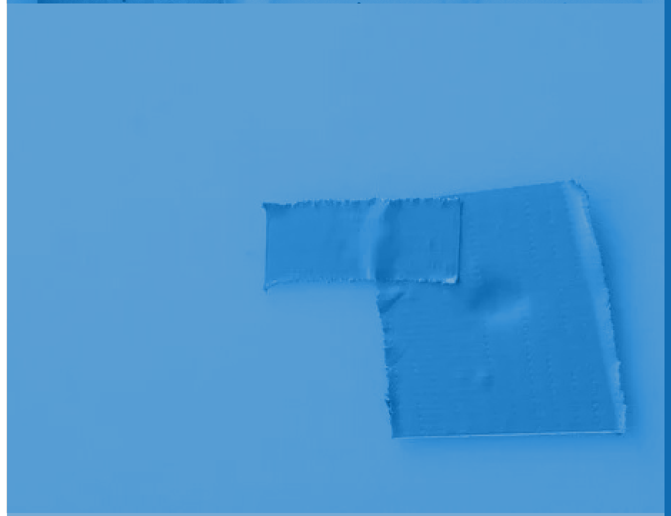


2.10 Design directions

> **RQ 2.3**
> What **product design strategies** are most applicable for the circular business model?

The clusters from the problem definition give a clear overview of which areas of the softtops can be improved. To give the design process some structure, these clusters were translated into design directions. The directions are based on the circular design strategies, defined by Bakker et. al. in the book 'Products That Last' (2019). The different directions vary in terms of their product integrity, which means they can still apply to a variety of circular business models. They are explored through a number of design sprints, after which they are used to develop and propose a circular business model.

> **Conclusion 2.3**
> - The circular business model has yet to be defined. However, three design strategies were defined, corresponding with design for **durability**, design for **repair** and design for **modularity**.



1 More durable softtop

This strategy is the most traditional form of sustainable product design, and is suitable for many different business models. Based on the insights from the analysis there are some new strategies that could be explored. Some questions that serve as a starting point for the ideation phase are:

1. How can we make the core with a material that doesn't absorb water?
2. How can we make the outer shell removable, so that the core can be dried or drained when it absorbs water?
3. How can we make the outer shell a membrane that is able to resist water, but can let water vapour escape?
4. Is there something psychological about the boards being perceived as becoming too heavy (when they're actually not) that can be avoided?

2 Repairable softtop

This strategy could be a very valuable one in combination with a business model where surf schools don't take ownership of the boards anymore. However, it could maybe also be applied to the current construction of softtops and wouldn't require a full redesign of the construction. It uses the power of the inner circle (Ellen Macarthur Foundation, 2013), by keeping the product intact at a relatively high level in the value chain.

1. How could we make standardized cuts from the outer layer, while keeping the core of the boards intact?
2. How can we repair the boards in a way that doesn't harm the perceived value, and maybe even adds to it?
3. How could we reconfigure materials in the outside layer, so that it only consists of reshapable materials (eliminating the need for adding new materials)?
4. How can we transfer knowledge on repairs to surf schools, and can it even be passed on to surfers through them?

3 Modular softtop

This strategy is mainly focussed on end-of-life scenario's (refurbishing, remanufacturing, recycling), and is also suitable for a business model with alternative ownership. Surfboards are big, and it's currently not possible to only replace part of the board when it breaks somewhere. This direction would look into ways to add modularity to the construction, and making it easier to reuse materials efficiently.

1. How can the board be broken up into smaller pieces without compromising structural integrity and flex?
2. How can modular pieces be connected mechanically, while still maintaining ease-of-use?
3. How can modularity also add customizability and adaptability, to also add value for surf schools?
4. How can ease of disassembly make recycling more feasible?

Design

Design exploration

The first part of this chapter diverges into the three different design directions. Each direction is explored individually, by creating and prototyping different ideas that could help achieve the design goal. What are the possibilities and how can we create valuable solutions with what we already know? These things help narrow down different business opportunities into one circular business model.

Figure 19 -
Prototype of
removable shell

3.1 More durable softtop

As mentioned at the end of the previous chapter, the goal of this strategy is to make the boards last longer by avoiding them absorbing water, and thus becoming heavier. The questions stated served as a starting point for the ideation process.

How might we ...
1 ... make the core with a material that doesn't absorb water?
2 ... make the outer shell removable, so that the core can be dried or drained when it absorbs water?
3 ... make the outer shell a membrane that is able to resist water, but can let water vapour escape?
4 ... avoid the psychological effect of boards becoming too heavy?

Removable shell
The idea behind a removable shell is to allow the core to be dried if it absorbs water. To test the idea, a prototype was made where the outer rail of the board consists of an inflatable tube, which holds a neoprene cover tightly onto the bottom.
The main functions of the outer layer are to ensure safety and to protect the core from denting, which are criteria that the neoprene meets. But the neoprene also adds a bit of stretch, which allows the cover to be removed more easily.

3.2 Repairable softtop

The goal of this strategy is to make boards repairable. The problem with repairing now is that it's very difficult to do without the right knowledge, it adds new unnecessary material, and it diminishes the boards visually. The challenge lies mainly in making repairs accessible and easy-to-use for surf schools themselves. This doesn't necessarily mean an entirely new construction, but it also allows for experimenting with the current construction.

How might we ...
1 ... make standardized cuts from the outer layer, while keeping the core of the boards intact?
2 ... repair the boards in a way that doesn't harm the perceived value, and maybe even adds to it?
3 ... reconfigure materials in the outside layer, so that it only consists of reshapable materials (eliminating the need for adding new materials)?
4 ... transfer knowledge on repairs to surf schools, and can it even be passed on to surfers through them?
5 ... make leaks more visible?

Repair kit
To test whether the current construction could be suitable for a repair strategy, a repair tool was designed and prototyped. The idea of the tool as that it allows the user to create standardized cuts in the outside layer, so that standard replacement patches can be used. The tool has adjustable depth, so that different cuts could be made based on how deep the cut goes into the board. The result did not work very well. The picture shows a cut that was made on a flat part of the deck, but making cuts on the rail using this tool was not possible. It was also a lot more difficult than just using a Stanley knife. However, a similar looking tool that uses heat to cut through the foam could potentially be a good solution.

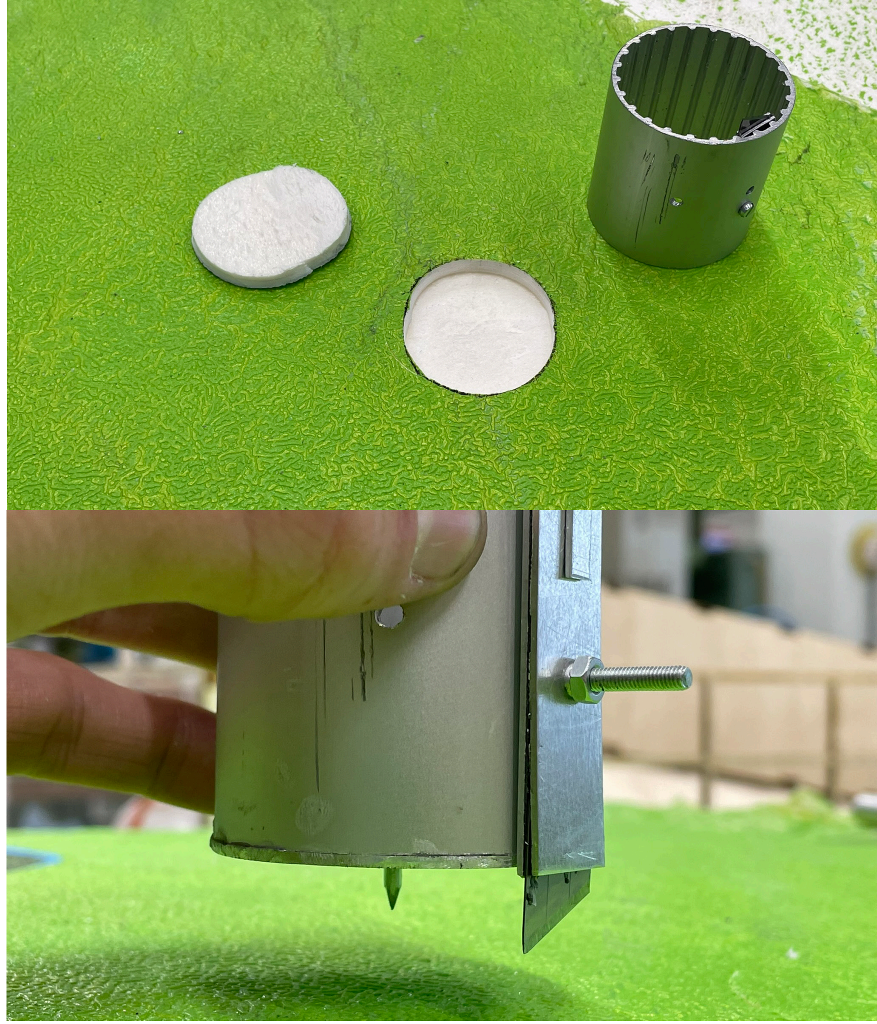


Figure 20 -
Prototype of repair
tool

3.3 Modular softtop

There are many ways to achieve modularity, and this direction explores a few of them.

How might we ...

1 ... break the board up into smaller pieces without compromising structural integrity and flex?

2 ... connect modular pieces mechanically, while still maintaining ease-of-use?

3 ... also add customizability and adaptability to modularity?

4 ... make recycling more feasible with ease of disassembly?

Reversible adhesives

One of the ways to connect different parts of the board in a modular way is by using reversible adhesives. Niaga is a company that produces glue that dissolves under high temperatures, making disassembly easy and ensuring a full recovery of the materials (Niaga, n.d.).

The idea behind this is to divide the board into three longitudinal strips of foam with laminated wooden stringers in between them, which provide stiffness. This way only part of the board has to be replaced in case of severe damage. This construction was tested using a small rocker bench, as shown in figure 21.

Figure 21 - Prototype of glued construction

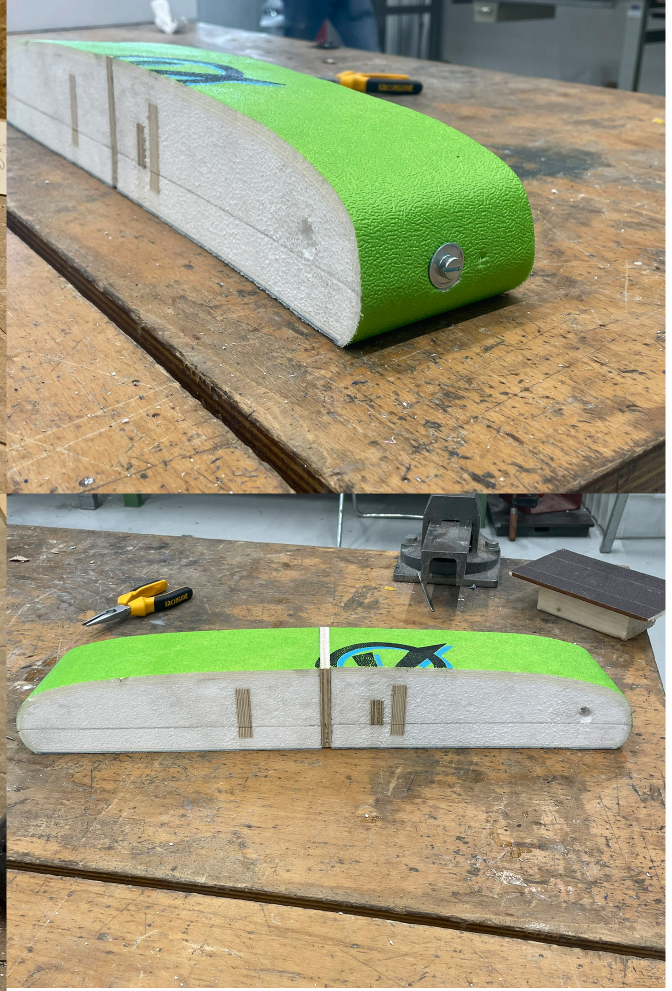


Figure 22 - Prototype of modular structure

Mechanical structure

Another way of achieving modularity is to divide the entire board into similarly produced smaller pieces, that are screwed together. For example, the middle of the board could be made of a strong material (wood or aluminium) to which small side pieces are mounted using a hole that runs through the width. This idea was tested by prototyping a small cross section. The prototype consisted of a centre stringer, and two side pieces (figure 22).

Business model development

Now that we have an understanding of the possibilities within the different design directions, it's time to look at how these could fit into a desirable experience for surf schools and surfers. This part will explore what form of circular business model fits the target group best. Through co-creation with surf schools, specific value propositions are designed and integrated into the business model on a systems level.

3.4 A circular business model

There are different ways and principles that can be used to develop a business model in line with the circular economy. The overarching theme is to always think in systems. On the one hand, there is the reverse flow of materials, which can happen on different product levels. On the other hand, there have to be new (circular) value propositions, which convince users to adopt a new form of consumption model. These things have to be integrated into one business model, which has to ensure the system is a viable one.
There are a few circular business model archetypes, described in the book *Products That Last* (Bakker et. al,. 2020). Based on the ideas generated in the design exploration, three of them could be relevant for softtops, and are explained here.

The classic long life model
This first type of business model is all about durability. It is mostly focused on improving the product, and not so much about adding a service to it. This usually means that the price becomes a bit higher, but customers will not have to change in their user behaviour as much.
In the scope of this project, the Long Life Model is mostly suitable for the *design for durability* direction. Softtops would have to be designed to last as long as possible, in order to gain a competitive advantage.

The Gap Exploiter Model
The Gap Exploiter Model is about utilizing the residual value in products, which others are not able to access. In the case of softtops, it would mean that they could be bought back from surf schools to repair and resell them. Only selling a repair service would also be a possibility.
The *design for repair* and *design for modularity* directions would be most suited for this model. The focus within this model would still be on improving the product, but with a small service in the value proposition.

The Access Model
The Access Model is the most different from the traditional consumption model. Consumers no longer have ownership over the products they use, but pay for access to a product over a certain period of time. The interesting thing about this is that the product supplier suddenly becomes financially dependent on the lifetime of their products, which means product quality becomes a big driver for them.
Within this model, surf schools could pay a yearly fee in exchange for a certain number of boards, with service included. At the end of the season, the boards would be picked up and brought back to the distributor for them to be repaired. Competitive advantage could be created by using all three different design directions.

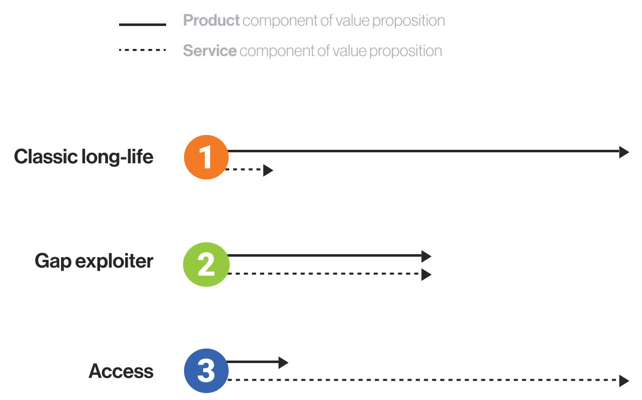


Figure 23 - Focus of value proposition in CBM archetypes

3.5 Co-creating with surf schools

RQ 1.7
What **personal drivers** motivate potential users to choose for a certain surfboard?

During the interviews conducted for the analysis part of this project, the needs and wants of surf schools were already mapped out. Using the *Value Proposition Canvas* developed by Osterwalder et. al. (2014), some ideas for value propositions for the different types of models were developed. These are shown in figure 24. The full canvas and detailed breakdown of the value propositions can be found in Appendix 2.

To gather feedback on these value propositions from potential users, three co-creations were done with different surf schools. These helped discover new value propositions, and evaluate whether surf schools would actually adopt one of these models.

Figure 24 - Value proposition based on analysis

1. Extra **safe** and **longer lasting** softtop, with a 5 year **warranty**
2. Professional softtop **repair service**, that offers a **buy-back** option for softtops
3. Softtop **subscription service**, that always guarantees **quality** softtops and handles all **logistic** around the boards

Goal

To discover and develop new value propositions for surf schools through a circular business model.

Method

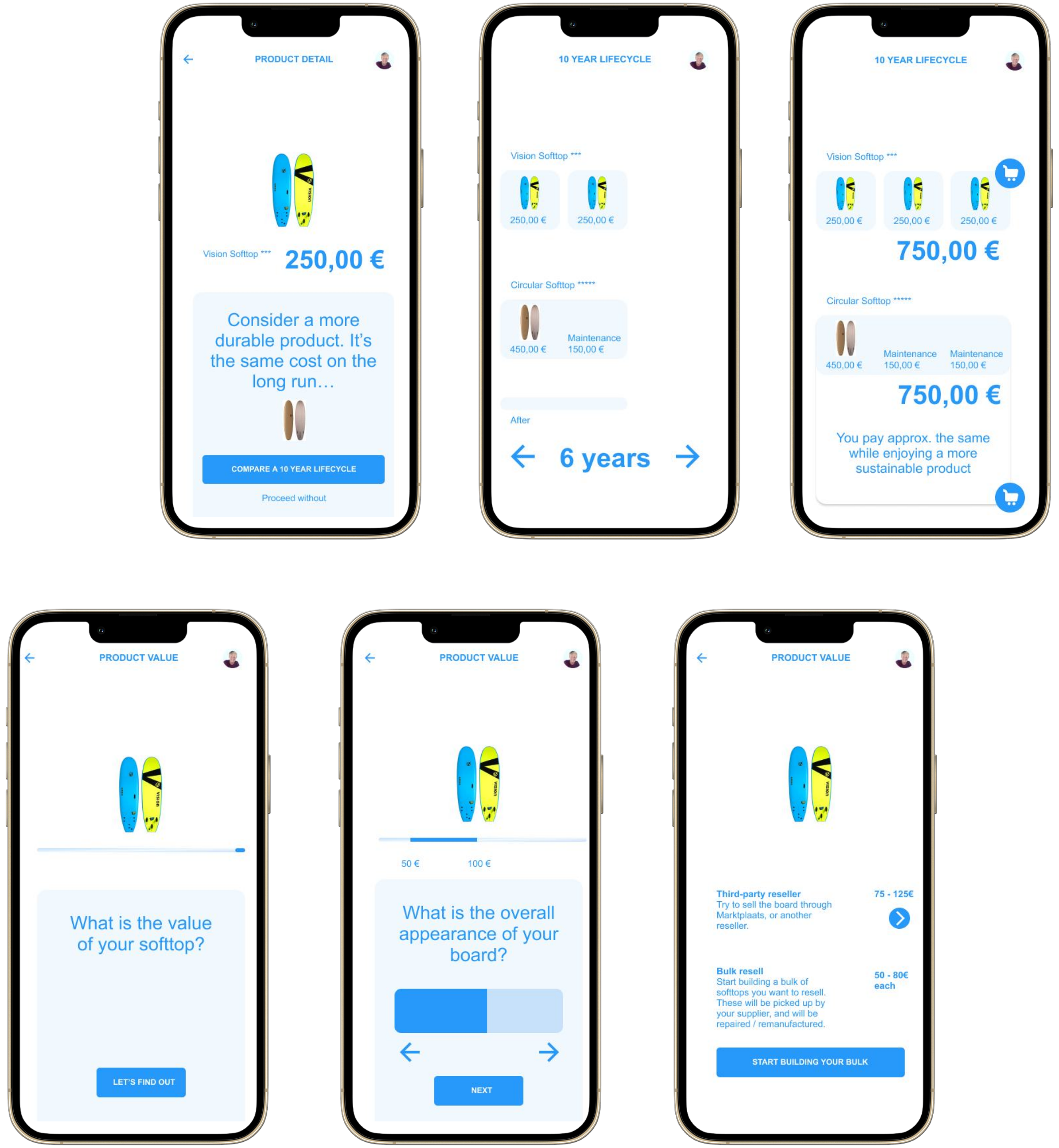
The co-creations were done at a quiet spot within the surf schools, and consisted of an introduction and three short sessions. All participants signed a consent form prior to participating in the co-creation (Appendix 3).

The *first session* took participants through the three different forms of business models, by showing them short written stories. Each story was followed by a semi-structured interview about how they would envision this model, and what factors would drive them to choose for this model or not. The stories and questions can be found in Appendix 3.
The *second session* made participants interact with three basic prototypes, inspired by UX patterns from the Circular Experience Library (Post, n.d.). The prototypes (corresponding with the different models) were very similar in user interface, but probed the participants to provide feedback by showing them how it would work in practice.
The *third session* was used to have an open discussion about the ideal envisioned model of the participants. A visual of a product-service scale with the three business model archetypes was used as a tool for brainstorming new value propositions. This tool is shown with the results on the next page.

During the sessions, data was collected using audio recordings and post-its to cluster the different insights. Feedback on the different models was divided into *pains and gains*, the most important *personal drivers*, and new *value proposition ideas*.

Figure 25 - Co-creation sessions

Figure 26 - Interfaces from UX prototypes



Prototypes

Figure 26 on the left shows a few screenshots of the UX prototypes used during the co-creation. The prototypes took participants through each of the business models by making them interact with realistic information.
For example, the first prototype showed them what a more expensive, but longer lasting softtop would mean financially over a period of 10 years. The second prototype gave an estimation of how much the softtop supplier would be able to give in a buy-back option.
This way, the prototypes probed participants to provide feedback on details, and what they think would be a realistic scenario and why. The complete UX prototypes for each of the models are also shown in Appendix 3.

Results

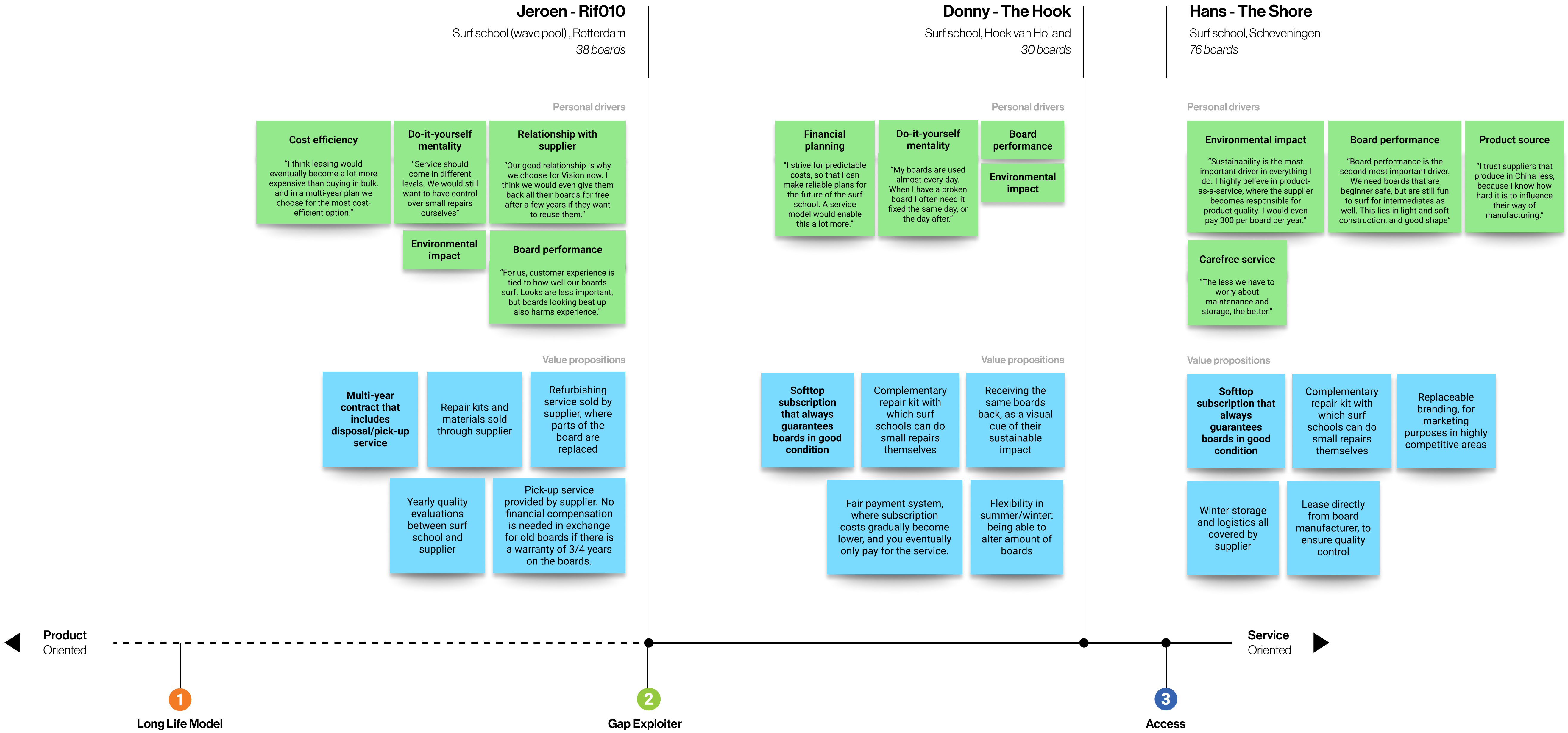
The results from the co-creation are shown in figure 27 on the next pages.
The first part of the figure, the *personal drivers*, contains feedback on the different models and prototypes.
For each surf school, it shows the most important motivations to choose for a certain model, and corresponding quotes from the interviews. One thing that came up with multiple surf schools, is the **quick-fix-mentality** that they have. They are used to having to repair their own boards the same day, because of the demand during the high season. This mentality could be used, as surf schools will be likely to adopt a repair method themselves, when this would be given to them.
Another overlapping theme was the importance of board **quality and performance**. All surf schools mentioned this as one of the most important drivers, as softtops play an important role in providing quality surfing lessons to their customers. Always having to ensure the quality of the boards is the reason why they replace all of them after only a few seasons. A service-based business model opens up great opportunities, as it could take away the worry of degrading board performance. One surf school even mentioned being willing to pay 300 Euro's per year for a board, which is more than the price of a new board for surf schools (around 200-250).
The second part of figure 27 shows the *value propositions* that were co-created with the surf schools.
All participating surf schools found themselves envisioning their ideal business model somewhere between the middle and service-oriented side of the product-service scale. The primary reason they gave for this is that surf schools are not looking to own softtops. They are purely looking for the functionality of being able to provide surfing lessons on them, and that a service-model would guarantee this. As this is only the case for 7 months per year, shifting **ownership** could also take away the financial burden of having to store the boards during the off-season. There was no surf school that saw potential in the long life model, because this is what the system already looks like, and current suppliers are not living up to their promise of improving the longevity of their products.

Key findings

The results from the co-creation have given us some interesting insights. These will be used to develop a proposition for a circular business model for softtops in the next subchapter.

Conclusion 1.7
- The demand during the high season results in a **quick-fix-mentality**
- **Quality and performance** of boards come first, even before environmental impact
- Surf schools are not looking for **ownership**. Shifting to a service model would guarantee quality and performance,

Figure 27 - Results from co-creation



3.6 Softtops-as-a-service

RQ 1.8
What kind of **new value propositions** can be introduced in the business model?

With the results from the co-creation, I developed a vision for the product-service system. Together with the physical design of the softtop, this system is the driving force behind the circular business model. The envisioned business model can be described as follows:

*A **softtop subscription service** that uses the natural rhythm of the surfing seasons to keep a balance between board use - and restoration.*

Rhythmic restoration
There is a natural flow in the way the surf seasons are timed throughout the year. Every surf school has a downtime in winter, during which most softtops are stored away in containers. This time can be used to restore the boards, and take away the costs of storage space for surf schools.

Cascading performance
The current lifecycle of softtops already utilizes the cascading performance needs of its users. Surf schools reach a point where their boards are too worn out for use on a professional level. After this, they sell them to surfers, who demand less from the performance of the softtops. The service integrates these levels of use into one system. If after numerous cycles, refurbishment is not an option anymore, it could still be offered to individual surfers through the same system with a different subscription. Keeping it in the same system can make sure that use rates are still high, and keeps the material loop closed.

Personally tailored
Every surf school has a different mindset on their board maintenance. Lead times for replacements are kept short, but surf schools also receive repair kits through the system if they prefer to do it themselves.

Sustainable learning
By providing surf schools with educational tools on the maintenance of softtops, they can already educate surfers on repairing boards (and the environmental impact that surfboards usually have). This can allow them to charge a bit extra for a surfing lesson.

Conclusion 1.8
- The personal drivers discovered during the co-creations resulted in a **softtop subscription service** for surf schools.
- **Rhythmic restoration** allows boards to be used during the high-season, and restored in the off-season.
- **Cascading performance** makes use of the lower performance demands of individual surfers.
- Subscriptions are **personally tailored** to suit the variations in the way of working of different surf schools.
- Repair **education tools** allow surf schools to include sustainability in their surf lessons.

System design

Now that we have a clear understanding of the business model and new value propositions of softtops-as-a-service, we can start looking at the concept driving this model. What exactly would the system around the model look like, and how is the design of the boards adapted to this system?

3.7 Introducing: Tides

> **RQ 3.1**
> How can the personal drivers of the target group be used to create a **desirable system** around the boards?

Tides is a product-service system for softtop surfboards. It consists of three different recovery strategies, which make smart use of residual value in materials and all have their own touch points in the overarching service system. The name *Tides* is symbolic for the natural flow in the surfing season, which dictates the different recovery strategies. The idea is to make use of this flow, instead of trying to fight its force with expensive measures.
The visual on the right shows a simplified representation of this flow, and division of processes over the lifetime of the softtops. A more detailed explanation of these is given later in this subchapter.

Recovery strategies

It is the natural flow of the surfing season that dictates the different recovery strategies, which is why these are based on the characteristics of each touchpoint. During the ebbing tide, the use rate of boards is high and downtimes cannot be long, whereas during the rising tide, boards are not used. Figure 29 on the next page contains a complete overview of the different recovery strategies, and at what touchpoints they are implemented in the system.

Figure 28 - Use flow in product-service system

What? **Different levels of interventions**
Each failure category comes with a suitable recovery intervention, corresponding with the value of the board and remaining potential in materials.

Why? **Categorising types of failure**
Although boards are put under extremely variable use scenario's, the different types of board failures can be divided into three categories. These categories, based on board condition, help determine the right level of recovery for every board throughout its lifecycle.

When? **Finding the right touchpoints**
The recovery strategies are based on use demand during the flow of the seasons. This is why each strategy has corresponding periods of implementation during the lifetime of the softtops.

Who? **Stakeholders involved in each intervention**
Who has responsibility over each failure situation is an important aspect of the success of the system. Surf schools want to have control over their board supply, but are paying for a service and might also harm board integrity. As restoration becomes more complex, this responsibility shifts from consumer to supplier.

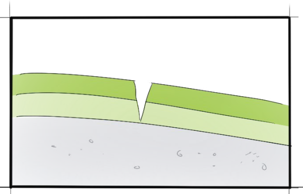
Figure 29 - Overview of the product-service system

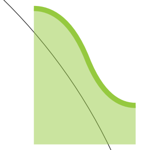
1

Repair

Prevent further damage
This intervention is a temporary solution. It is about making the boards last until the end of the season without them deteriorating further. The focus here is to not hide these temporary solutions, but embrace them as something that adds aesthetic.

- Outer shell is **ripped**
- Damage is within **limit of repair patches**
- Board is still **surfable**, but is absorbing water





Ebbing tide
The *Repair* strategy is used during the entire surfing season, when boards are used intensively

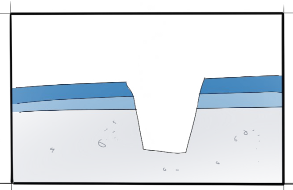
Surf schools + Surfers
Surf schools and surfers who lease the boards do repairs themselves, using a repair kit. A repair learning tool can be used for first-time users.

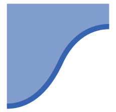
2

Repair +

Restore from small damage
These repairs are meant to restore the boards permanently in a professional manner, without compromising the possibility for refurbishing

- Outer shell is **ripped**
- Damage is larger than **standard patches**
- Board is **surfable**, but **visibly run-down**





Rising tide
The *Repair+* strategy is used during every off-season, when boards are not used. It is also used during the ebbing tide when board are too damaged to use repair patches.

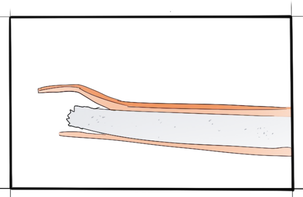
Surf schools + Manufacturer
Repairs that fall under this category are done using more advanced tools and are usually done by the manufacturer. However, surf schools that really want to do it themselves can get the materials and instructions on how to do so.

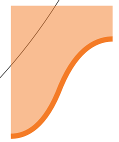
3

Refurbish

Restore from severe damage
Refurbishing is done when boards are not repairable within the limits of the material, or when it becomes cheaper to do than repair. This is the case with big delaminations for example. Certain damaged materials and parts of the board get stripped and replaced.

- Outer shell is **delaminating** over a large surface area
- Core is **damaged and rotting**
- Board has become notably **heavier** from absorbed water
- Board is **not surfable** anymore





Rising spring tide
The *Refurbishing* strategy is used around every 2nd or 3d season, when many repairs have been done.

Manufacturer
Refurbishing is always done by the manufacturer, as draining the boards takes time and reskinning is a difficult process.

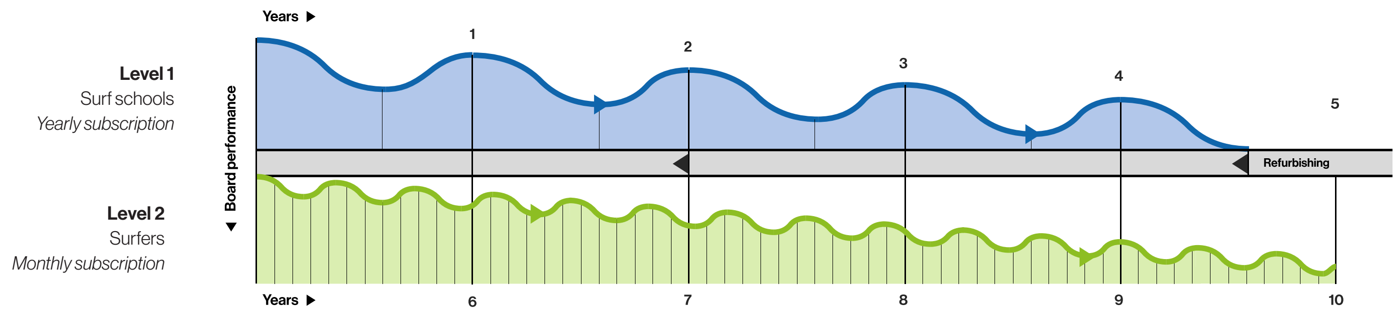
Subscriptions

Tides makes use of the cascading performance requirements of softtops, by implementing two subscription levels. One is targeted towards surf schools, who have high demands of softtop performance, while the other focusses on individual surfers, who demand a lot less of the boards.

In the first level, boards are offered to surf schools through a yearly lease. They use them during the high-season (April - October), after which they are taken away and repaired. This is done for a minimum of 5 years. When the outer shell of boards has been repaired so much that it starts lowering the performance too much, the boards are refurbished and make the transition to the second subscription level.

The second subscription level is for individual surfers, who can lease the boards by the month. Within this level, the boards are not repaired periodically, but only when a board is not usable anymore (with *Repair* patches), or when it switches between users. After the boards have transitioned from level 1 to level 2, they are used by individual surfers until they can not be repaired or refurbished anymore. The materials in the boards that still hold value at this point are used for repairs on other boards, and the rest of the material is discarded.

Figure 30 -
Subscription levels



Product journey
The current linear lifecycle of Vision softtops was discussed in the Analysis chapter, but is shown again in a simplified form in figure 31. The figure next to that shows the circular product lifecycle of the system.
It contains one full-year cycle for two different subscription forms: surf schools and surfers. It also shows where in the product journey the different recovery strategies are implemented, and a rough estimate of the proportion of the board flow in each recovery strategy.

Conclusion 3.1
- **Tides** is a product-service system, through which softtops can be accessed by surf schools and surfers.
- Softtops are restored through three different **recovery strategies**, which are strategically timed so that surf schools can always have working boards during their high-season.
- Two **subscription levels** offer a tailored experience between surf schools and surfers, based on performance requirements.

Figure 31 - Old linear lifecycle

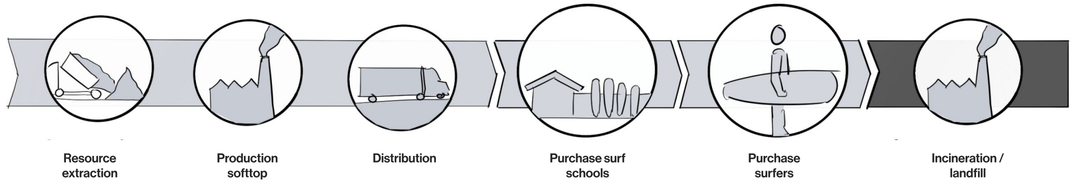
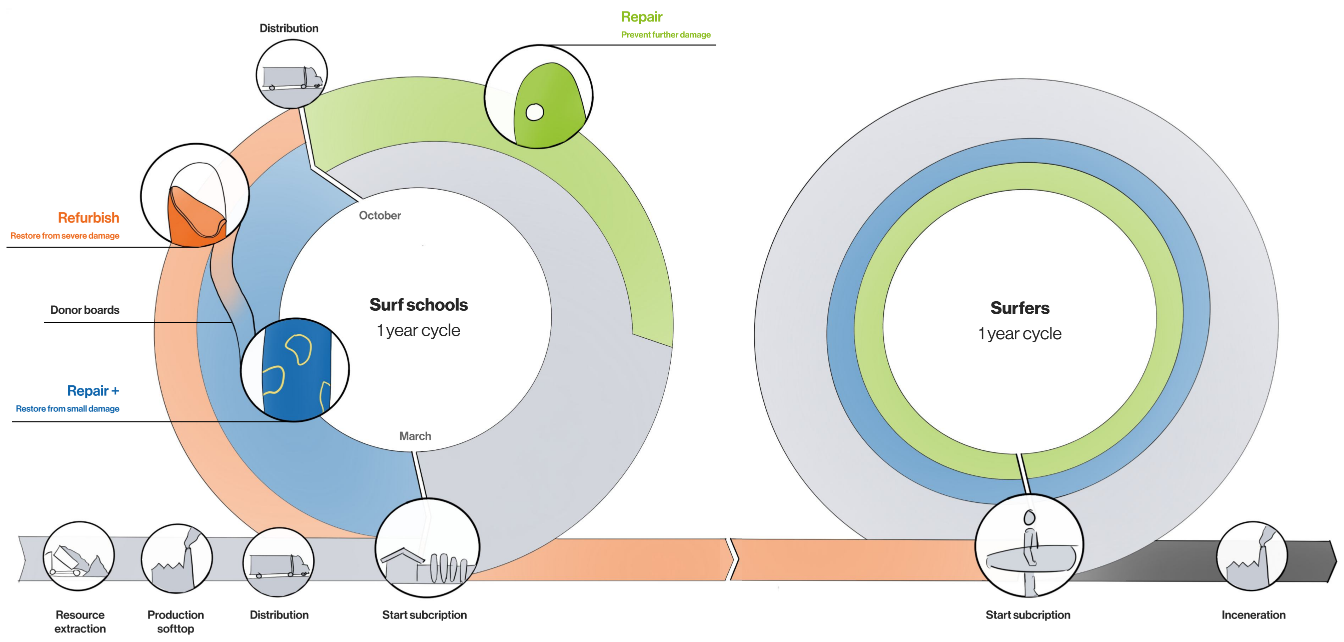


Figure 32 - New circular lifecycle



Product design

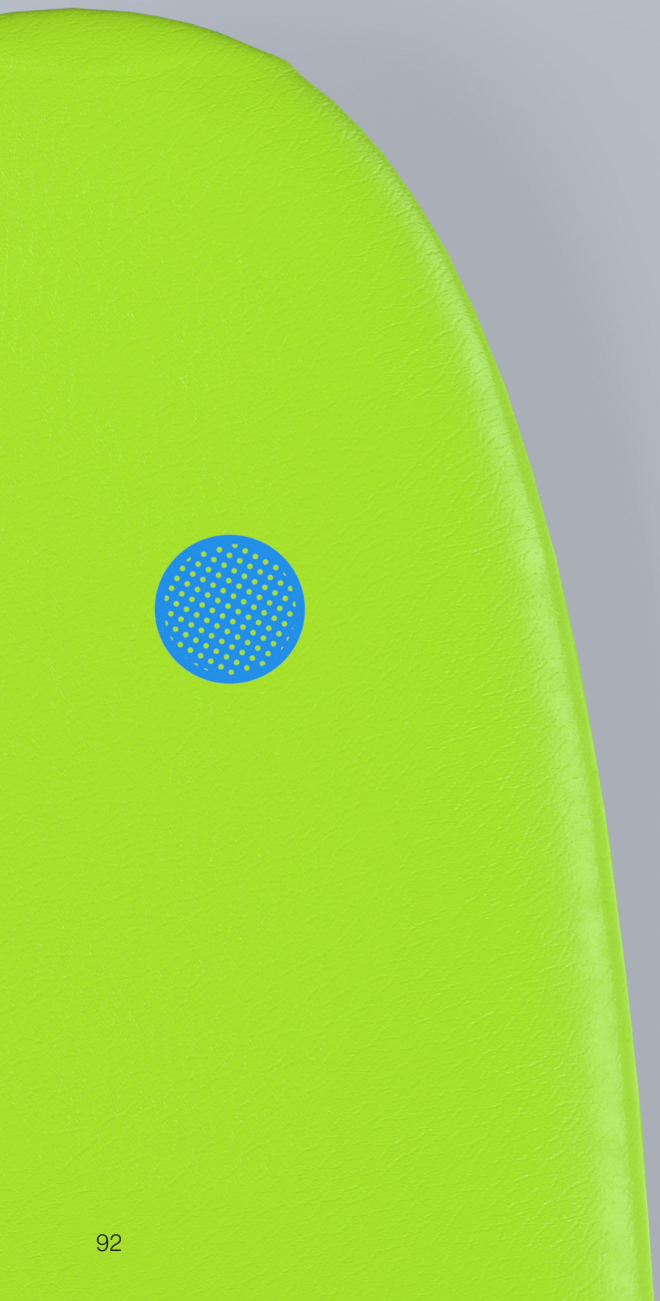
The previous part explained the design of the system, using which Softtops-as-a-service can be realised through a desirable user experience. This part looks at the product design side of the project. How do the recovery strategies work exactly, and how would the current design of softtops need to be modified to fit these strategies?

3.10 Recovery strategies

> **RQ 3.2**
> In what ways is the desired system **manifested**?

Tides makes use of three different recovery strategies. The points at which they are implemented and aim of each strategy is different, which is why their degrees of intervention differ from each other. Over the next few pages, the goal of each recovery strategy - and how this goal is achieved - is explained.

As developing every recovery strategy into a technical proof of concept was too large of a scope for this as a graduation project, only one was worked out into detail. *Repair* is the first step towards a functioning circular business model, which is why this strategy was worked out into a working proof of concept. Chapter 3.13 shows the *Repair* concept through working prototypes and process visuals, forming a base for the other recovery strategies to be developed further.
The other strategies were also conceptualised and prototyped, but not into a working proof of concept. They are shown in more detail in Appendix 6 and 7.



How it's done

The *Repair* recovery strategy is designed to temporarily seal the boards, so that they can still be used for the remainder of the surfing season. This is to prevent small cuts and damages, which make up for a large part of all failures, from making the core absorb water.
Repair is done by replacing damaged foam with standard pre-manufactured foam sealing patches. The patches are designed to fit in with the aesthetic of the existing softtop, but also to not hide the fact that it's a repair.
The design of the patches was inspired by *Kintsugi* and *Sashiko*, which are Japanese mending practices that use repairs as something that adds value, instead of the other way around. Another important characteristic is that the patches don't harm the softtop performance or safety. This is why the patches on the top are grippy and soft, and on the bottom they provide a very smooth surface.
The installation of the patches can quickly be done using basic tools and the patches are made to be watertight, no matter the skill of the person installing them. How exactly these things are incorporated into the technical design of the patches is explained in chapter 3.10.

Temporary repair patches

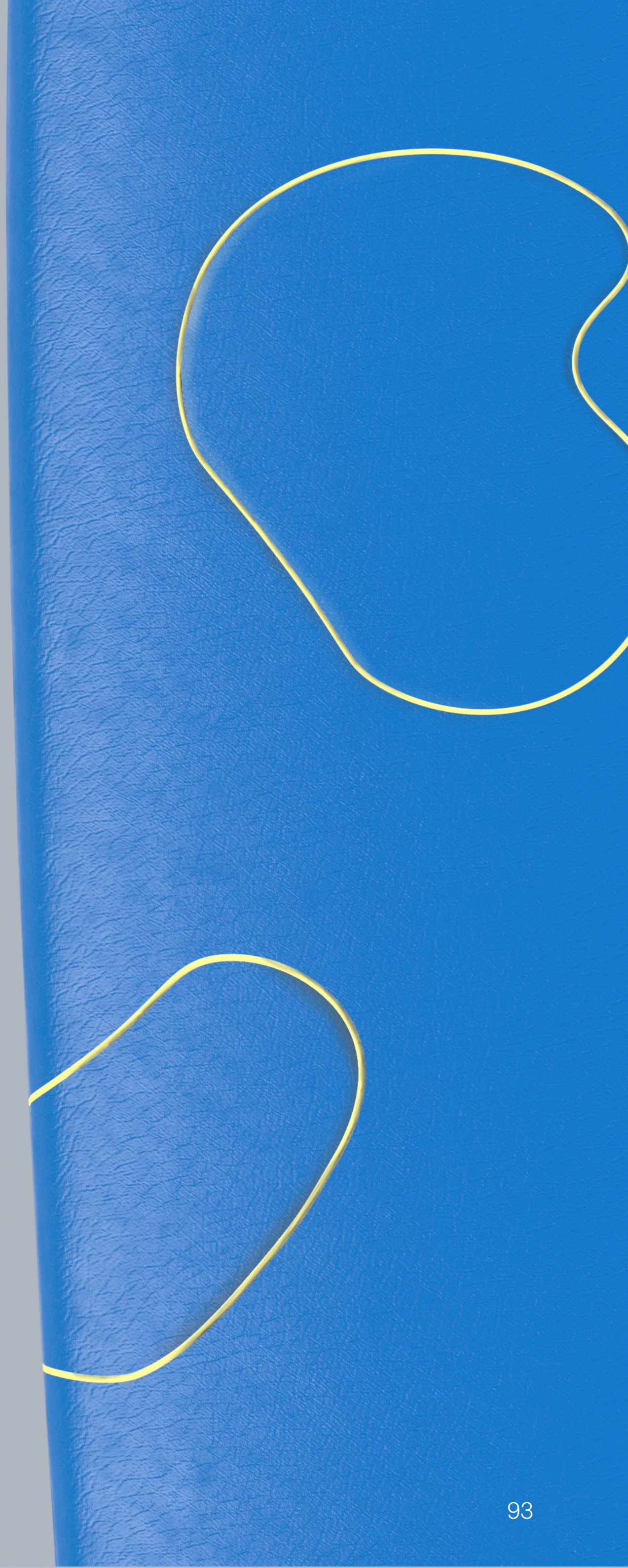
REPAIR

How it's done

The *Repair+* strategy is used to repair damages exceeding the patch limits, and to repair everything in a professional manner at the end of the season (rising tide). This is done by removing foam that is damaged, and then removing a part at the tail so that most of the water in the board can leak out by using gravity. Only damaged foam is replaced and resealed using tools that enable a semi-industrial process and make the results more smooth. Important factors in this are the aesthetics and sense of trustworthiness of the repairs for users. Similar to the idea of the pre-made foam patches, is embracing the repairs as something that can add value.
How this process is done exactly is not fully developed yet. However, the development of the concept so far and latest prototypes are shown in Appendix 6.

Professional foam replacement

REPAIR+



How it's done

The *Refurbish* strategy is done at a point where boards would normally be landfilled or incinerated. Its most important feature is removing the water from the core. This is done by removing the skin of the board and letting the water evaporate from its core. After this, boards are checked for their foam integrity and are either re-skinned, or finally recycled if the core is too damaged.
The removed foam from the re-skinning process is used as donor material for the *Repair+* strategy. As much material as possible is reused this way, and only truly damaged foam is recycled.

> **Conclusion 3.2**
> - **Repair** is the first recovery strategy, which is used to temporarily fix softtops so that they can stay in use until the end of the high-season.
> - **Repair+** is used during the off-season, to professionally restore the boards while reusing as much material as possible.
> - **Refurbish** is the final strategy, and is used when boards can't be repaired anymore without seriously lowering performance. Old skins from refurbishing are used in Repair+.

Complete drying and reskinning

REFURBISH

3.11 Design criteria

> **RQ 2.4**
> What **requirements** do boards have to fulfil to fit the circular business model?

To test the final concept on its desirability and feasibility, a list of requirements was compiled. This list consists of performance requirements, which are based on the performance of current softtops, as well as requirements resulting from the design interventions (recovery strategies). Some of the performance requirements (strength, fracture toughness, shock absorbance) have yet to be quantified, but this did not fit within the time scope of this project. This should be done after prototyping and testing the new construction design, to validate the results.

Category		Requirement
1 **Safety**	1	Board should have good **shock absorption**
	2	Board should not have any **sharp parts**
	3	Board should have a **maximum weight** of 10 kg
2 **Surf quality**	1	Board should have **continuous rocker** in the nose and be **flat** throughout the rest of the board
	2	Board should have good **buoyancy** (maximum weight-to-volume ratio of X kg /L)
	3	Board should have low **sliding friction** on the bottom
	4	Board should have good **traction** on the upper surface
3 **Durability**	1	Board should have good **strength** over the length of the board
	2	Boards should have good **fracture toughness**
	3	Boards should have good **shock absorption / impact resistance** in outer layer
	4	Boards should have good **resistance to wear**
	5	Boards should be **resistant to temperatures** of up to 60 degrees C
	6	Outer shell of board should be **water resistant**

Table 2 - Performance criteria

Table 3 - Design intervention criteria

Category		Requirement
4 **Repair**	1	Repairs should (re)create a **watertight seal** in the outer layer of boards
	2	Boards should be repaired while maintaining their **level of modularity**
	3	Repairs should be **accessible** within 1 day
	4	Repairs should be possible to do **individually**
	5	Repairs should be possible to do within **15 minutes** for first time users with instructions
	6	Repairs should be possible to do within **5 minutes** for experienced users
	7	Repairs should be done **without expensive tools** (exceeding 20 euros)
	8	Repair materials should come with a clear **manual** to teach the process
	9	Repairs should be **visually appealing**
	10	Repairs should create **sense of trust** in repair with user
	11	Repairs should last a minimum of **1 surf season** (7 months)
	12	Repairs on deck should be **soft**
	13	Repairs on deck should have **good traction**
	14	Repairs on bottom should be **slick** and **level with the surface**
	15	Repairs should **visually indicate** when water gets into repair
5 **Repair+**	1	Repairs should **restore board weight back to original** by draining excess moisture
	2	Repairs should **reshape core** to its original shape
	3	Repairs should (re)create a **watertight seal** in the outer layer of boards
	4	Repairs should not add **new permanent materials** to construction, that cannot be separated
	5	Repairs should have a standard **lifetime** of at least **5 years** under surf school use
	6	Repairs should be **visually appealing**
	7	Repairs should be done with the **same material** as the initial construction
6 **Refurbish**	1	Materials in construction should be laminated **without irreversible adhesives**
	2	Water in board should be **removable** within 1 month
	3	Re-laminating boards should bring them back to the **initial shape**
	4	Removing old skin should be done in a way that **preserves old usable foam**

Conclusion 2.4

- A list of **performance** requirements was developed, based on current use of softtops.
- A list of requirements for every **recovery strategy** is a result of the new product-service system.

3.12 Construction design

RQ 2.5
What could be an **alternative construction** that fits these requirements?

The current construction design of Vision softtops was discussed in the Analysis part of this report, and was used to ideate and prototype the three recovery strategies. However, not all Vision constructions are the same. This made it challenging to design something that fits all currently existing softtops, and something that might still have delivered unwanted results. This is why the concept also proposes a construction design that suits all recovery strategies. This construction design is based on the current design of Vision softtops but also proposes some new features, enhancing the recovery processes.

Double foam layer
The older Vision boards make use of a multi-layer construction, where a thin and tough outside layer is backed with a few layers of backing foam to prevent the EPS from denting. On the newer boards there is only one layer of foam, presumably to cut on production costs. The concept makes use of a two-layer construction, with a tough outside layer and a softer inside layer. This inside layer is also used to heat bond the layers to the EPS core. The aim of this construction method is to allow for easier and more fool-proof repair. The two heat bonded layers are separable, making it easier to make strong watertight seals by overlapping foam replacement patches. This will be shown in more detail in chapter 3.13

Modular tail block
The boards contain a modular tail block, made of extra tough foam. Removing the tail block allows us to drain of used softtops also showed a big concentration of water in the EPS and wooden stringer. This is shown in Appendix 7.
The tailblock is now screwed onto plastic inserts that are attached to the main body. For future development, testing with hollow aluminium stringers will be done. These stringers could be used to screw the tailblock to, as well as to pull the water out of the EPS by attaching a pump to the bottom. This could speed up the process, as opposed to letting gravity do the work.

Fin inserts
A problem that was encountered many times during the project, was the EPS absorbing water through the fin screw holes. In the new construction, round tube inserts will be installed to stop this from happening.

Conclusion 2.5
- A new concept for a **softtop construction** was designed, based on the requirements from the product-service system.
- A **double foam layer** enables easy and trustworthy temporary repairs.
- A **modular tailblock** allows water to be removed from the board during recovery.
- **Fin inserts** minimize water absorption from the fin connections.

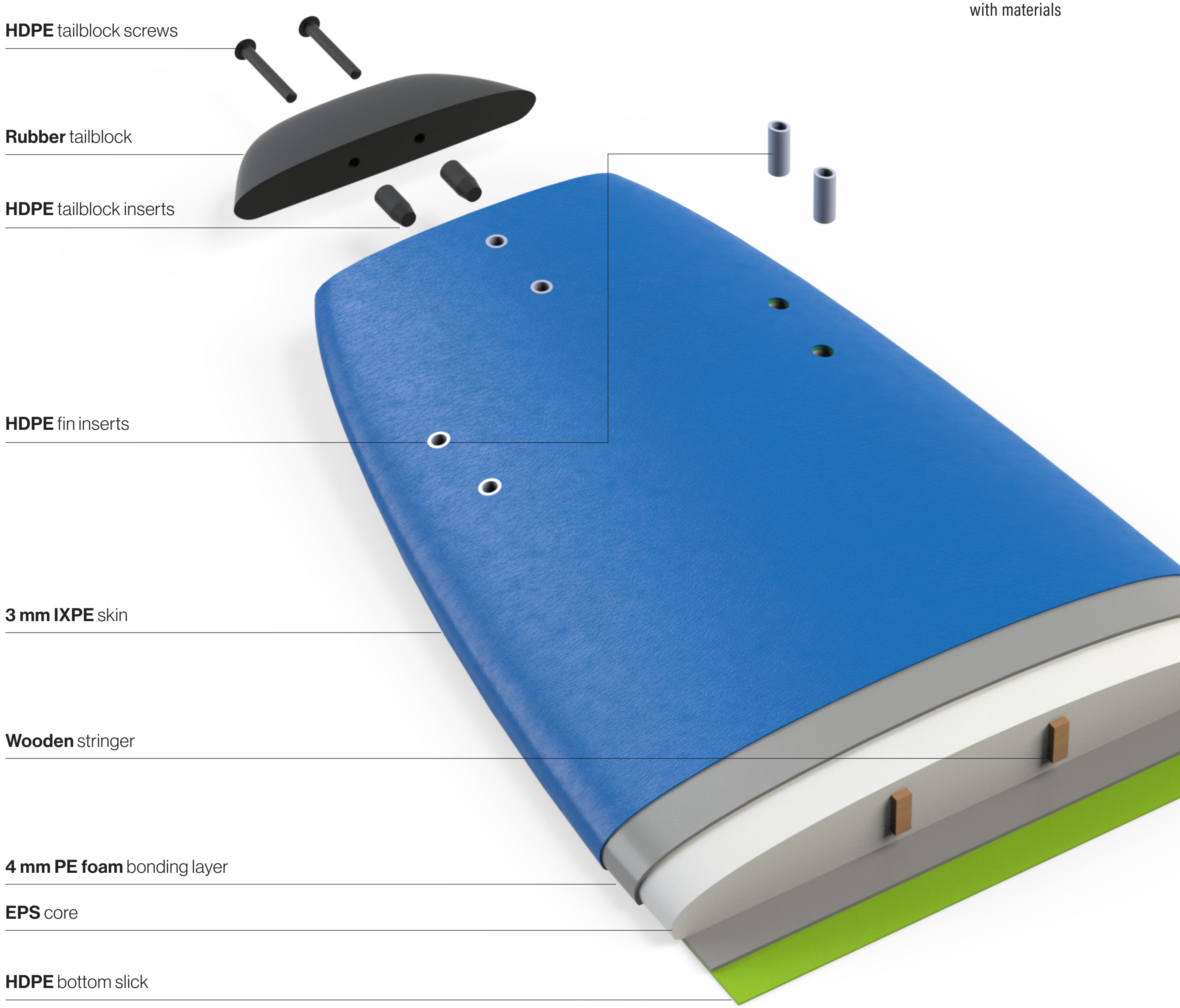


Figure 33 - New construction design with materials

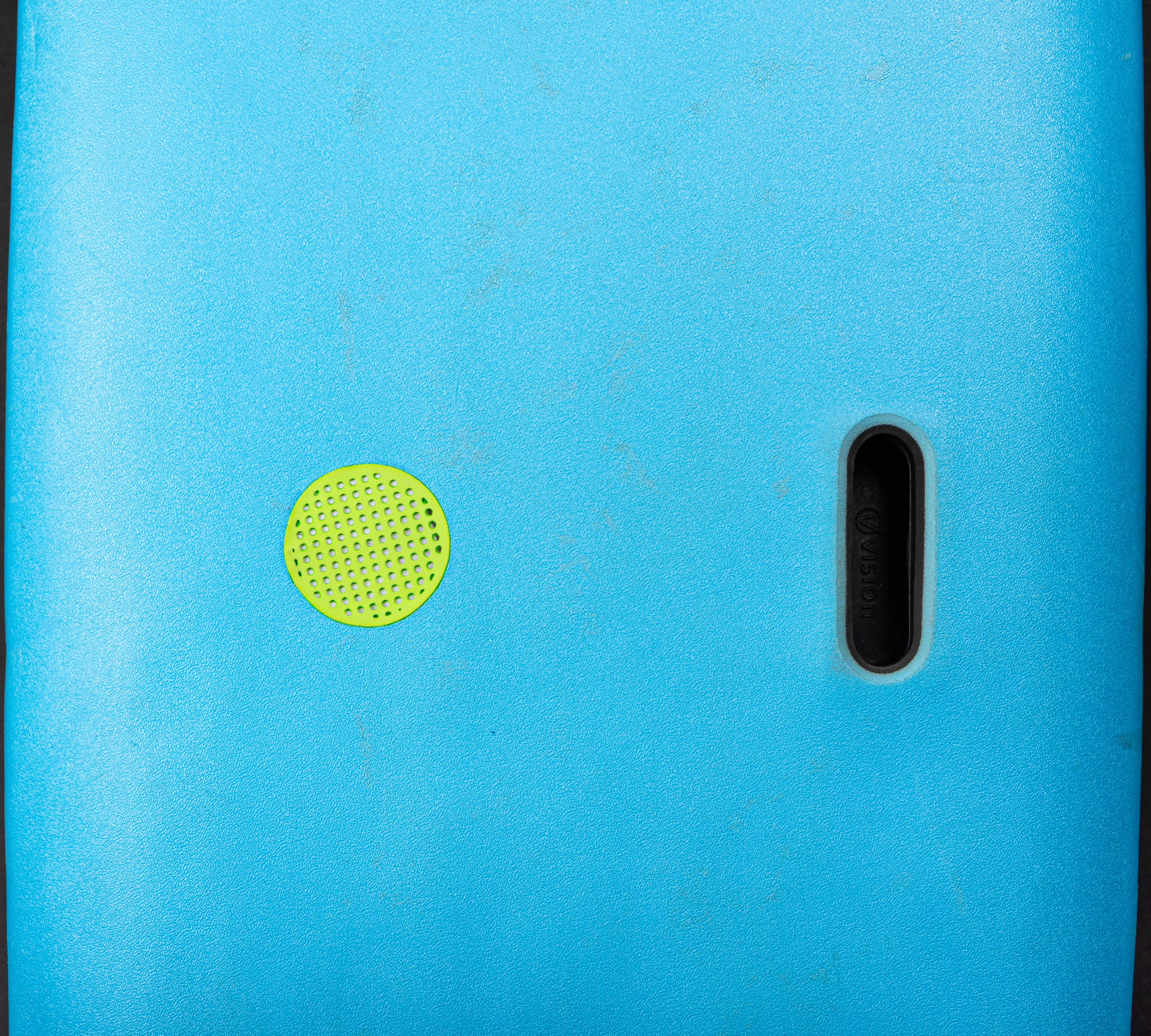
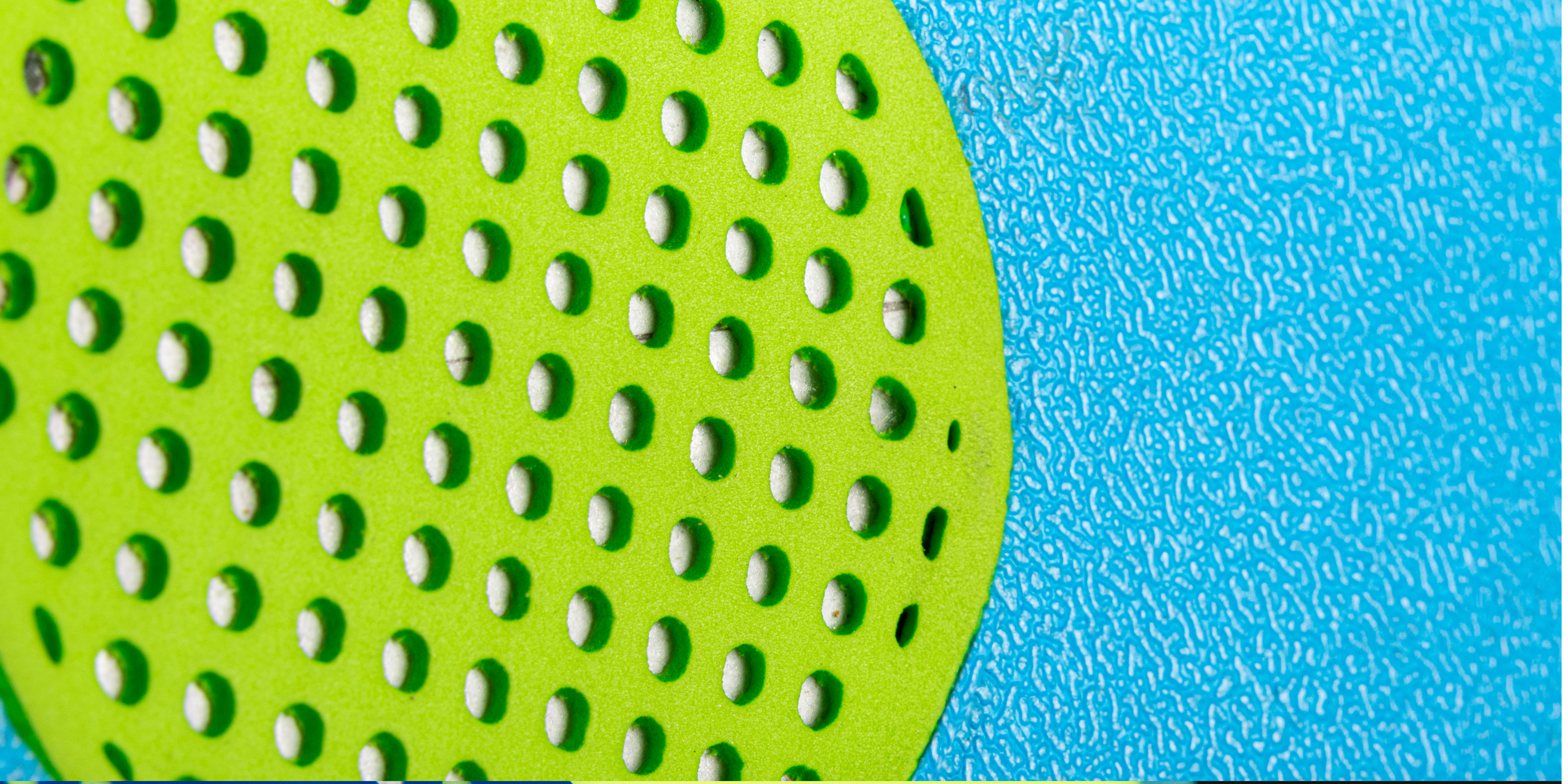


Figure 34 - Prototype of *Repair* concept on an existing Vision softtop

3.13 Repair

RQ 3.2
In what ways is the desired system **manifested**?

Repair is the first step in the realisation of *Tides* as a product-as-a-service system. If surf schools would continue to repair boards the way they do now (with an abundance of adhesives), the *Repair+* and *Refurbish* processes would become a lot more difficult. This is why the project focused on developing a technical proof of concept for the first recovery strategy: temporary repair patches.



Design

Repair patches are pre-made foam - and vinyl stickers, with which surf schools can temporarily fix their boards to keep them in the water during the high season. The patches are designed to fit the aesthetic of the boards, by using materials with a similar look and feel as the existing materials in the boards. However, the playful patterns and contrasting but fitting colours give an extra aesthetic to the patches. They don't hide the fact that the boards have been damaged, but rather embrace it.
A dotted pattern was used for this batch of repair patches, but patterns can be customized based on the requested design and the amount of necessary patches. For instance, surf schools could get customized patches with their logo in them. Some variation in past prototypes is shown in Appendix 5.

Water indication

The reason why the patches are semi-transparent is that they are also an indicator for water intake. This is so that users can easily see when patches start to leak again, but also as a way of creating insurance for the supplier. It enables them take measures if users have not installed the patches right, or become negligent in swapping them when needed. The supplier could change the subscription price based on damage from negligent behaviour, to prevent this from happening as much as possible.
The Repair kit includes a protection pad, which is placed underneath the patch. These protection pads are coated with a liquid contact indicator. This layer changes from its white colour to a bright red as soon as it comes in contact with water. This way, it instantly becomes visible when water is getting underneath the sealing patch.

Figure 35 - Colour change of protection pad

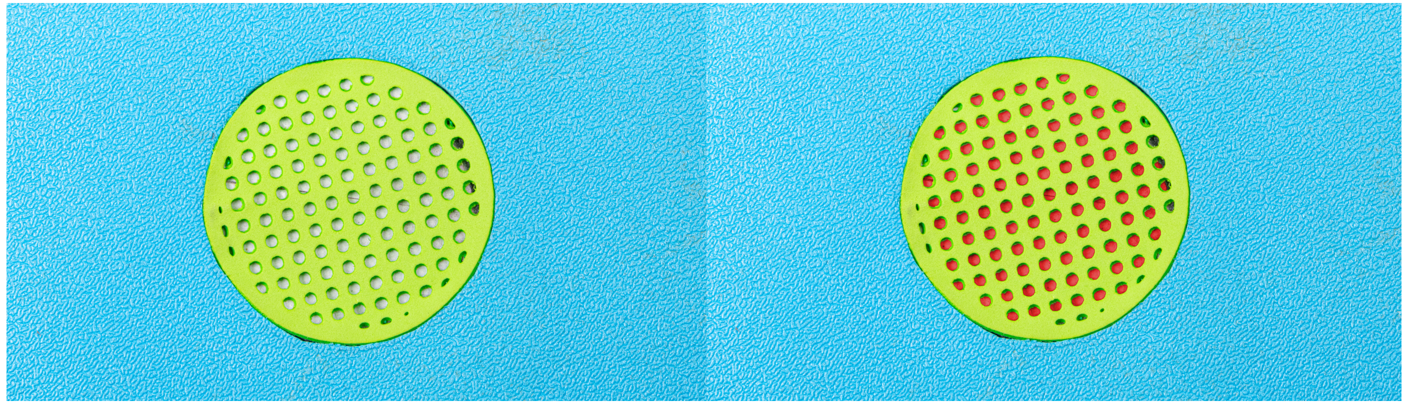


Figure 36 - Exploded technical drawing of deck *Repair* strategy

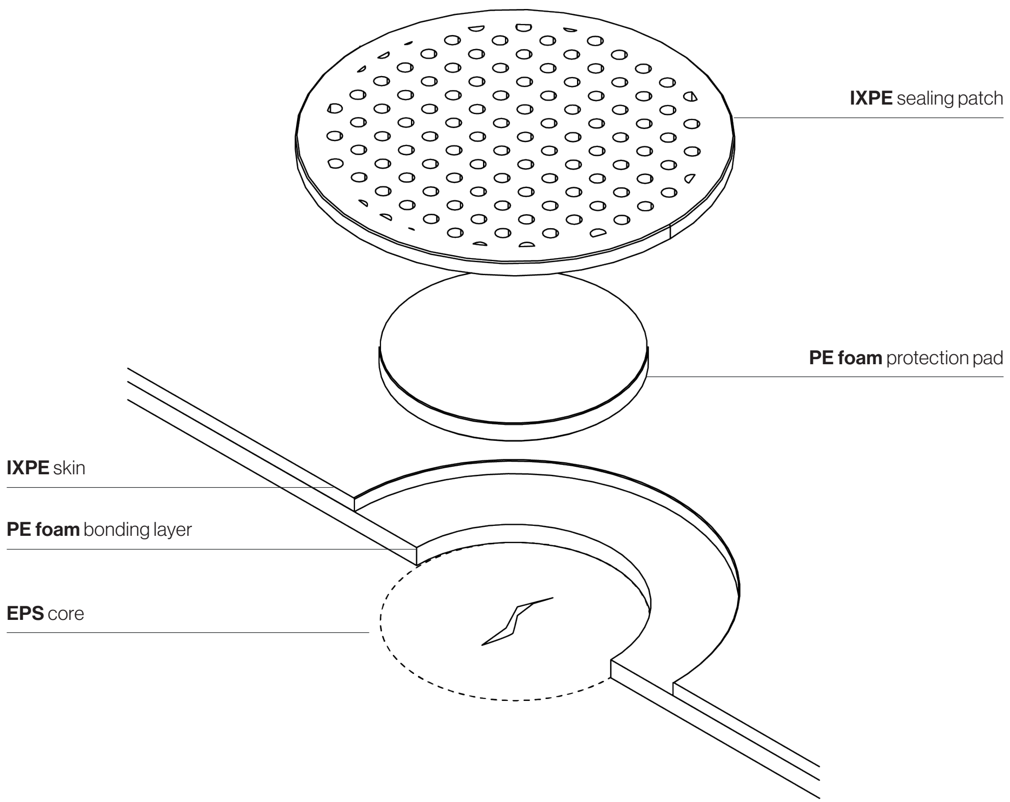
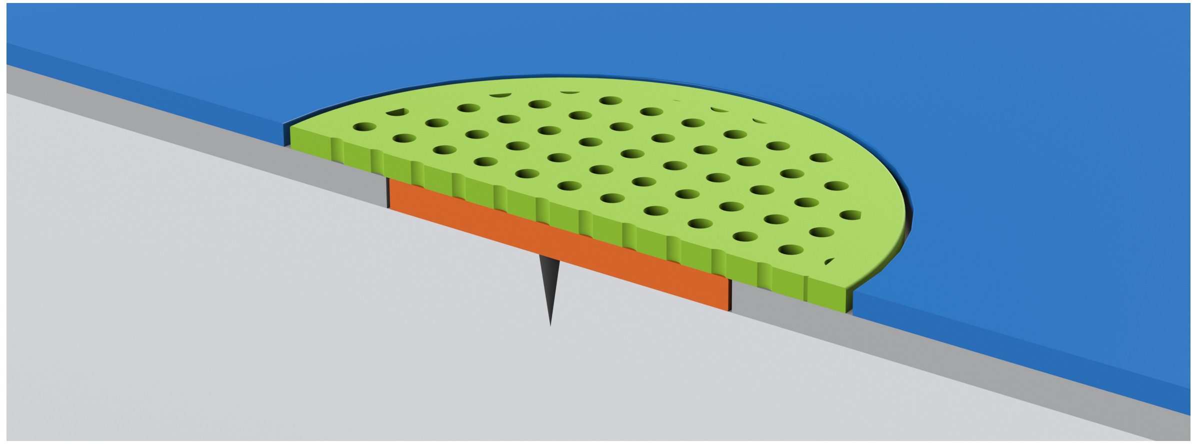


Figure 37 - Detail of deck *Repair* strategy



Technical details

The way the damaged foam is cut from the board, and repair patches are stacked over the wound in the board makes for a watertight seal. The way this is done is shown in figures 36 and 37. The seal is not affected by how precisely the cut fits the repair patch. It uses a relatively large surface area from the PE foam to adhere the sealing patch to. This way, the effectiveness of the Repair patches is not dependent on the practical experience of the user.

The patches come in a number of standard sizes, ranging between 50 and 120 millimetres in diameter. They are circle shaped because this is generally the most effective shape for stress distribution, and it doesn't have sharp edges that can start peeling easily.

The adhesive used on the sealing patches is a solvent rubber adhesive, which are strong and water resistant adhesives (Avery Dennison, 2023).

Installation

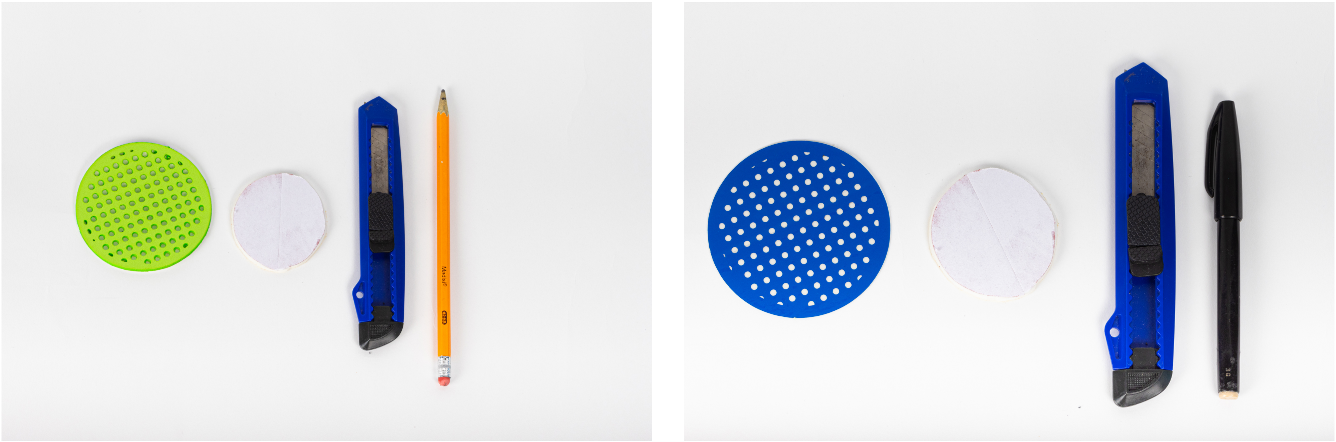
The patches are designed to be quickly and easily installed, even for users without a lot of practical experience. The only tools needed for a repair, are the pre-made protection pad and sealing patch, a (Stanley or exacto) knife, and a pen or marker (figure 38).

The installation process of the patches, both for the deck as for the bottom, is shown on the next page. This step-by-step guide also acts as a learning tool for first-time users. For users who are familiar with the process, installing one patch can be done within a few minutes.

Conclusion 3.2

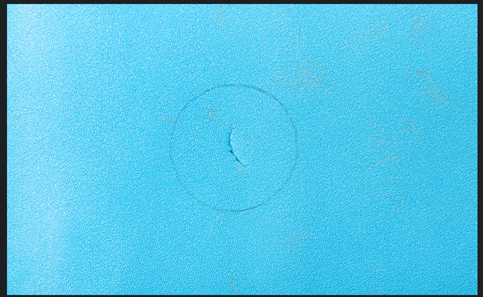
- **Repair** patches are quick and easy-to-use tools, with which surf schools temporarily reseal their boards in case of small damages.
- The patches include **water indication** pads, through which users can easily see when repairs start leaking again.
- The patches are designed to be an addition to the **aesthetic** of softtops, and to create a **sense of trustworthiness** with users.

Figure 38 - Necessary tools for installation on deck (left) and bottom (right)



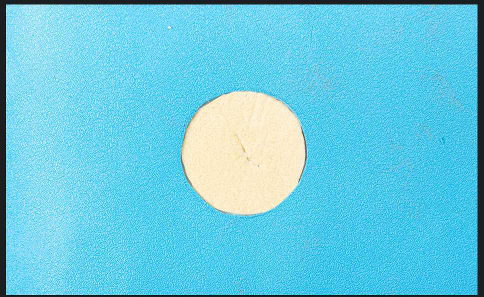
1. Identify leak

The first step is identifying a leak in the board. A cut is easily spotted, but it can be difficult to see whether it actually exposes the core of the board. A good trick to do this is by checking whether you can press the foam around the wound all the way to the core, and feel the EPS. If this is the case, the board can absorb water.



2. Mark the cutting line

Take the largest patch from the repair kit, and place it so that the wound is centred underneath it. Take a pencil (marker is hard to remove from foam), and mark the cutting line around the patch.

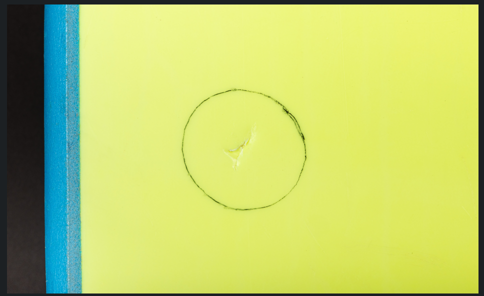


3. Cut first layer

Grab the Stanley knife and lock it with the blade 3mm exposed. Cut the foam on the marked circle, keeping the blade at a 45 degree angle. Peel off the outer layer of foam.

1. Identify leak

Identifying a leak works similarly to the upper side process. The outer layer of HDPE might be tough to press, which is why you can also use a blow dryer to heat up the material around the wound. If water comes bubbling out, there is definitely a need or repair.



2. Mark the cutting line

Mark the cutting line. You can also use a marker here, since this is easy to erase from the material.

3. Cut material

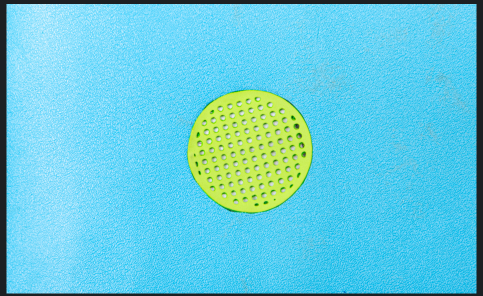
Grab the Stanley knife and lock it with the blade 6mm exposed. Cut the material (around the circle) all the way to the core. Remove all the material that's layered on top of the EPS.

4. Cut second layer

Take the small patch from the repair kit, and trace it on the inner layer of foam. Cut the circle using the same knife (3mm deep) and peel off the second layer of foam. This cut will be covered by the patch, so doesn't have to be as smooth.

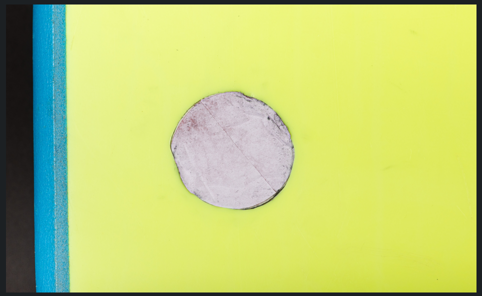
4. Place protection pad

Place the protection pad on the wound. There is no need for glue because the foam will be sealed by the outer patch.



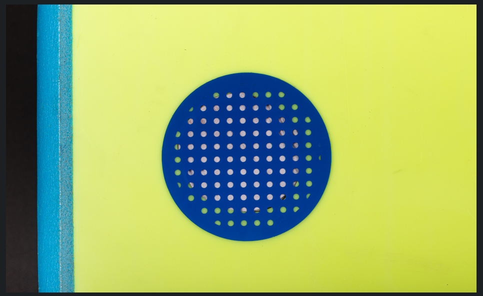
4. Place sealing patch

Peal off the sticker cover and place the foam sealing patch in the opening. Press firmly around the edges of the patch, making sure it adheres well to the foam underneath. The patch should be kept dry for 24 hours, after which it is completely water resistant again.



4. Place protection pad

Place the protection pad on the wound. There is no need for glue because the foam will be sealed by the outer patch.



4. Place sealing patch

Take the thin sealing patch, and place over the protection pad. Try to place it centred over the pad, but there is no need for perfect placement as the bond between the patch and the HDPE is very strong. Also keep dry for 24 hours.

3.14 Cost-price calculation

At the start of the next chapter, the developed concept will be tested and evaluated on its desirability with potential users. However, to get an idea of the viability of the system as a whole, making an estimation of the costs can also be a valuable tool. This subchapter will break down the cost of the system into its different elements. As not all of the recovery strategies have been fully developed, some assumptions have to be made in order to make this estimation. These assumptions sometimes have to be quite broad, but they will be briefly explained here. The full cost price estimation can be found in Appendix 9.

Production

At the base of the system are the initial production costs. Since the redesign of the construction uses almost the exact same materials as the original Vision construction, their wholesale price was used as a guideline. Their board price for surf schools starts at €200, so production and shipping costs are estimated at approximately €120 per board.

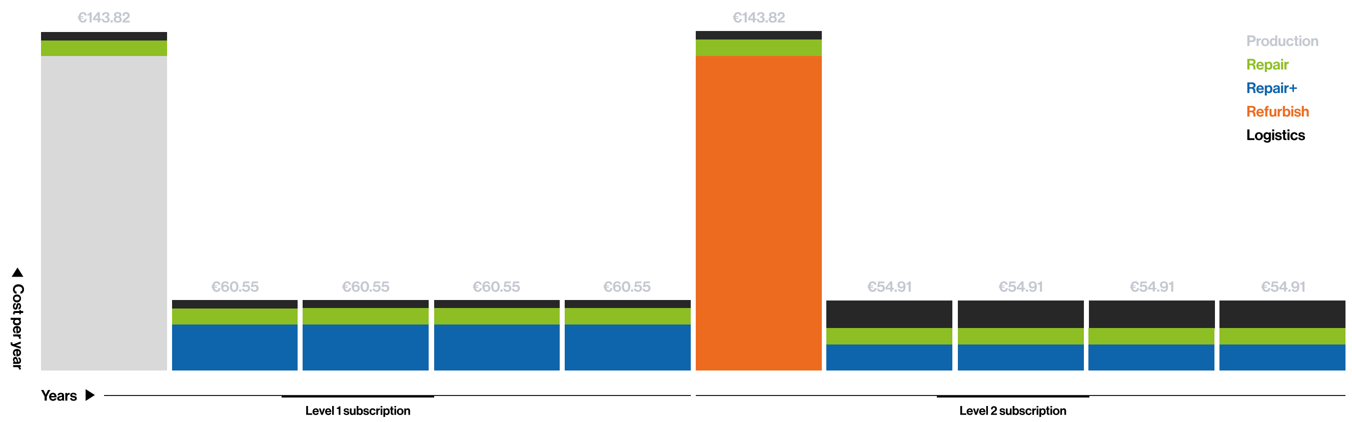
Recovery strategies

In estimating the costs for the three recovery strategies, a batch size of 70 softtops was used (one surf school), as this would be the size for a pilot study.
The *Repair* strategy was analysed in detail, based on the current prototype that was developed. The costs for the material for one deck repair resulted in €3.19 and those for a bottom repair were €2.27. For estimating the yearly cost per board, a total of three repair kits for each side was used (which is probably on the high side). This resulted in a total cost of €16.37 per year per board for the *Repair* strategy.
The estimation for the *Repair+* strategy contains the cost for adhesive materials, and a heat cutting tool which was now used in the latest prototypes. However, the cost for this strategy are mainly in labour, as it is still a manual process in the concepts current state. Two repairs per hour resulted in a total cost of €18.36 per repair. For the level 1 subscription, two repairs per year were used, and for level 2 only one was used. This is because the boards are used less intensively with surfers than with surf schools, and are therefore less likely to break.
The cost of the *Refurbish* strategy is the most complicated to estimate, as this one is the least developed. For this calculation, the same price as production is used, resulting in €120 per year. This assumption is based on the fact that a lot less material is necessary, but production costs will be a lot higher if it's done locally.

Average yearly cost

To make a final cost estimation of the system, only the logistic costs are still needed. For these costs, the transport from and to users were taken, and added to a rough estimation of storage costs. These costs are higher for subscription level 2, as these boards have to be transported more often with monthly leases.
The final cost breakdown is shown in figure 39 on the right. The total costs of this 10 year plan are €767.84 per board, resulting in an average **yearly cost of €76.78**.
This estimation is of course a very rough one, as many of the costs can not be broken down in detail yet. However, it does give an idea of within what range the service might be offered. This range can be used to gather feedback from users on the viability of the model. It also shows that a big investment will have to be done before implementing the system. Income will be generated yearly, meaning that it will take some years before a break-even is reached from the production of the boards.

Figure 39 - Yearly cost breakdown of the product-service system



Evaluation

Concept evaluation

Since not every recovery strategy has been designed in detail, the concept is difficult to evaluate as a whole within this report. However, the *Repair* strategy was made into a working prototype, ready to be tested with users. In this part, the requirements from the previous chapter are used to test and evaluate the *Repair* concept with potential users.

4.1 User testing

The previous chapter set several clear requirements for the *Repair* strategy, which led to the final design of the patches. However, these were only prototyped and tested by me, not by users themselves. The goal of this evaluation was to test the installation and seals with patches installed by potential users. The installation was set up to evaluate ease of use, while using basic tools. The resulting repairs were then evaluated on perception of trustworthiness, aesthetics, and finally on water tightness. This last aspect will be discussed separately, in chapter 4.2.

Research goals

1 Test Repair concept on ease of installation using basic tools (req's 4.4, 4.5, 4.7, 4.8)

2 Test Repair concept on aesthetics (req 4.9)

3 Test Repair concept on sense of trust (in water tightness) (req 4.10)

4 Test Repair concept on water tightness (4.1)

Participants

The *Repair* concept was designed with surf schools as primary user in mind. However, the *Repair* process should also be applicable to users without as much experience with softtops as surf schools have. This is why the user test was done with participants that fit both groups. In total, the installation was done with 2 participants without any knowledge or experience with softtops, and 2 surf instructor. Both surf instructors had prior experience with repairing softtops with adhesives.
All participants signed a consent form, agreeing to participate with the study (Appendix 10).

Method

The user test consisted of an intro, familiarizing participants with the concept and idea of the user test, and three different activities. The first activity was installing the deck repair, the second activity installing the bottom repair, and the test was concluded with a short interview.
For both of the installations, participants were given the process manual with pictures and short written directions (Appendix 10). After having read the manual, the process was carried out and timed. No feedback was given during the installation process unless participants were really stuck in the process. Participants were also asked to mention any ideas or doubts they had out loud. After the installations, they were briefly asked about their experience and the challenges they faced during the process. The installations were done with *Repair* prototypes that were all made in one batch, using the same materials. They were done on similarly sized softtop samples, cut from the same board.
In the concluding interview, participants were asked to rate the repairs from 1-5 on aesthetics (1=not nice to look at, 5=nice to look at) and sense of trustworthiness (1=not trustworthy, 5=very trustworthy).
During the user tests, data was recorded by taking notes of the process, and taking pictures of the process and end results.

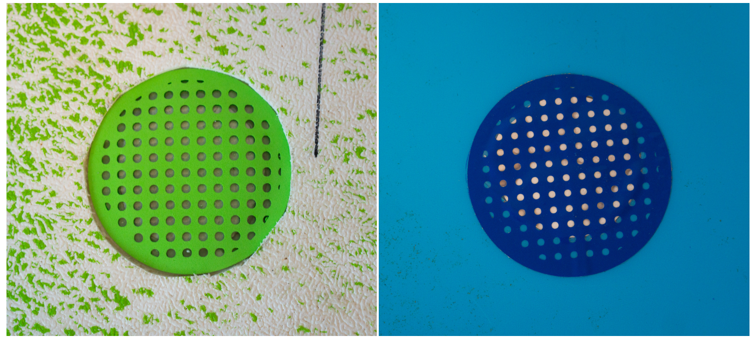
Figure 40 - Test environment with non-experienced surfers (above), and surf instructors (below)

Results

The results of the user tests are shown on the page on the right. The average time it took to install the deck patch was *10 minutes and 42 seconds*, and it took *5 minutes and 24 seconds* for the bottom patch. The first installation fit within the 15 minute maximum with all participants, and the second time (but first time for bottom) was already within 5 minutes on a few occasions.

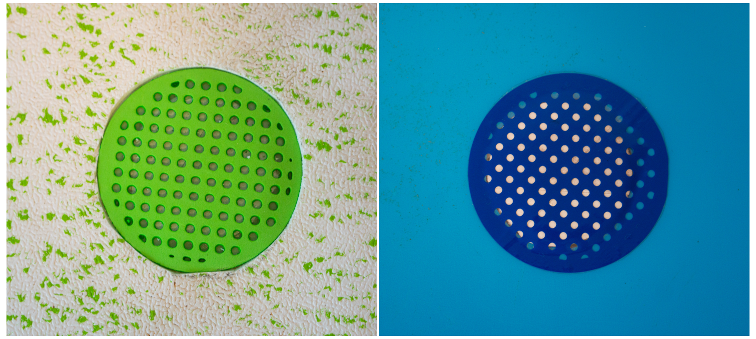
A lot of feedback was received from users during and after the installations. This feedback reflected on the installation process and the manual. This is shown in figure 41 on the next pages.
The feedback is broken down into pains and gains (of which the first are most present, as participants mainly talked about challenges they faced during the process). The pains and gains are divided by installation steps, during which they occurred.
Something that popped up in nearly every test, was that participants had trouble with the protector pad. They tried peeling off the indicator tape from the pad, and had difficulties with finding out which side of the pad to place upwards. A takeaway for the design of the pads could be to make the colour of the pad itself different to that of the indicator tape, and also the foam in the board. This would make the process a lot more clear in the images.
Something else that happened a few times, is that participants wanted to trace the wrong pad or patch.
A change in the design of the manual could be to start with a clear 3D overview of the finished repair, with the corresponding names of all the parts. The steps where users have to trace around a part should also include an image that refers to the overview.
What also came up, is that peeling the material from the bottom is quite difficult. Advising users to use a screwdriver to lift the material would be helpful, as well as prevent knives from breaking.

After the installation and giving feedback on the process, the participants were asked to rate their repairs on aesthetics and trustworthiness. The deck repair scored an average of *2.75 on aesthetics* and *3.5 on sense of trust*. The bottom repair scored an average of *4.25 on aesthetics* and also *4.25 on sense of trust*.
These results indicate a better overall satisfaction with the bottom repair, than with the deck repair. The main reason for this was that participants found the finish of the deck repair quite rough, as most of the participants had peeled the layers a bit too deep after the first cutting step. This resulted in the patches not being completely flush with the surface. The cutting not being perfectly in line with the sealing patch also lowered trust in the deck repair. The bottom repair patches are always flush with the surface, which is why it was rated better on both categories.
Another interesting aspect that was mentioned by the surf instructors, was that repairs are usually not done by the people who carry responsibility over the boards. These tasks are usually given out to surf teachers with less experience, who don't care as much about how repairs are done and how they look. This makes ease-of-use and installation time even more important aspects.



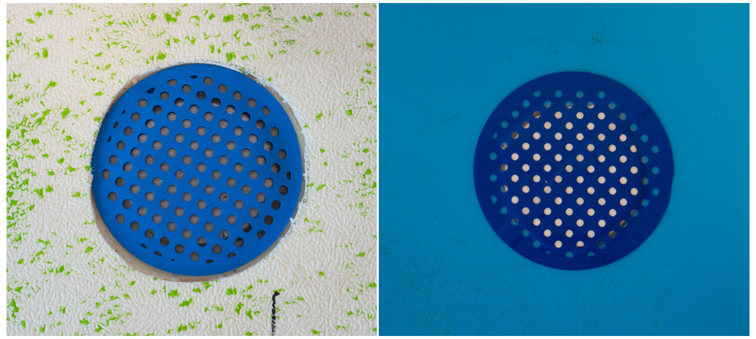
Participant 1
Non-experienced surfer

Installation time deck: **9:22 min**
Installation time bottom: **6:03 min**



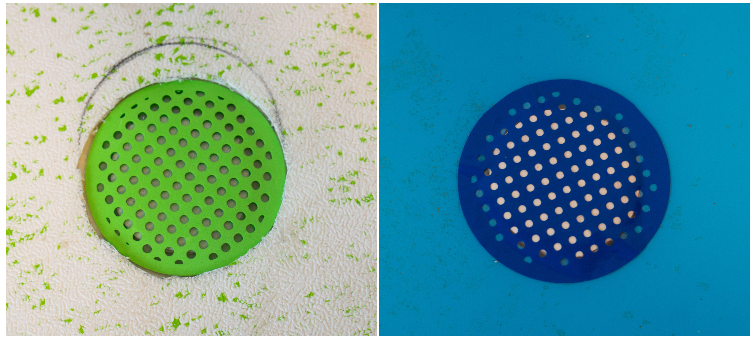
Participant 2
Non-experienced surfer

Installation time deck: **9:10 min**
Installation time bottom: **4:19 min**



Participant 3
Surf instructor

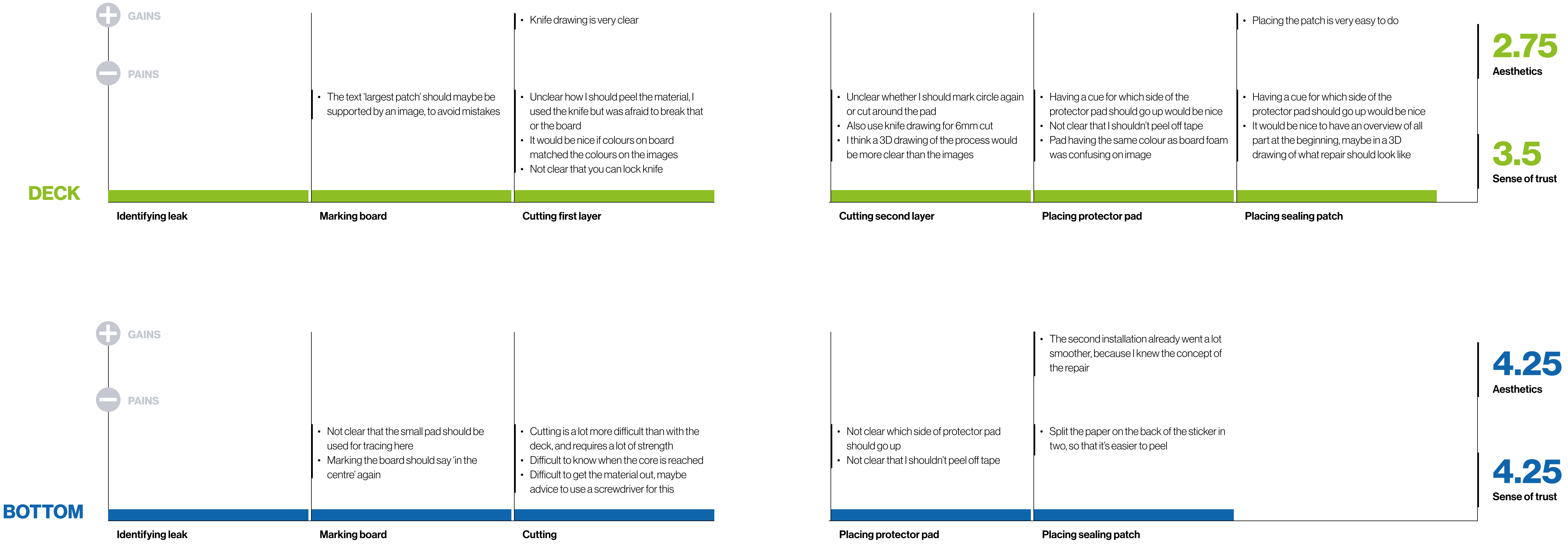
Installation time deck: **14:41 min**
Installation time bottom: **5:24 min**



Participant 4
Surf instructor

Installation time deck: **9:35 min**
Installation time bottom: **5:51 min**

Figure 41 - User experience map from concept evaluation



Key findings

With the test results, we can look back at the research goals and start reflecting on the design requirements that the *Repair* concept should meet. This will serve as a clear overview of where the concept currently is, and will help determine directions for the future of the project.

Ease of use - This aspect of the concept turned out to be more important than previously assumed, as the people within surf schools who are interested in the quality of the repairs often delegate this task to other, less interested, employees.
The first installation using the manual fit within the maximum time requirement, and it's highly likely that this will also be the case for experienced users. The second repair (and first for bottom) was already done within 5 minutes on a few occasions.
The satisfaction with the user manual was still quite divided, and could still be improved. A manual with images that have matching colours with the actual board and repair tools, or a manual with 3D drawings of actions could make the learning process more smooth.

4.4	Repairs should be possible to do **individually**
4.5	Repairs should be possible to do within **15 minutes** for first time users with instructions
4.6	Repairs should be possible to do within **5 minutes** for experienced users
4.7	Repairs should be done **without expensive tools** (exceeding 20 euros)
4.8	Repair materials should come with a clear **manual** to teach the process
4.9	Repairs should be **visually appealing**
4.10	Repairs should create **sense of trust** in repair with user

Table 4 - Tested requirements and their current development stage

Aesthetics - The aesthetics of the *Repair* method was also an important requirement. Repairs on the deck score lot lower in the user test than repairs on the bottom, which could be improved by making sure that the patches on the deck are always flush with the surface. The redesigned construction only uses two layers of foam (instead of the 4 in the test sample), which should significantly lower the chances of users peeling off too much foam. However, this should still be a point of focus in further development.

Sense of trust - The deck repair also created a lower sense of trust than the bottom repair, because of the gaps around the sealing patches. This effect could be minimised by designing a complementary standard-sized (heat) cutting tool, but this would make the process a lot more expensive and less accessible. Another solution could be to use a dark coloured second layer, so that the open space around the patches becomes less visible.

Table 4 on the left shows the results of the tested requirements. A green dot indicates that the requirement has been met, orange indicates that it's a work in progress, and the grey dots are requirements that haven't been quantified.

4.2 Seal testing

Besides the requirements discussed in the previous subchapter, and perhaps most important, is the water tightness of the *Repair* patches. In this part, the patches installed by users are tested on their resistance to water.

Method

The water tightness of the samples from the user tests was evaluated by making use of the water indication pads in the repairs. These very quickly turn to a bright red when in contact with water, which makes it easy to spot when patches start leaking.
To test the samples on leakage, they were all separately placed in large see-through containers with water. The amount of water (around 20 degrees C) in the containers was aimed so that approximately half of each sample was submerged. The samples were left in the containers until the water indication pad went red, after which they were flipped around and submerged into the water again. The submersion time until each repair started to leak was measured for each sample, by checking up on the samples at different times spread around the day.

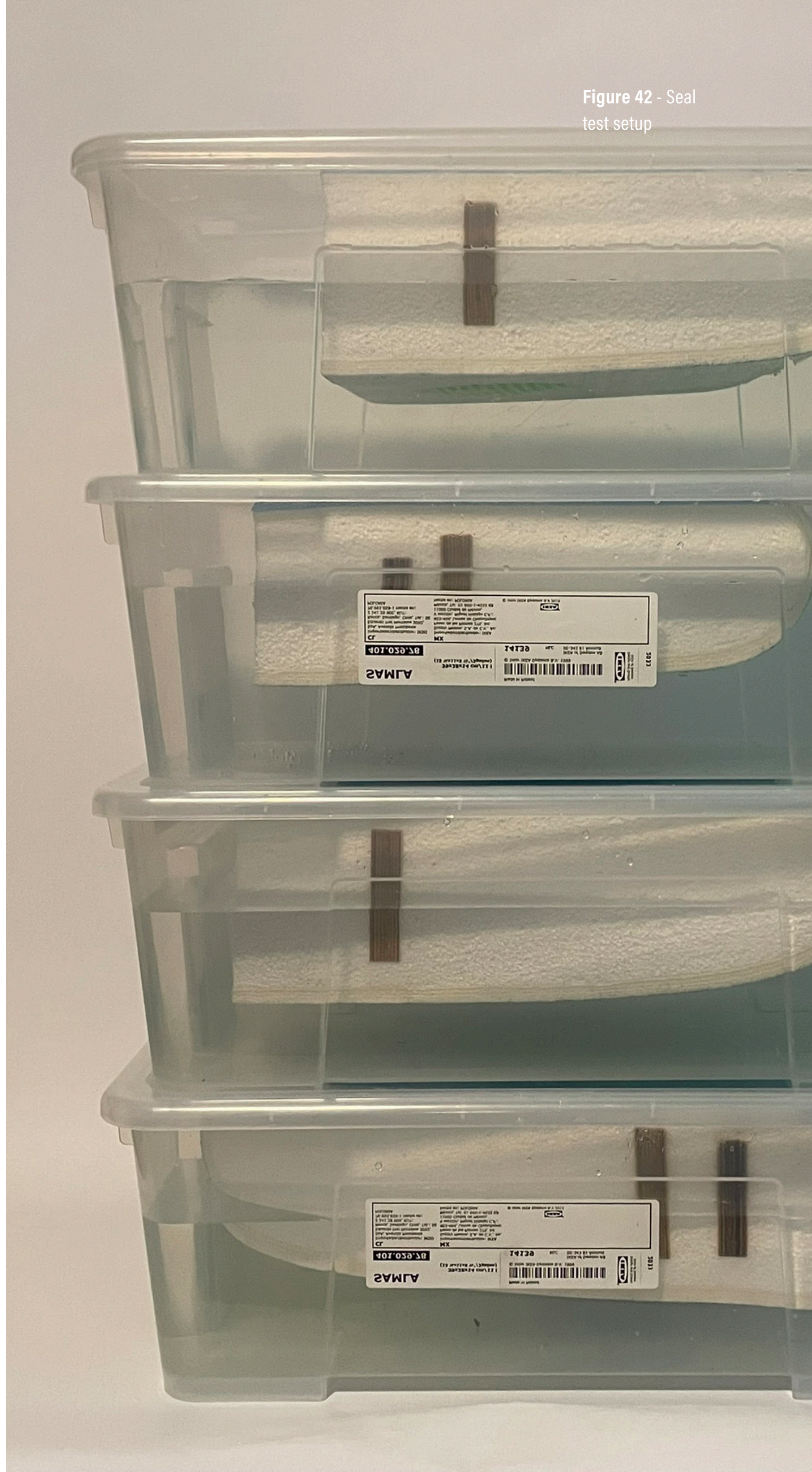


Figure 42 - Seal test setup

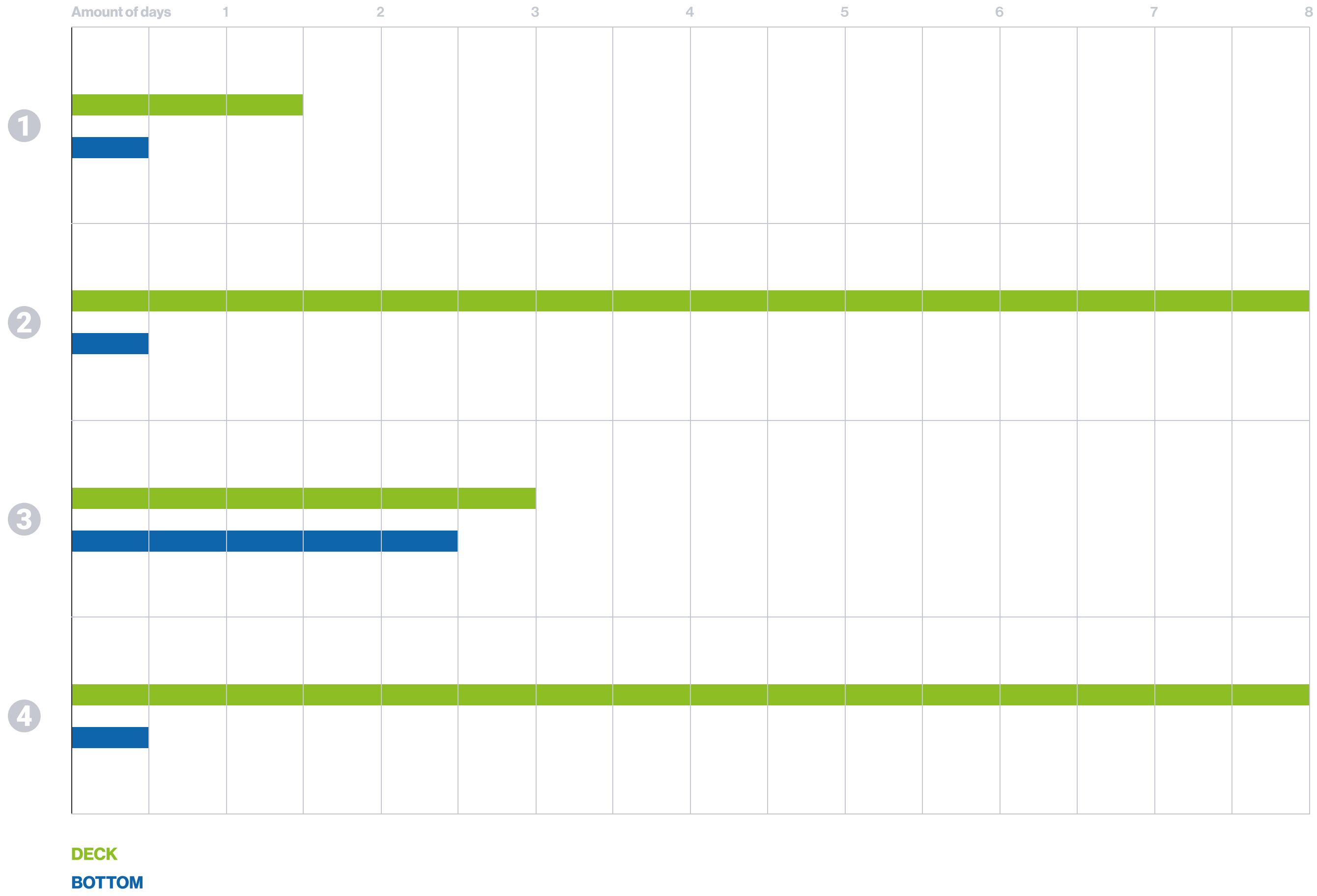


Figure 43 - Board samples from the user test and their submersion time until water leakage

Results

The results of the seal test are shown in figure 43 on the left. The first and most interesting note is that three of the bottom patches showed water leaking quite quickly after submerging them in the containers. This happened after 1 hour already. The reason for this is probably that the patches were now prototyped by attaching two strokes of the sealing tape to each other. This means that there is a small gap from the overlapping tape, which probably couldn't be sealed completely on the hard HDPE material.

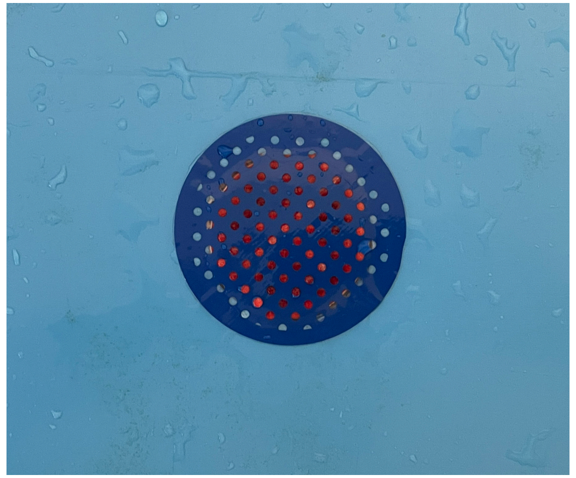
This was not the case for the patches on the top, where two of the four didn't end up showing water leakage at all (after 8 days). Because the deck patches are installed on a layer of soft foam, the gaps in the sealing patch could be filled up by the foam.

Key findings

Unfortunately, no final conclusion can be made on the water tightness of both of the sealing patches. The However, the results do have implications for the further development of the patches.

Deck repair - The principle of the deck repair has been validated with this evaluation. The patches have good adhesion on the soft inner foam, and can be submerged in water for at least 8 days. It has also shown that the precision of the cut probably doesn't have an influence on the water resistance of the seal, but this would need further testing.

Bottom repair - The results of the bottom repair have shown that the patches will have to be made out of one adhesive sheet. Overlapping multiple layers results in small gaps, which will let water through. Another test should be done with larger sealing stickers, or smaller patches.



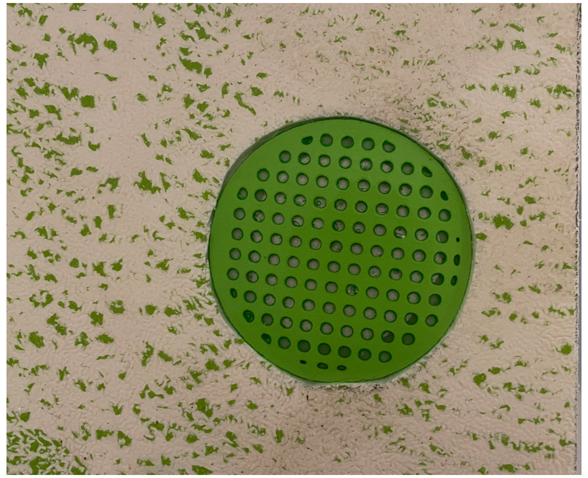
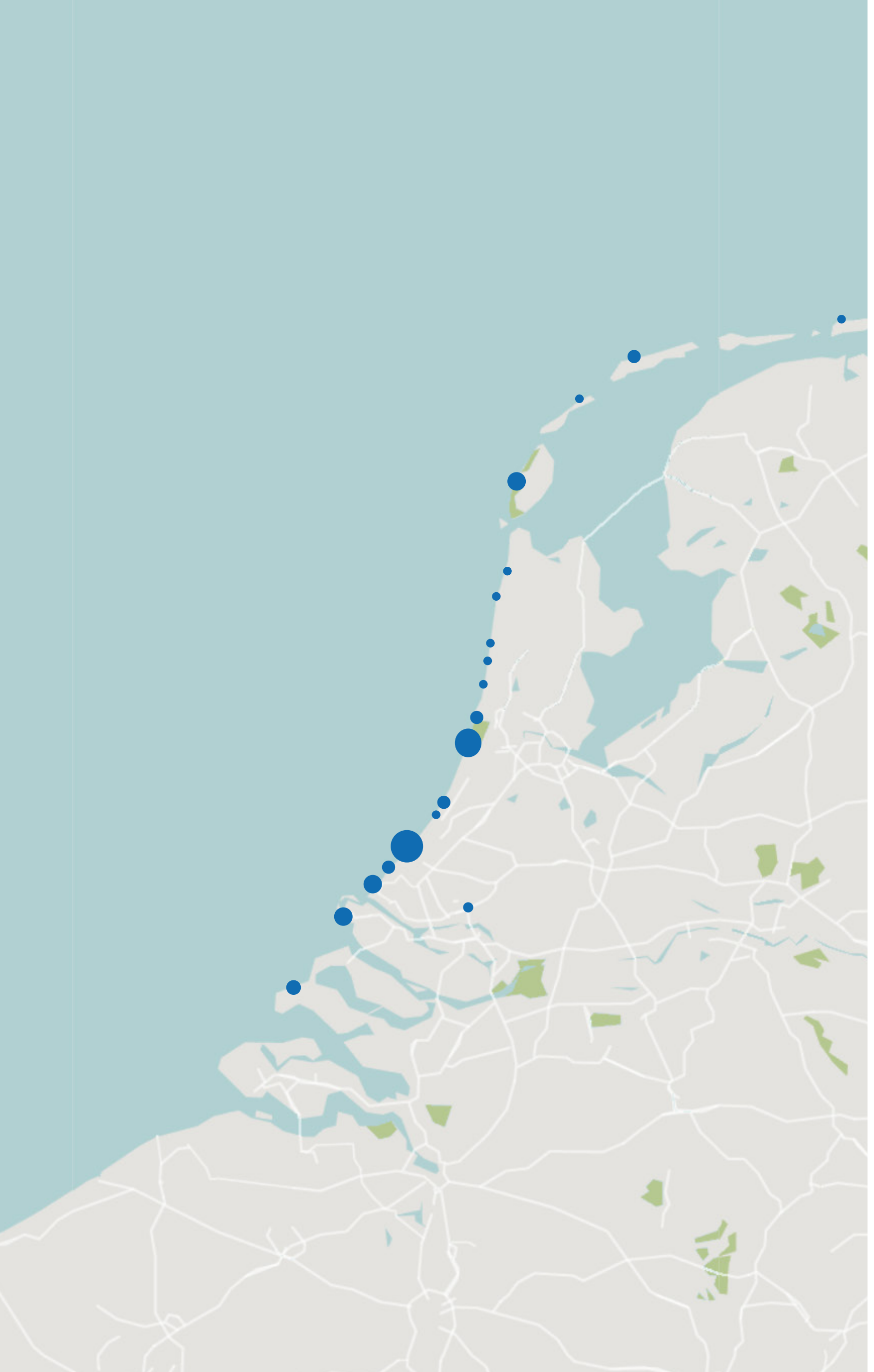


Figure 44 - Sample with water leakage (left) and without (right)

Figure 45 - Concentration of surf schools in the Netherlands



4.3 Impact analysis

> **RQ 3.3**
> How much **CO2** and **waste** could be saved with the implementation of the system?

The goal of this project is to minimize the waste and CO2 emissions from softtops. *Tides*, the proposed product-service system, minimizes this by making optimal use of the materials in softtops through the different recovery strategies. In this subchapter, we will take look at the two different lifecycles and make an estimation of the possible impact of the system.

As only one of the recovery strategies has been developed and tested, it's still too early to do a full analysis on the new circular lifecycle of the concept. However, with one of the recovery strategies partly validated and having the requirements for the other two, we can make an estimation of the extended lifetime.

Market size

The Netherlands already counts 38 different surf schools. A quick estimation of the size of these surf schools was made by comparing amounts of online reviews and social media activity with those of the surf schools that were interviewed for the project. This estimation results in a total of around 1800 softtop surfboards that are used every year (full list of surf schools and sizes is shown in Appendix 11). A visual of the location of these surf schools is shown on the left.

Only surf schools within the Netherlands are used for this impact analysis, and surf camps are left out of scope. Surf camps are also a relevant target group for *Tides*, but would need a different international logistic system around it, which would make estimating the impact a lot more difficult.

Waste and CO2 reduction

Based on the average lifetime of 2-3 years for Vision softtops, we can assume that 1800 Dutch softtops corresponds to an average 720 new softtops coming in from China every year. This number only represents softtops in surf schools.

With *Tides*, boards are professionally repaired every year extending their regular lifetime to at least 5 years. After this period, they are refurbished by replacing the skin, giving them another minimum of 5 years of intensive use. The old skins get used in the *Repair+* process, meaning that only the remaining core ends up as waste. In total, this results in boards effectively lasting at least 4 times as long as softtops currently do. This corresponds to a reduction of 540 boards that end up as waste every year.

Wavechanger has done an LCA on different types of surfboards and their CO2 emissions (2022). According to them, the carbon costs of the construction and materials of a typical 7 foot softtop is approximately 59.45 kg of CO2. The disposal of the waste of the board is estimated to be 11.36 kg of CO2.

If we assume that refurbishing the softtops costs around 50% of the emissions of a new softtop (same construction costs but less material), and that every year a little bit is added for the manufacturing of the *Repair* patches, we can make en estimation of the CO2 emissions of the product-service system in comparison to normal production.

The CO2 emissions for *Repair* patches (weighed at 1.5 grams) are estimated using data on vinyl and EVA foam material from the IDEMAT database. This resulted in a footprint of 0.02 kg per patch. The materials for *Repair+* are not included as these come from old refurbished boards. Emissions from transport are also based on data from IDEMAT, assuming that boards travel an average of 200 km by truck every year. This results in a footprint of 0.1 kg of CO2 per board. The total estimated footprint of the new lifecycle of the product-service system is shown in figure 46 on the next page.

Figure 46 - Estimated footprint of old linear lifecycle (top) and new circular lifecycle (bottom)

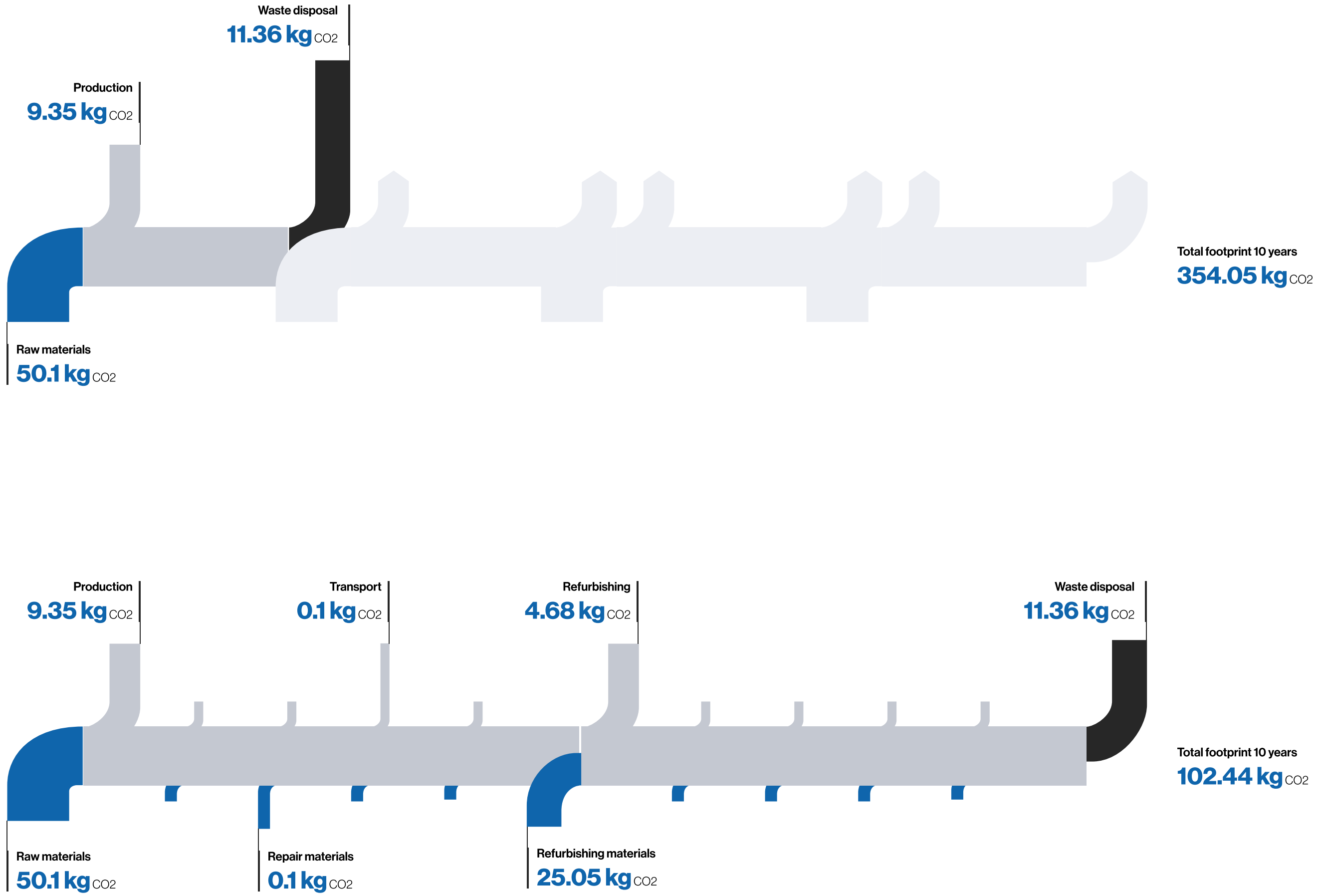


Figure 46 shows that the integration of *Tides* could save 251.61 kilograms of CO2 in 10 years, when compared to the current use of softtops. This equals 25.16 kg of CO2 per year, per board. If we use this data for the entire Dutch surf school market, we end up with a yearly reduction of approximately 45 tonnes of CO2.

Limitations

This estimation environmental impact is of course a very rough one. Differences in data from the Wavechangers LCA and my personal estimation of the emissions of the recovery interventions might be the result of different calculation methods and databases. The emissions of the *Repair+* and *Refurbish* strategies are also a rough estimation, as these haven't been prototyped and tested yet. However, this quick analysis does show the potential of the developed system. It shows that prolonging the lifetime by focussing on repair can have a lot of impact on the long run. It also eliminates a lot of waste, by efficiently using materials. This impact can be made, if the other recovery strategies are developed and tested further, and are integrated into the system.

Conclusion 3.3

- The **lifetime** of softtops could be extended by a factor of 4 when the three recovery strategies would be implemented, which corresponds with a reduction of 540 boards that end up as waste every year.
- This extended lifetime would correspond with a yearly reduction of **45 tonnes of CO2** for the Dutch surf school market.

Conclusion

We have almost reached the end of this report. In this part, we look back at the design goal and research questions defined at the beginning of the project. What have we learned from the project analysis, and have we reached the desired outcomes? The answers to these questions are translated into recommendations for the future of this project.

4.4 Conclusion

> **RQ 1**
> What could be a potentially viable **target group** within the surfing community, and what form of **circular business model** would fit their needs and behaviour?

The beginning of the project looked into different types of surfers and surfboards. A few different categories were defined, and the choice was made to focus on softtop surfboards and their primary user: surf schools.

High-performance surfboards come in many different sorts and shapes, and have to fulfil many requirements to suit the needs of the more experienced surfer. Softtops are mostly used by beginning surfers, and enable more of a one-size fits all approach. This created more opportunity and space to design in. Next to this, a large share of the softtop market is taken up by a specific type of consumer: surf schools. These factors led to the project being scoped as: a **circular softtop for surf schools**.

To find out what type of circular business model could fit the needs of surf schools best, several interviews and co-creations were done at different surf schools in the Netherlands. This led to the proposition of a **softtop subscription service**. This service-model is characterised by the guaranteed quality of softtops, by restoring them periodically during the off-seasons. The model also makes use of cascading performance needs, by implementing a second subscription level for individual surfers. These demand less of the boards, and can extend the effective lifetime of the boards significantly.

A cost price calculation of the business model was made, based on the estimated extended lifetime of the boards. This should be used to conduct a study on the viability of the model with surf schools, as this has yet to be evaluated.

> **RQ 2**
> How can the traditional **construction** of the surfboard be modified to **minimize waste** and **CO2** footprint, and better fit the circular business model?

The softtop that is currently used in most of the surf schools in the Netherlands is produced by **Vision**. The project also looked at the physical construction of this softtop, and why it is currently not suitable for a circular business model.

The reason why softtops deteriorate and are eventually discarded, is because the outer foam layer breaks and starts to leak. This causes the core to absorb water, making the boards heavier. The materials currently used in softtops make them very difficult to repair, and recycling is near impossible. Surf schools currently use adhesives to reseal the outer layer of the boards, further limiting end-of-life strategies.

Through the analysis, a new concept for a **softtop construction** was designed. The concept includes a double outside foam layer, enabling a new repair method that opens up other end-of-life possibilities. It also introduces a modular tail block, which can be used to easily remove absorbed water from the core. Another added feature is the use of inserts around the fin connections, making them more watertight. These design features mostly contribute to the durability and repairability of the boards.

RQ 3
How can the construction design and business model be integrated into a **system** that enhances **user experience**?

The final research question looked into integrating the construction design with the subscription model, to create a system that is desirable for surf schools. The product-service system that resulted from this is called ***Tides***.

Tides makes use of the natural flow in the surfing seasons to restore boards as efficiently as possible. Three **recovery strategies** were designed, each serving a different goal and having their own touchpoints in the product lifecycle.

The first strategy, *Repair*, is a temporary recovery method designed to keep boards in use during the high-season. It includes foam and vinyl sealing patches that are used to replace damaged foam, without the use of irreversible adhesives.

The second strategy, *Repair+*, is used to professionally restore the boards during the off-season. Damaged foam is replaced with reused foam from old boards, in a way that doesn't lower the aesthetic value of the boards.

Refurbish is the final strategy, and is used when boards can not be repaired anymore, without seriously harming its performance. In this process, boards are reskinned and are moved to the subscription level for individual surfers. The foam from old boards that still holds value is reused in the *Repair+* process.

Within the scope of this project, only the first recovery strategy was developed into a working prototype. This prototype was evaluated with potential users, and tested on its requirements. The outcomes were promising, but the water tightness of the bottom repair needs further development and testing.

The final concept of Tides as a product-service system was also used to make an estimation of the reduction in waste and CO2 emissions. With an extended lifetime from 2-3 years to a minimum of 10 years, the system could reduce the amount of boards that end up as waste from Dutch surf schools every year by 540. Considering the added material of the different recovery strategies, this could correspond with a reduction of 45 tonnes of CO2 emissions per year.

Future recommendations
The estimations of the costs of the system and the reduced waste and CO2 emissions, are still very broad ones. In order to make a more specific evaluation of the viability of the system and its environmental impact, the concept should be developed further.

First of all, the prototype of the *Repair* patches should be iterated on once more, and should be tested further in real use scenarios. It will be interesting to see how the bottom patches hold over time, and whether the deck patches won't be damaged when put under pressure by surfers.
The *Repair+* and *Refurbish* strategies should be conceptualised and tested further, to improve their quality and to see whether their processes could be automated. This could drive the costs of the system down more, and will also help make a realistic estimation of the extended lifetime of the boards.

Finally, the construction design will have to be prototyped and tested. An important feature to evaluate is the ability to remove water from the core, by letting it leak or evaporate. This should fit in with the Repair+ period of the concept. More experimenting could also be done with alternative materials than the ones currently used. Something that has potential to explore more, is making the rails of the board in a different material than the core, as by far the most dings end up being on the rails of softtops. *All these aspects could contribute to the potential implementation of Tides, ultimately resulting in lowering the environmental footprint of the surfing industry.*

4.5 Reflection

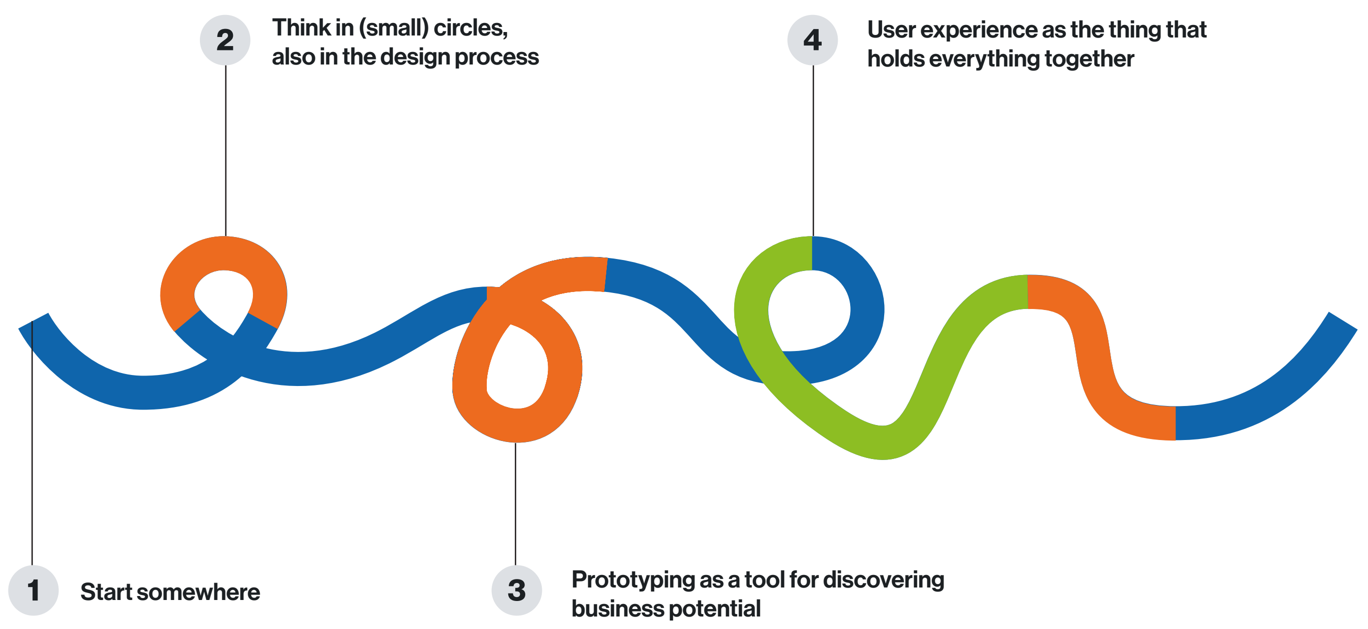
Having concluded the results of the project within this report, I want to take some time to reflect. This graduation project has been a big learning experience for me; both on a personal level, as well as from a circular design perspective. In this reflection, I want to look back at the final results of the project, and at the things I learned in the process of getting there.

How do you design for a circular economy?
This was the big overarching question I had in my mind at the beginning of this project. In my eyes, most of the projects and methods I've designed with over the course of my studies all had a very clear starting point. The human-centred design method, for example, always starts with the user. Who you're designing for, and finding their needs and wants, are the first points of focus. Material-driven design starts with a material or technology, and then looks at the most suitable context to place it in. Business design starts from an economic perspective, and looks at how this can be used to make change. All design methods I knew seemed to start from one of these three pillars of design: *people, technology or business*.
In designing for the circular economy, this starting point was a mystery to me. In my idea, all three pillars were equally important in a circular economy framework, and even go simultaneously during the design process. So as I didn't really have a structure to hold onto, this project also consisted for a large part of navigating myself through a circular design process.

The first, and maybe most important takeaway, is to just *start somewhere*. As I didn't have a clear starting point, I decided to start by investigating the wants and needs of surf schools as a target group, and to start ideating different business models. Through interviews, this quickly made me discover a lot of things about the product itself too. I think there is not a specific approach you have to take in starting to analyse the context you're designing for, but that it's best to get the ball rolling as fast as possible.

The second thing I learned is to *think in circles*, and not only for the thing you're designing, but also in the process. As I mentioned, my idea was that the different pillars of design have to be developed simultaneously in a circular design framework, but this was not a very realistic approach. I figured that if I used really short design sprints, I would be able to navigate between the business model side and the product design side quickly. This turned out to work really well. It allowed me to quickly explore the possibilities within a certain direction, which I could use to get a better idea of how feasible a certain business model would be.

The third learning experience was to also use *prototyping as a tool for discovering business potential*. I noticed how difficult it is to validate ideas in an early stage, as things tend to stay very theoretical from a business model perspective. As I started to gather feedback from surf schools, I started using UX prototypes as a tool for communicating ideas. This was helpful, as it allowed me to make things tangible. It gave potential users something to really give feedback on, as opposed to keeping everything theoretical.



The fourth and final learning I want to reflect on, is *user experience*. In my eyes, this is the thing that ties everything together. I felt like the business model and the construction design were two separate paths the project was taking. The moment I started thinking about the details of the system through which the boards could be offered to surf schools, is when I started seeing everything becoming part of one story. The use of the *Tides* analogy finally also made it easier to communicate the concept.

Challenges of the Circular Economy
However, I also came across some challenges during the design process. The introduction of this report briefly discussed the drop in circularity, despite its rise in popularity. Why this is exactly is hard to tell, but I think I have come across some of the things that make the transition to a circular economy a challenge.

Something I came across a few times, is how difficult it is to make change in a market that is saturated with cheap products. As most softtops are made in China, it is almost impossible to compete with their production methods, and it is even more difficult to influence their way of producing. I think the complexity of the supply chain makes the influence that brands have on their manufacturers quite small. This might be why a Vision hasn't changed their product, despite their willingness to take feedback from users. I think the design approach that this requires is a lot more focussed on really new and innovative value propositions.

Another thing I experienced is how easy it is to gather bad data. I've felt that potential users usually have the tendency to emphasise how important sustainability is to them, and that their decision making is mostly driven by this. However, in prototyping some of the business models, I found out that in many cases there are other more important drivers at play than sustainability. This makes it really important to think about the way you are communicating ideas to your target user.

These things were good learning experiences, which I will also remember for future projects. However, I think there are a lot more challenges that come with circular design, which I have yet to explore.

Me as a designer

At the beginning of this project, I had quite a clear end goal in mind. The image of my final presentation I had in mind, was me standing next to a personally made prototype of a surfboard. My love for making things (and surfboards), was the reason why I got into doing the project. However, I quite quickly realised how this was a very optimistic end goal, with no real foundation to make an impact with. Completely focussing on the construction of surfboards would be trying to shape the project around my current capabilities as a designer. I realised that this wasn't the right approach if I really wanted to make an impact, so I decided to do it differently. I decided to do it the other way around, and focus on the context first and then familiarise myself with the area of design I thought was holding the best solution.

This was quite a challenge, as it pushed me to use methods I wasn't really familiar with. It pushed me to think about business and systems thinking a lot more than I was used to. Besides the fact that I think it probably provided the most valuable results, it also turned the project into a really great learning experience. I think I have started to profile myself as a context-driven designer much more than I did at the start of my Masters. I have started to gain interest in the idea of the reverse T-shaped designer, as opposed to Tim Brown's idea of what designers should be (Baratta, 2017). This idea places the importance of context and different design workplaces above having one deep expertise in a certain design field. This has started to resonate with how I see design, as this project has helped me realise that making an impact is very context-driven, and is not just a result of doing what you're good at. All of this has made me very curious to see in what ways I can apply this idea in my future profession as a designer.

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Interview questions (Dutch)

INTERVIEW GUIDE SURF SCHOLEN

Huidige situatie

1. Kun je iets vertellen over hoe jullie huidige inkoopsysteem van boards eruit ziet? Welke boards kopen jullie, wanneer en hoe veel kopen jullie er, waar komen ze vandaan en hoe duur zijn ze dan?
2. Hoeveel worden jullie boards tijdens het seizoen gebruikt en hoe gaan surfers met de boards om? Hebben jullie nog een manier om te voorkomen dat mensen slecht met boards omgaan?
3. Kun je iets vertellen over veelvoorkomende problemen/schades die ontstaan aan de boards, en hoe ontstaan die meestal?
4. Wat gebeurt er op het moment dat er schade ontstaat aan de boards? Repareren jullie ze zelf, brengen jullie ze ergens heen, of vervangen jullie ze?
5. Zijn er nog andere manieren waarop jullie de levensduur van jullie boards proberen te vergroten?
6. Wat doen jullie met jullie boards in het off-seizoen en van wanneer tot wanneer is dat?
7. Wat gebeurt er aan het einde van de levensduur van jullie boards? Wanneer is een board voor jullie echt niet meer te gebruiken, en na hoe lang gebeurt dit meestal?
8. Kun je iets vertellen over hoe het doorverkopen van jullie boards werkt? Hoeveel verdienen jullie daaruit terug en aan wat voor surfers verkopen jullie meestal?
9. Hoe vergelijken jullie in levensduur en het gebruik van jullie boards met andere surfscholen?
10. Weet je toevallig ook wat er gebeurt met boards die echt helemaal kapot zijn, worden die verbrand? Hoeveel zijn dit er?

Toekomst

11. Duurzaamheid staat hoog op jullie agenda. Hoe past jullie huidige gebruik van surfboards daarin en hoe zijn jullie van plan om hier n de toekomst mee om te gaan?
12. Hoe erg bepaalt het vervangen van boards jullie financiele toestand? Heeft de levensduur en aankoop hiervan veel invloed of niet?
13. Zouden jullie financiele ruimte hebben om grotere investeringen te doen voor duurzamere alternatieven? Zo ja, hoeveel ruimte is hiervoor?

Appendix 1 - Analysis interviews

Interview The Hook

INTERVIEW - Donny, *The Hook*

1 - Boards

Hoeveel boards hebben jullie gemiddeld door het seizoen heen?
Ongeveer 30

Hoeveel boards vervangen jullie hiervan elk jaar?
Soms nul, soms veel. Meestal vervang ik om de 3 jaar alles.

Hoe duur zijn de boards die jullie kopen?
Tussen de 300 en 450 euro. Ze zijn van Vision. We hebben voornamelijk het Takeoff en Flare model.

Hoe lang gaan boards gemiddeld mee?
Gemiddeld zo'n 3 jaar denk ik. De Takeoff is een stuk beter dan de Flare, die laatste gaat heel snel kapot als je hem in de zon laat liggen en is niet geschikt voor surfscholen. Wel zou ik deze kopen als ik voor mezelf een board nodig zou hebben, want hij surft beter.
De 9 footers gaan wel maar 1 jaar mee, die worden gewoon veel meer gebruikt dan de kleinere.

Waar komen ze vandaan?
Taiwan

2 - Seizoen

Van wanneer tot wanneer loopt jullie seizoen?
1 mei tot 1 november.

Hoeveel worden boards gemiddeld gebruikt?
Ze liggen in het hoogseizoen gemiddeld zo'n 2x per dag in het water.

Wat doen jullie met boards zodra het seizoen is afgelopen?
Dan gaan ze weer in de container. Sommige verhuren we voor 50 euro ook de hele winter, dan mogen mensen ze meenemen. Dit loopt alleen nog niet zo storm.

Houden jullie ook boards beschikbaar in het laagseizoen?
Ja voor langere periode huren wel. Ik geef ook wel eens surflessen aan mensen met hun eigen materiaal in de winter.

3 - Repairs / de downflow

Wanneer is een board niet meer te gebruiken?
Als de buitenkant helemaal loslaat. Ook als ie een stuk zwaarder is geworden door het water en gaat zinken.

Interview The Hook

Repareren jullie zelf wel eens jullie boards?
Ja met siliconelijm (blob). Dit houdt ze dan waterdicht. Ook laat ik ze wel eens lang in de zon drogen zodat het water in de plank verdampt.

Wat doen jullie met boards die niet meer te gebruiken zijn?
De meeste probeer ik te verkopen via marktplaats. Sommigen zijn echter te slechte staat en daar probeer ik iets anders van te maken.

Hoeveel verdienen jullie terug met doorverkoop?
100 euro voor een board. Sommige zijn alleen in slechtere staat en gaan voor iets minder, en ik kan ook niet alles doorverkopen.

Wat is de meest voorkomende manier waarop boards kapot gaan?
De foamlaag laat los of er komen gaten in.

Waarom gebeurt dit denk je?
Er gebeuren ongelukken, mensen gaan er slecht mee om, of ze blijven te lang in de zon liggen. Veel voorkomende dingen zijn wel dat ze door het zand gesleept worden (schuurt de onderlaag kapot) of het zout er niet afgespoeld wordt.

Hoe hoog staat duurzaamheid op jullie agenda?
Hoog.

Wat proberen jullie hier al aan te doen?
We verkopen en gebruiken zo veel mogelijk dingen met een oog op duurzaamheid.

Interview The Shore

<u>INTERVIEW - Hans, *The Shore*</u>

Huidige situatie

Kun je iets vertellen over hoe jullie huidige inkoopsysteem van boards eruit ziet? Welke boards kopen jullie, wanneer en hoe veel kopen jullie er, waar komen ze vandaan en hoe duur zijn ze dan?
We kopen om de 2 jaar ongeveer 70 nieuwe boards. Dit zijn Vision boards, uit Taiwan. We krijgen ze voor minder dan de normale verkoopprijs omdat we ze in zulke grote batches bestellen.

Hoeveel worden jullie boards tijdens het seizoen gebruikt en hoe gaan surfers met de boards om? Hebben jullie nog een manier om te voorkomen dat mensen slecht met boards omgaan?
Over het algemeen slecht, beginners hebben geen idee wat ze doen. We proberen ze wel te vertellen dat ze niet in het zand moeten surfen, niet op de planken moeten zitten, en ze niet door het zand moeten slepen.

Kun je iets vertellen over veelvoorkomende problemen/schades die ontstaan aan de boards, en hoe ontstaan die meestal?
Er komen gaten in en bij de finboxen lopen ze vol met water. Ook gaan de vinnen soms dwars door de boards heen als mensen elkaar aansurfen. Heb ook een keer een batch met boards gehad waarbij de laag aan de onderkant al na een week helemaal kreukelde en onbruikbaar waren geworden.

Wat gebeurt er op het moment dat er schade ontstaat aan de boards? Repareren jullie ze zelf, brengen jullie ze ergens heen, of vervangen jullie ze?
We proberen ze zelf te repareren. Ik gebruikte eerst hotglue maar gebruik nu twee componentenlijm, wat een stuk langer blijft werken.

Zijn er nog andere manieren waarop jullie de levensduur van jullie boards proberen te vergroten?
Zo voorzichtig mogelijk mee doen.

Wat doen jullie met jullie boards in het off-seizoen en van wanneer tot wanneer is dat?
Als het seizoen eindigt huren we de boards uit totdat we weer open gaan. We raken ze alleen bij lange na niet allemaal kwijt.

Wat gebeurt er aan het einde van de levensduur van jullie boards? Wanneer is een board voor jullie echt niet meer te gebruiken, en na hoe lang gebeurt dit meestal?
Meestal is een board na 2-3 jaar niet meer te gebruiken. Je voelt dat ze dan te zwaar zijn geworden door al het water wat in het board is getrokken.

Kun je iets vertellen over hoe het doorverkopen van jullie boards werkt? Hoeveel verdienen jullie daaruit terug en aan wat voor surfers verkopen jullie meestal?

Dan verkopen we ze in een tweedehands sale voor ongeveer 80-100 euro. Vaak posten we op marktplaats en social-media wat, en dan komen mensen naar onze surfschool.

Hoe vergelijken jullie in levensduur en het gebruik van jullie boards met andere surfscholen?
Sommige surfscholen gebruiken boards die wat langer meegaan, zoals de Ocean And Earth boards, maar dit zijn beginner boards. Deze zijn gecoat met epoxy en glasvezel en zijn keihard, dus als je er een tegen je hoofd krijgt ga je knock-out.

Weet je toevallig ook wat er gebeurt met boards die echt helemaal kapot zijn, worden die verbrand? Hoeveel zijn dit er?

Toekomst

Duurzaamheid staat hoog op jullie agenda. Hoe past jullie huidige gebruik van surfboards daarin en hoe zijn jullie van plan om hier in de toekomst mee om te gaan?
We bieden al surfboard-as-a-service aan. Dan mogen mensen voor 75 euro per maand alle boards gebruiken die we hier hebben staan. Dit is vooral fijn voor mensen die nog wat boards willen uitproberen voordat ze investeren in een eigen. Ook hebben we een soort sharing service, waarbij mensen een board (moet wel een klein beetje uniek zijn) geven en vervolgens uit een hele pool alle boards mogen gebruiken. Als er iets kapot gaat betaalt iedereen een klein beetje mee. Voor onze lesboards hebben we alleen nog geen oplossing. We bestellen elk jaar wel een paar nieuwe boards van alternatieve merken om te kijken of we betere tegenkomen, maar dat is nog niet het geval geweest.

Hoe erg bepaalt het vervangen van boards jullie financiele toestand? Heeft de levensduur en aankoop hiervan veel invloed of niet?
Ja wel redelijk.

Zouden jullie financiele ruimte hebben om grotere investeringen te doen voor duurzamere alternatieven? Zo ja, hoeveel ruimte is hiervoor?
Ja we zouden wel meer willen betalen als het duurzamer is. 150 euro per jaar per board zouden we bijvoorbeeld wel kunnen betalen.

INTERVIEW - Jelmer, *Ripstar*

Huidige situatie

Kun je iets vertellen over hoe jullie huidige inkoopsysteem van boards eruit ziet? Welke boards kopen jullie, wanneer en hoe veel kopen jullie er, waar komen ze vandaan en hoe duur zijn ze dan?
We hadden Softech boards in het verleden, nu Vision. We hebben prettig contact met vision en hun boards zijn ook van redelijk goede kwaliteit. We kopen elk jaar 70-90 boards in en ze zijn voor ons 220-250 euro per stuk. Ze gaan dan ongeveer 3-4 seizoenen mee, waarbij ze ongeveer 4 maanden per jaar in gebruik zijn. Dit is wel 2 seizoenen bij onze goede camps, en dan nog 2 bij de kindercamps waar ze niet in hele goede staat meer hoeven te zijn.
We hadden een keer een slechte batch tijdens corona, dit was het Flare model ipv het Takeoff model. Toen was de kwaliteit heel slecht.

Kun je iets vertellen over veelvoorkomende problemen/schades die ontstaan aan de boards, en hoe ontstaan die meestal?
Er komt wel eens een vin doorheen of er komen gaten in. Het deck kan ook delamineren door de zon. Als er dan een bubbel inzit en je die doorsnijd is ie lek en niet meer te repareren. Dan kun je hem eigenlijk weggooien. We proberen donkere kleuren in de boards te vermijden omdat die in Frankrijk en Spanje veel te heet worden.
Over het algemeen zijn de meeste dings die je ziet aan de rails van de softtops. Deze zijn eigenlijk een soort bumper, waar soms scherpe dingen tegenaan komen als je ze lat vallen, of ergens tegenaan stoot.

Wat gebeurt er op het moment dat er schade ontstaat aan de boards? Repareren jullie ze zelf, brengen jullie ze ergens heen, of vervangen jullie ze?
We doen kleine reparaties aan het begin of einde seizoen. We gebruiken siliconelijm.

Wat doen jullie met jullie boards in het off-seizoen en van wanneer tot wanneer is dat? Worden jullie boards veel verplaatst tussen plekken?
90% van de boards worden op locatie opgeslagen, en daar gebeurt in het laagseizoen niks mee. Begin april (vlak voor het seizoen) sturen we een opbouwteam naar de locatie en toe die kijken naar de boards. Als er dan iets gerepareerd moet worden doen ze dat zelf.

Wat gebeurt er aan het einde van de levensduur van jullie boards? Wanneer is een board voor jullie echt niet meer te gebruiken, en na hoe lang gebeurt dit meestal?
Als ie snapped of als je voelt dat de stringer niet meer heel is. Dit gebeurt gemiddeld na 4 jaar. We proberen ze dan te hergebruiken als bankjes, versiering, of iets anders op de camps.

Kun je iets vertellen over hoe het doorverkopen van jullie boards werkt? Hoeveel verdienen jullie daaruit terug en aan wat voor surfers verkopen jullie meestal?

We verkopen eigenlijk geen boards door. Heel af en toe op aanvraag maak ik wel eens een deal voor iemand. Als we boards afschrijven kunnen we er echt nog maar een paar tientjes voor krijgen en dat is het vervoeren naar Nederland niet waard.

Weet je toevallig ook wat er gebeurt met boards die echt helemaal kapot zijn, worden die verbrand? Hoeveel zijn dit er?
Het wordt naar een afvalverzamelpunt gebracht. Hier worden ze denk ik gewoon verbrand.

Toekomst

Duurzaamheid staat hoog op jullie agenda. Hoe past jullie huidige gebruik van surfboards daarin en hoe zijn jullie van plan om hier in de toekomst mee om te gaan?
We hebben de doelstelling om klimaatneutraal te worden. We eten alleen vega en compenseren voor onze busreizen.

Wat heeft jullie nieuwe bestuur van het bedrijf voor invloed op wat voor keuzes hierin worden gemaakt?
Ik maak de keuzes voor de surfscholen. Als het om grote bedragen gaat, zoals bij surfboards, overleg ik wel met collega's.

Hoe zou een service-based business model eruit zien voor jullie?
Ik zie dit wel zitten. Wel zouden we niet verantwoordelijk willen zijn voor het terughalen van de boards. Deze slaan we nu gewoon bij de campings op, en als we deze helemaal terug naar Nederland zouden moeten halen wordt het een stuk minder duurzaam ook. Ook willen we wel het ripstar logo op de boards hebben.
De kosten van opslag en reparatie zijn niet echt hoog, maar toch zou het wel wat schelen als we het niet zouden hoeven doen.

Hoe zou een board er in jouw ogen uitzien in deze situatie?
Topsheet die je eraf kunt halen en een hele sturdy onderkant.

INTERVIEW - Tim, Softdog Surf + Surfblend

1 - Boards

Waar komen jullie boards vandaan?
Bij Surfblend gebruiken we boards van Softdog surf. Deze boards komen uit china, want Europa is te duur. Softdog is ontstaan vanuit Surfblend, omdat we bij de surfcamps eigenlijk elk jaar een hele lading nieuwe boards moesten kopen. Toen zijn we gaan nadenken over een softtop die zo lang mogelijk mee gaat.

Hoe worden ze gemaakt?
Dubbele laag glasvezel en bamboo deck, 1 laag glasvezel bottom. Bij de finboxes zitten PVC pijpjes waar de vinnen doorheen komen. Zo is ie helemaal afgesloten en gaat ie minder snel lekken.

Waarom nog een extra laag bamboe?
Voor extra sterkte onder de foamlaag.

Hoe worden lagen op elkaar geplakt?
Epoxy en lijm.

Voor wie zijn jullie boards getarget (surfscholen / gevorderde pleziersurfer)?
Surfscholen. Alleen surfscholen in Spanje en Frankrijk zijn nog lastig te bereiken omdat die gewoon elk jaar zo goedkoop mogelijke boards kopen.

2 - Repairs / EOL

Is duurzaamheid iets waar jullie mee bezig zijn?
Ja, we gebruiken ipv bubble wrap nu kartonnen dozen.

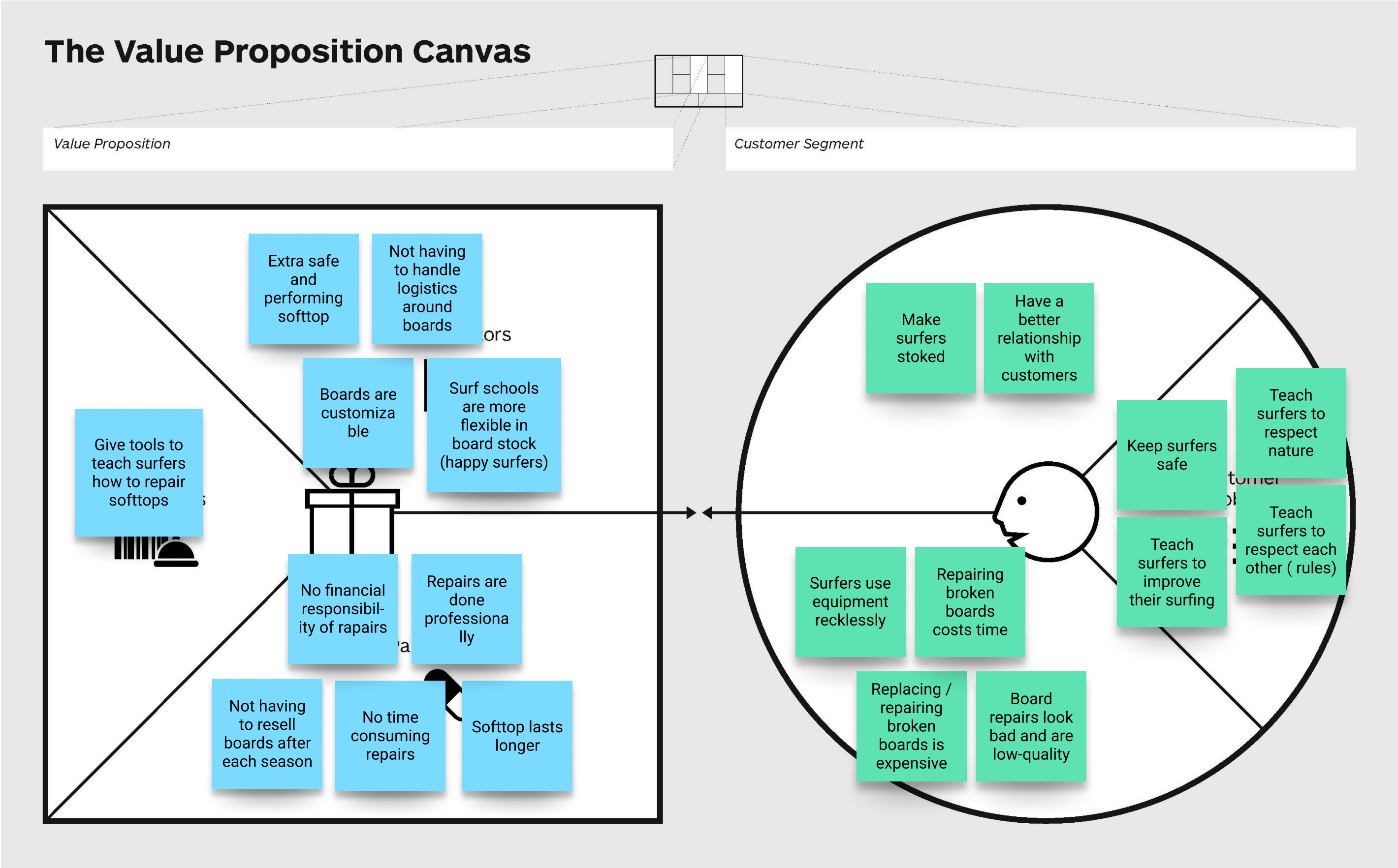
Hoe lang gaan jullie boards meestal mee?
Deze boards gaan nu meestal 3-4 jaar mee.

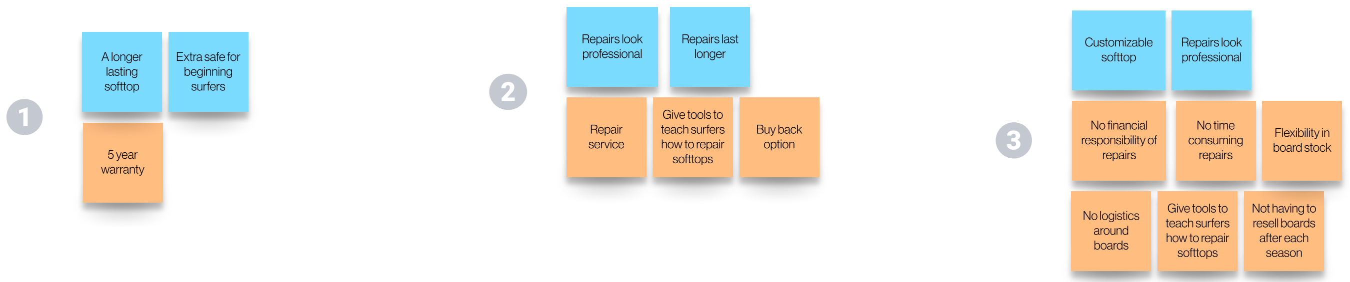
Bieden jullie ook reparaties aan?
We bieden repair kits aan met IXPE foam en lijm. Ook raden we aan om de finboxen met flexibele lijm te repareren (silicone) als er beschadigingen aan zijn.

Kunnen boards gerecycled worden?
Nee

Wat gebeurt er anders met jullie boards aan het einde van hun levensduur?
Aan het einde van surfcamps wordt een tweedehands board sale georganiseerd. Dan worden ze lokaal verkocht voor ongeveer de helft van de prijs.

Appendix 2 - Value proposition canvas





Appendix 3 - Co-creation

Setup

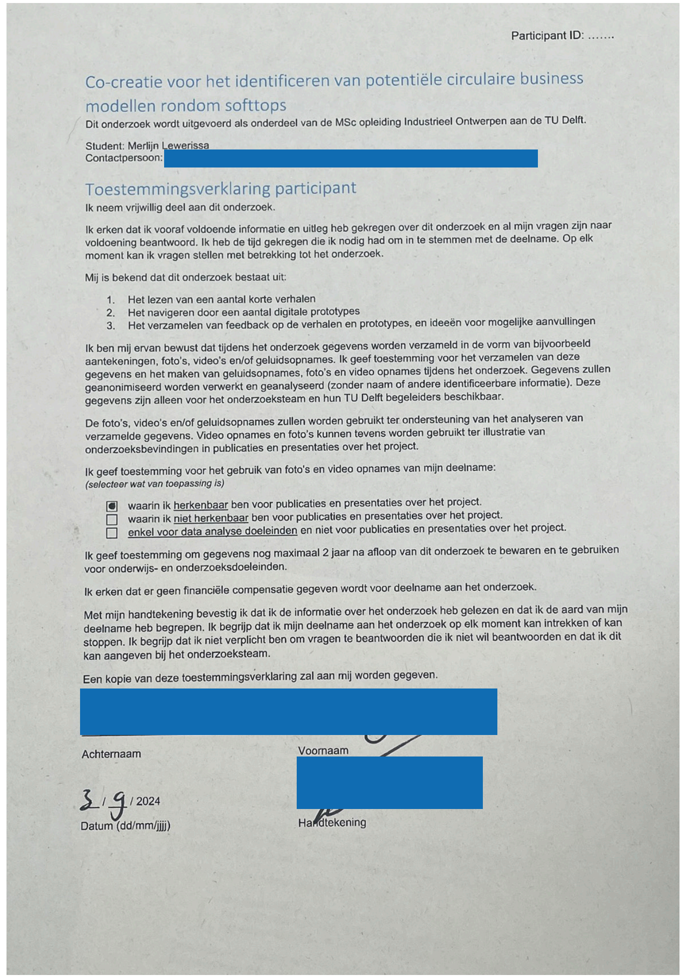
Goal - *To validate current - and develop new value propositions for surf schools through a circular business model.*

Intro - Explain session, and make clear that participants should be as honest and critical as they want to be

1 **Part 1, Storytelling** - Take participants through three different forms of business models (*1. classic long life model, 2. gap exploiter model, 3. access model*) by telling them a story. Each story is followed by a few open questions about how they would envision this model, and what pains and gains they would associate with it.

2 **Part 2, Prototype testing** - Make participants interact with three basic prototypes, corresponding with the different models. The prototypes are similar in user interface, but probe the participants to give feedback on whether they would use the system by showing them how it works in practice.

3 **Part 3, Presenting** - Introduce participants to my envisioned model.



Participant ID: ....

Co-creatie voor het identificeren van potentiële circulaire business modellen rondom softtops

Dit onderzoek wordt uitgevoerd als onderdeel van de MSc opleiding Industrieel Ontwerpen aan de TU Delft.

Student: Merlijn Lewerissa
Contactpersoon: [redacted]

Toestemmingsverklaring participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik vooraf voldoende informatie en uitleg heb gekregen over dit onderzoek en al mijn vragen zijn naar voldoening beantwoord. Ik heb de tijd gekregen die ik nodig had om in te stemmen met de deelname. Op elk moment kan ik vragen stellen met betrekking tot het onderzoek.

Mij is bekend dat dit onderzoek bestaat uit:

1. Het lezen van een aantal korte verhalen
2. Het navigeren door een aantal digitale prototypes
3. Het verzamelen van feedback op de verhalen en prototypes, en ideeën voor mogelijke aanvullingen

Ik ben mij ervan bewust dat tijdens het onderzoek gegevens worden verzameld in de vorm van bijvoorbeeld aantekeningen, foto's, video's en/of geluidsopnames. Ik geef toestemming voor het verzamelen van deze gegevens en het maken van geluidsopnames, foto's en video opnames tijdens het onderzoek. Gegevens zullen geanonimiseerd worden verwerkt en geanalyseerd (zonder naam of andere identificeerbare informatie). Deze gegevens zijn alleen voor het onderzoeksteam en hun TU Delft begeleiders beschikbaar.

De foto's, video's en/of geluidsopnames zullen worden gebruikt ter ondersteuning van het analyseren van verzamelde gegevens. Video opnames en foto's kunnen tevens worden gebruikt ter illustratie van onderzoeksbevindingen in publicaties en presentaties over het project.

Ik geef toestemming voor het gebruik van foto's en video opnames van mijn deelname:
(selecteer wat van toepassing is)

- [x] waarin ik herkenbaar ben voor publicaties en presentaties over het project.
- [ ] waarin ik niet herkenbaar ben voor publicaties en presentaties over het project.
- [ ] enkel voor data analyse doeleinden en niet voor publicaties en presentaties over het project.

Ik geef toestemming om gegevens nog maximaal 2 jaar na afloop van dit onderzoek te bewaren en te gebruiken voor onderwijs- en onderzoeksdoeleinden.

Ik erken dat er geen financiële compensatie gegeven wordt voor deelname aan het onderzoek.

Met mijn handtekening bevestig ik dat ik de informatie over het onderzoek heb gelezen en dat ik de aard van mijn deelname heb begrepen. Ik begrijp dat ik mijn deelname aan het onderzoek op elk moment kan intrekken of kan stoppen. Ik begrijp dat ik niet verplicht ben om vragen te beantwoorden die ik niet wil beantwoorden en dat ik dit kan aangeven bij het onderzoeksteam.

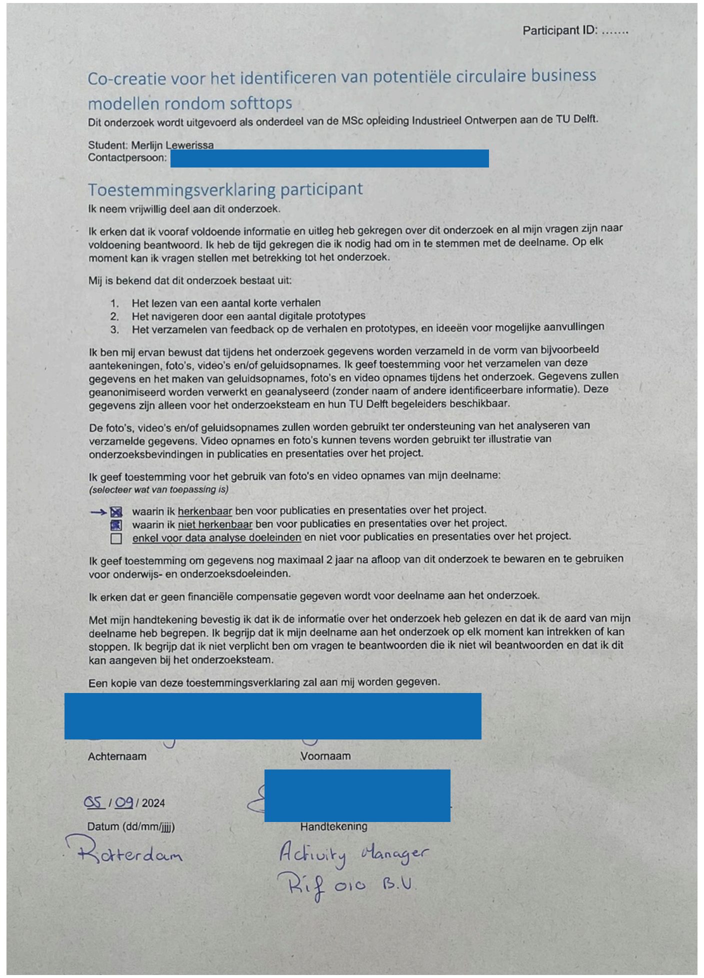
Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

[redacted]

Achternaam | Voornaam

[redacted]

3 / 9 / 2024
Datum (dd/mm/jjjj) | Handtekening



Participant ID: ....

Co-creatie voor het identificeren van potentiële circulaire business modellen rondom softtops

Dit onderzoek wordt uitgevoerd als onderdeel van de MSc opleiding Industrieel Ontwerpen aan de TU Delft.

Student: Merlijn Lewerissa
Contactpersoon: [redacted]

Toestemmingsverklaring participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik vooraf voldoende informatie en uitleg heb gekregen over dit onderzoek en al mijn vragen zijn naar voldoening beantwoord. Ik heb de tijd gekregen die ik nodig had om in te stemmen met de deelname. Op elk moment kan ik vragen stellen met betrekking tot het onderzoek.

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Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

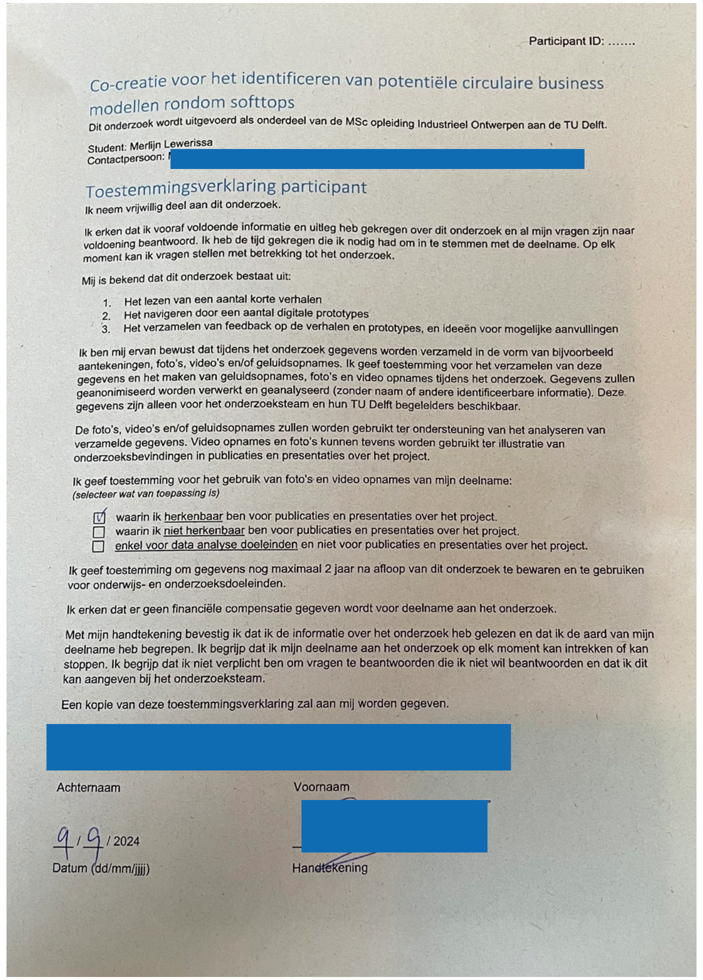
[redacted]

Achternaam | Voornaam

[redacted]

05 / 09 / 2024
Datum (dd/mm/jjjj) | Handtekening

Rotterdam | Activity Manager Rif 010 B.V



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Co-creatie voor het identificeren van potentiële circulaire business modellen rondom softtops

Dit onderzoek wordt uitgevoerd als onderdeel van de MSc opleiding Industrieel Ontwerpen aan de TU Delft.

Student: Merlijn Lewerissa
Contactpersoon: [redacted]

Toestemmingsverklaring participant

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- [ ] waarin ik niet herkenbaar ben voor publicaties en presentaties over het project.
- [ ] enkel voor data analyse doeleinden en niet voor publicaties en presentaties over het project.

Ik geef toestemming om gegevens nog maximaal 2 jaar na afloop van dit onderzoek te bewaren en te gebruiken voor onderwijs- en onderzoeksdoeleinden.

Ik erken dat er geen financiële compensatie gegeven wordt voor deelname aan het onderzoek.

Met mijn handtekening bevestig ik dat ik de informatie over het onderzoek heb gelezen en dat ik de aard van mijn deelname heb begrepen. Ik begrijp dat ik mijn deelname aan het onderzoek op elk moment kan intrekken of kan stoppen. Ik begrijp dat ik niet verplicht ben om vragen te beantwoorden die ik niet wil beantwoorden en dat ik dit kan aangeven bij het onderzoeksteam.

Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

[redacted]

Achternaam | Voornaam

[redacted]

9 / 9 / 2024
Datum (dd/mm/jjjj) | Handtekening

Appendix 3 - Co-creation
Consent forms

Stories + intervew questions (NL)

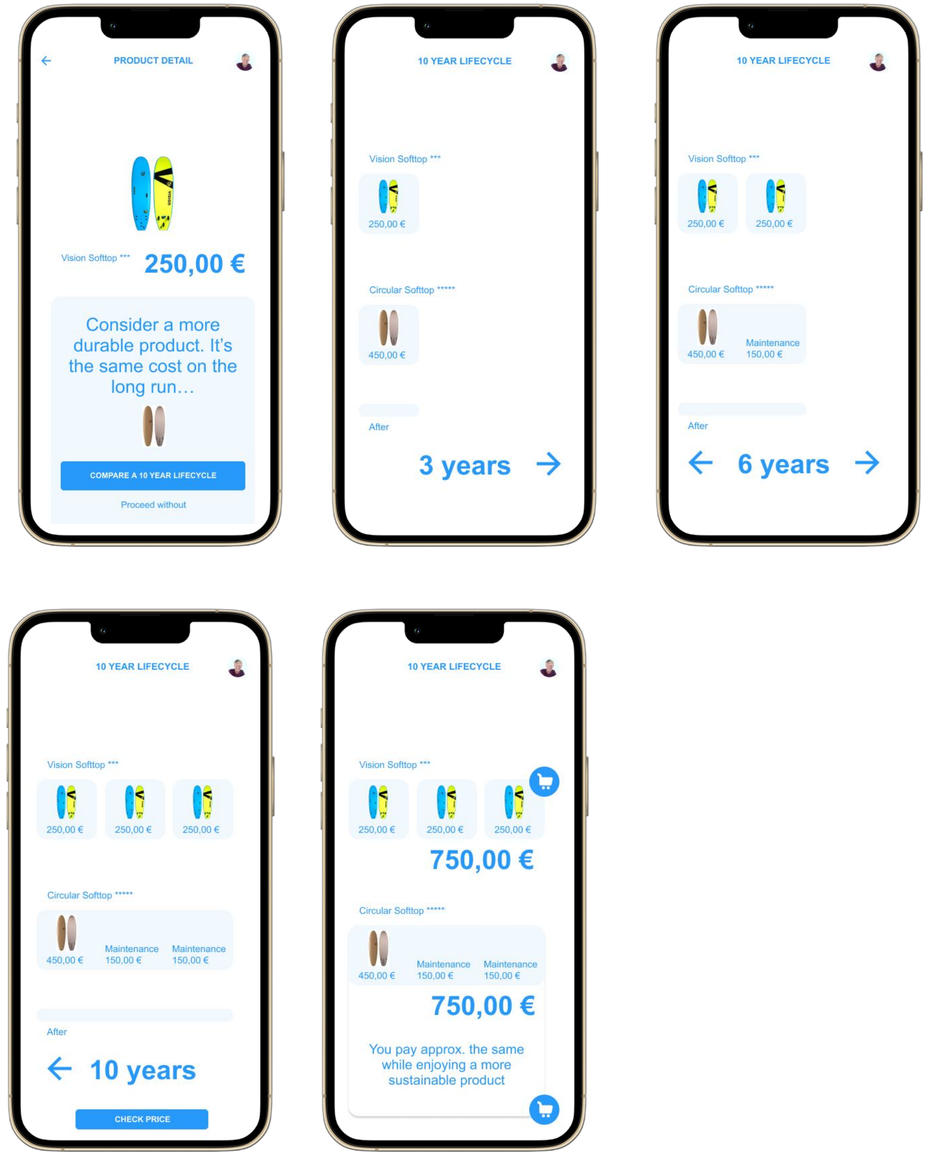
1 **Klassiek duurzaam** - Stel je voor dat er een nieuwe softtop beschikbaar is, waarbij een levensduur van minimaal 5 jaar wordt verwacht. De energie en materialen die het kost om het board te maken zijn vergelijkbaar met de huidige productie, maar omdat hij een stuk langer meegaat is het een veel duurzamer alternatief. De extra lange levensduur staan wel tegenover een iets hogere prijs.

2 **De tussenbater** - Stel je voor dat er door een nieuwe reparatiemethode meer waarde uit oude softtops gehaald kan worden. In plaats van de softtops proberen door te verkopen aan surfers, kun je ze nu ook allemaal voor een kleine prijs terug verkopen aan de leverancier. Dit is wat minder dan de verkoopprijs aan surfers, maar alle boards kunnen in een keer terug naar de leverancier.

3 **Toegang** - Stel je voor dat je afstapt van de klassieke manier van eigenaarschap. In plaats van het inkopen doen van een hele nieuwe lading softtops, om de 2 / 3 jaar, ga je de huurboards leasen. Je betaalt elk jaar een bedrag, en in ruil daarvoor beschik je het hele surfseizoen lang over X aantal softtops die in goede werkende staat zijn.
De boards zijn niet meer eigendom van je surfschool, maar van het bedrijf van wie je ze leased. Je kunt ze niet meer doorverkopen, maar onderhoud aan de boards hoef je ook niet meer zelf te doen. Ze worden vervangen als ze kapot gaan, en aan het einde van het seizoen worden ze allemaal opgehaald.

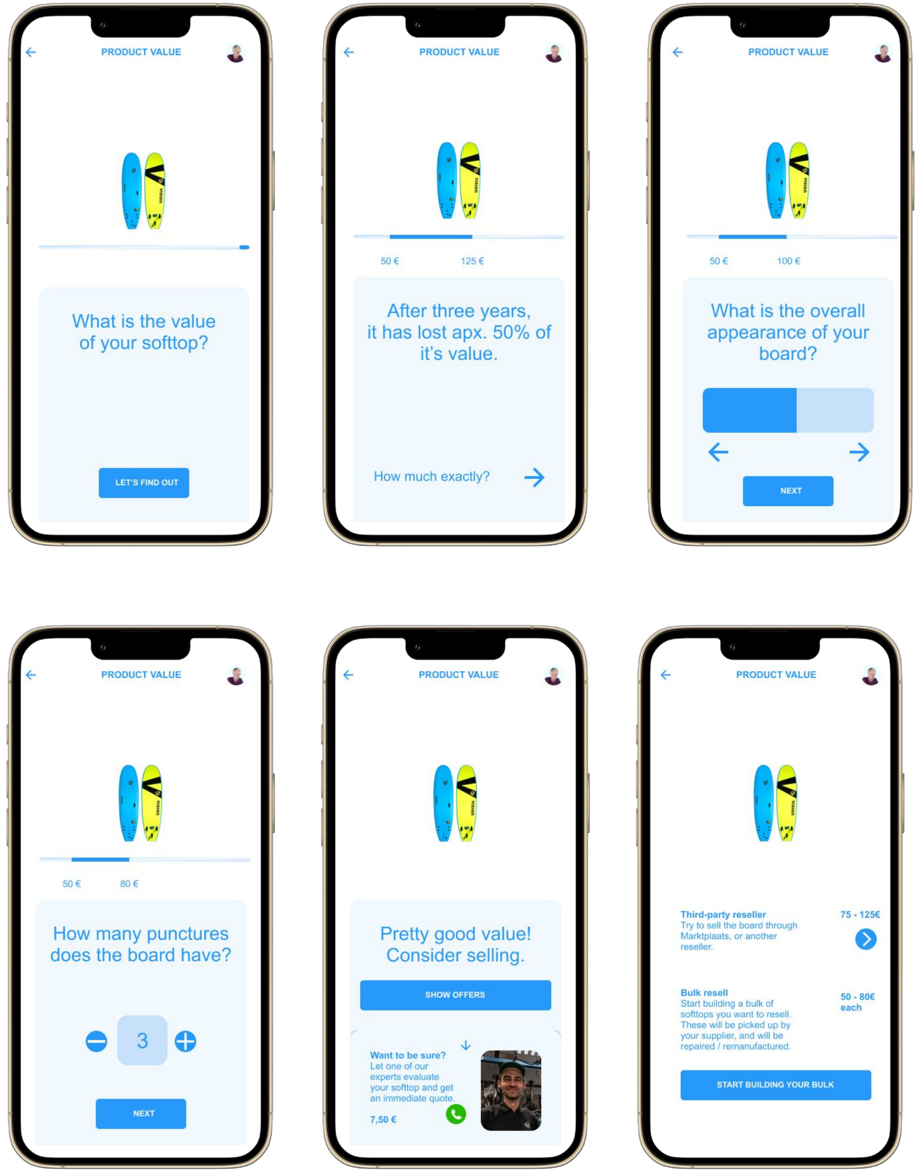
1. *Question 1 - Hoe zou je dit systeem voor je zien? Hoe past het in je huidige manier van surflessen geven, en wat zou er veranderen voor je?*
2. *Question 2 - Wat zijn de voor- en nadelen die je ziet van dit systeem?*
3. *Question 3 - Welke van deze dingen zijn belangrijk voor je, en waarom?*

UX prototype 1 (classic long-life)



Appendix 3 - Co-creation

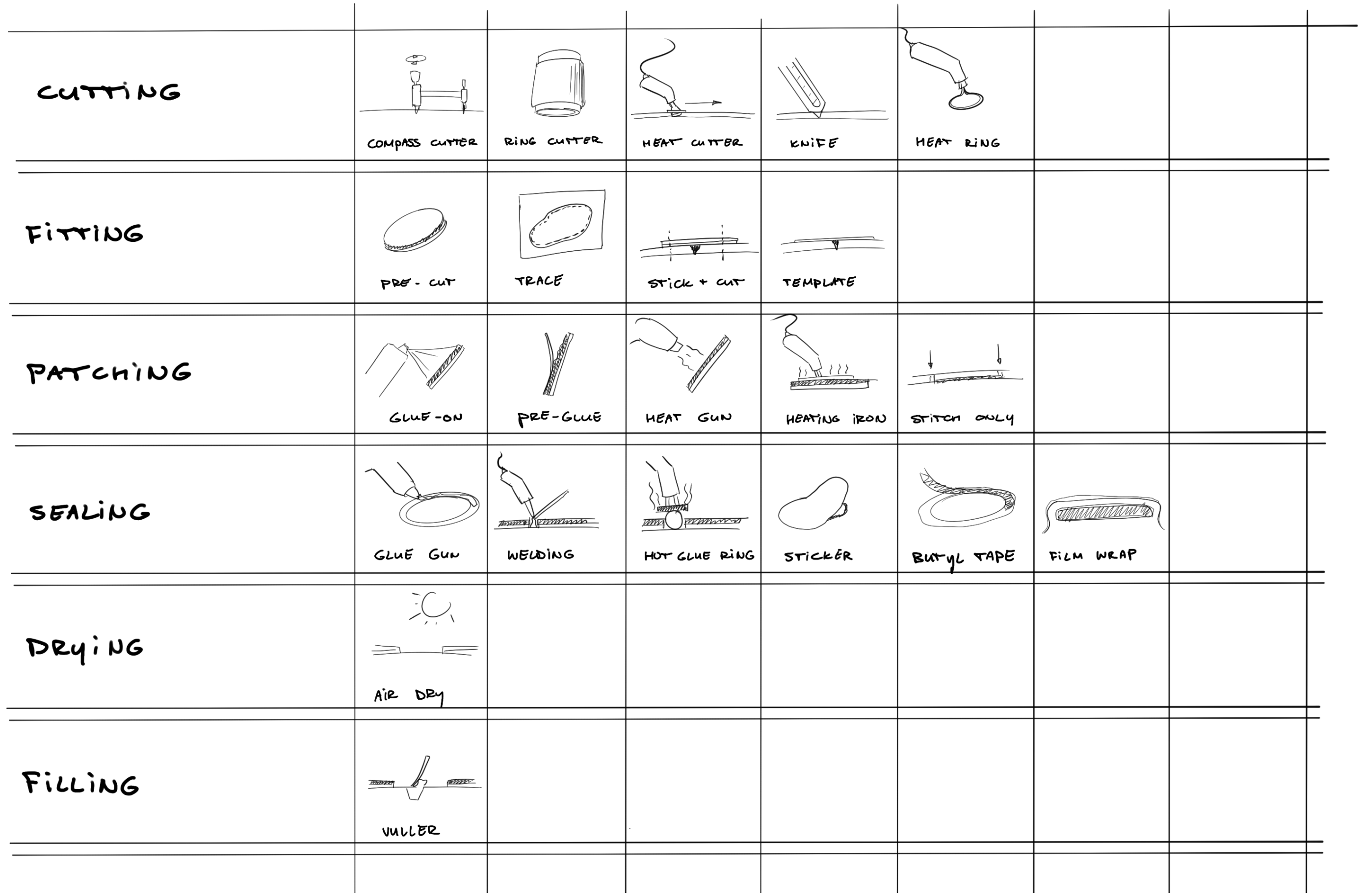
UX prototype 2 (gap exploiter)



Appendix 3 - Co-creation

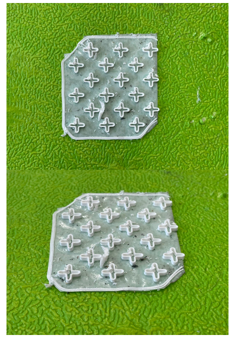
UX prototype 2 (access)

Appendix 4 - Morphological chart



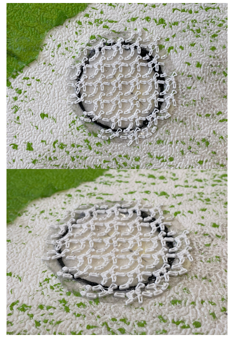
Appendix 5 - Repair conceptualising

Prototyping seals



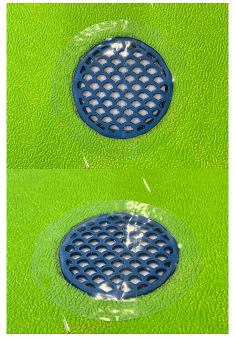
Option 1

1. 3D-print



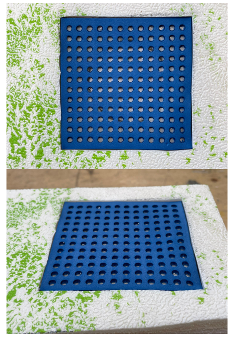
Option 2

1. Patch - 3D-print
2. Knife cut



Option 3

1. Patch - Lasercut
2. Cut - Knife cut



Option 4

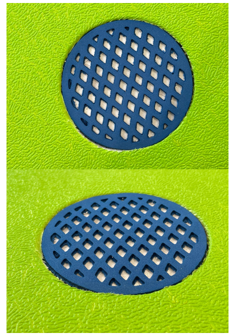
1. Patch - Lasercut
2. Cut - Knife cut
3. Seal - Layering

Option 5

1. Patch - Lasercut
2. Cut - Knife cut
3. Seal - Layering

Option 6

1. Patch - Lasercut
2. Cut - Circle drill
3. Seal - Layering

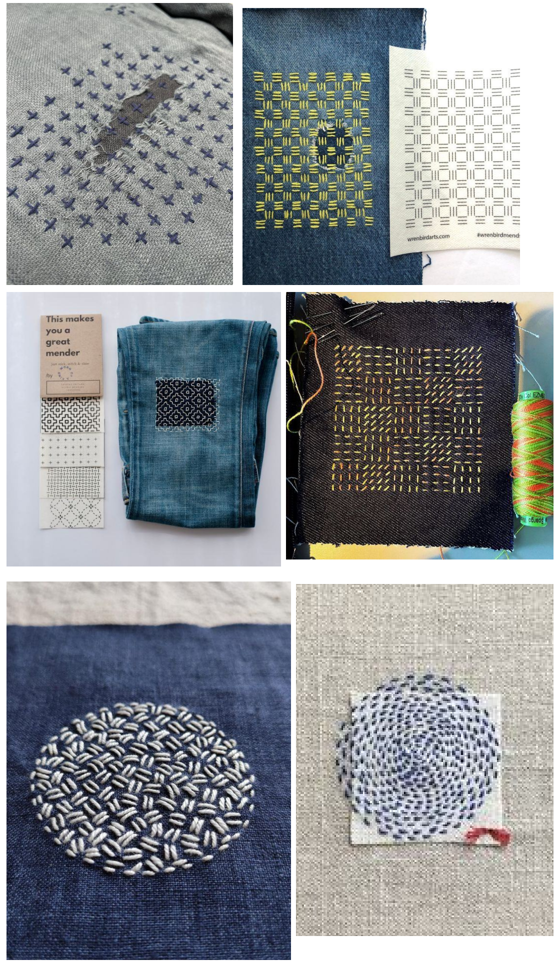


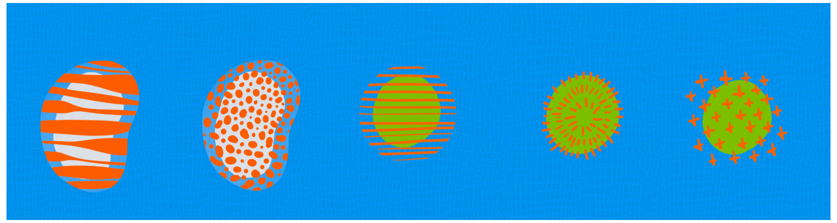
Option 7

1. Patch - Lasercut
2. Cut - Circle drill
3. Seal - Patch + rubber

Appendix 5 - Repair conceptualising

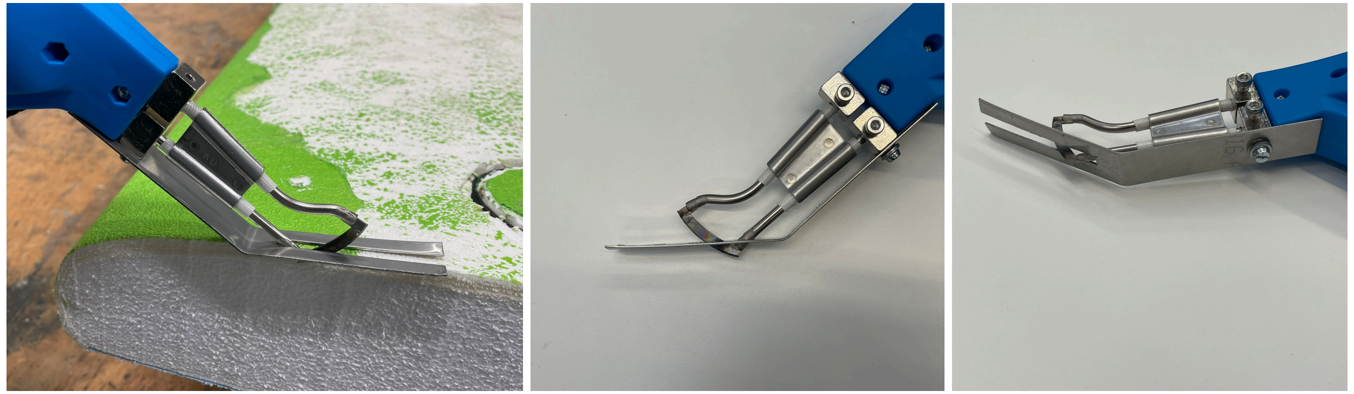
Sticker pattern design





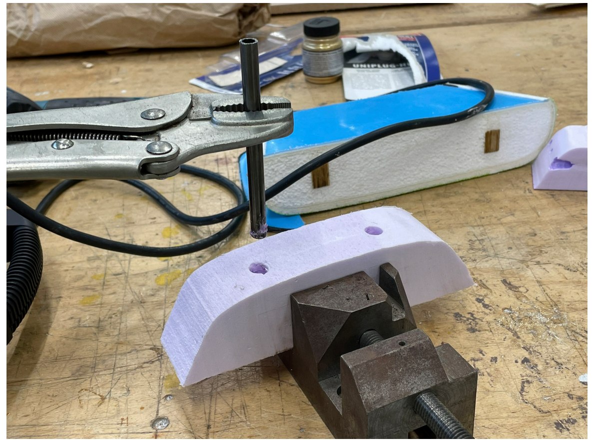
Appendix 6 - Repair+ conceptualising

Heat cutting tool + patch and film wrap prototype



Appendix 7 - Construction conceptualising

Modular tailblock prototype



Appendix 8 - Waterproof seal testing

Experiment setup

Appendix 8 - Waterproof seal testing

Results

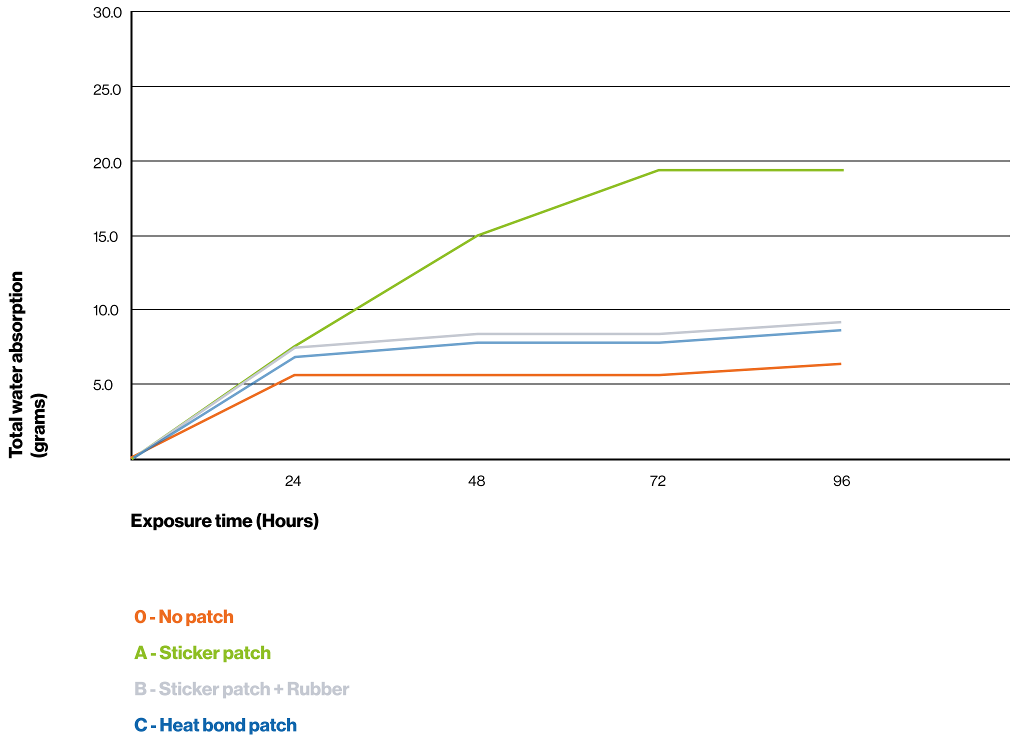
		Initial	24H	48H	72H	96H
Control	Sample	33.5	33.5	33.5	33.5	33.5
	Water	202.5	191.5	186.0	178.0	167.5
	Total	236.0	225.5	219.0	211.0	201.0
	Absorption	-	**0**	**0**	**0**	**0**
0 - No patch	Sample	126.0	131.5	131.5	131.5	132.0
	Water	199.5	185.0	178.0	171.0	162.5
	Total	325.5	315.5	309.5	302.0	294.5
	Absorption	-	**5.5**	**5.5**	**5.5**	**6.0**
A - Sticker patch	Sample	123.0	130.5	133.0	132.0	132.0
	Water	199.5	180.0	167.5	157.0	146.5
	Total	322.5	311.5	300.0	289.0	279.0
	Absorption	-	**7.5**	**15.0**	**19.5**	**19.5**
B - Sticker patch + Rubber	Sample	129.0	136.5	137.0	136.5	137.0
	Water	200.5	184.5	177.0	170.5	162.0
	Total	329.5	320.5	314.0	307.0	299.0
	Absorption	-	**7.5**	**8.0**	**8.0**	**8.5**
C - Heat bond patch	Sample	122.5	129.5	131.0	130.5	131.0
	Water	201.0	184.5	178.0	171.0	162.5
	Total	323.5	314.5	309.0	301.5	293.0
	Absorption		**7.0**	**7.5**	**7.5**	**8.0**

Initial conditions

Time - 5/10/2024, 1:30 PM
Temperature - 20 C

Appendix 8 - Waterproof seal testing

Results



Appendix 9 - Cost price estimation

Repair

COSTPRICE CALCULATION - REPAIR							
Part	**Subpart**	**Description**	**Seller**	**Cost**	**Amount**	**Per unit**	**Source**
	Foam patch	Material	Gerstaecker	€1.65	12	€0.14	
		Machining	Laserbeest	€1.25	3	€0.42	
	Sticker patch	Retail	Plakshop	€0.80	1	€0.80	
	Protector pad	Foam	Reused	€0.00	1	€0.00	
		Water indicator tape	Tapirtapes	€39.87	100	€0.40	
		Processing	-	€50.00	50	€1.00	
	Adhesive	Material	Hornbach	€36.99	250	€0.15	https://www.bol.com/nl/r
DECK REPAIR		Processing	-	€35.00	120	€0.29	
					Subtotal	€3.19	
					Amount	3	
					Total	€9.58	
	Protector pad	Foam	Reused	€0.00	1	€0.00	
		Water indicator tape	Tapirtapes	€39.87	100	€0.40	
		Processing	-	€35.00	50	€0.70	
	Sticker patch	Material	Boer&vanwijk	€350.00	300	€1.17	
		Screenprinting	Boer&vanwijk	€0.00	1	€0.00	https://www.boerenvanw
BOTTOM REPAIR		3M adhesive layer	Boer&vanwijk	€0.00	1	€0.00	
					Total	€2.27	
					Amount	3	
					Total	€6.80	
					Total	€16.37	

Appendix 9 - Cost price estimation

Repair+

COSTPRICE CALCULATION - REPAIR+							
Part	**Subpart**	**Item**	**Seller**	**Cost**	**Amount**	**Per unit**	**Link**
Materials	*Adhesive*		Sikaflex	€12.00	30	€0.40	
	Spray adhesive		Hornbach	€36.99	100	€0.37	
	Foam		Reused	€0.00	1	€0.00	
Tools	*Heat cutter*		Expondo	€95.00	1000	€0.10	
Processing	*Labour*			€35.00	2	€17.50	
					Total	€18.36	
					Amount	2	
					Total	€36.73	

Appendix 9 - Cost price estimation

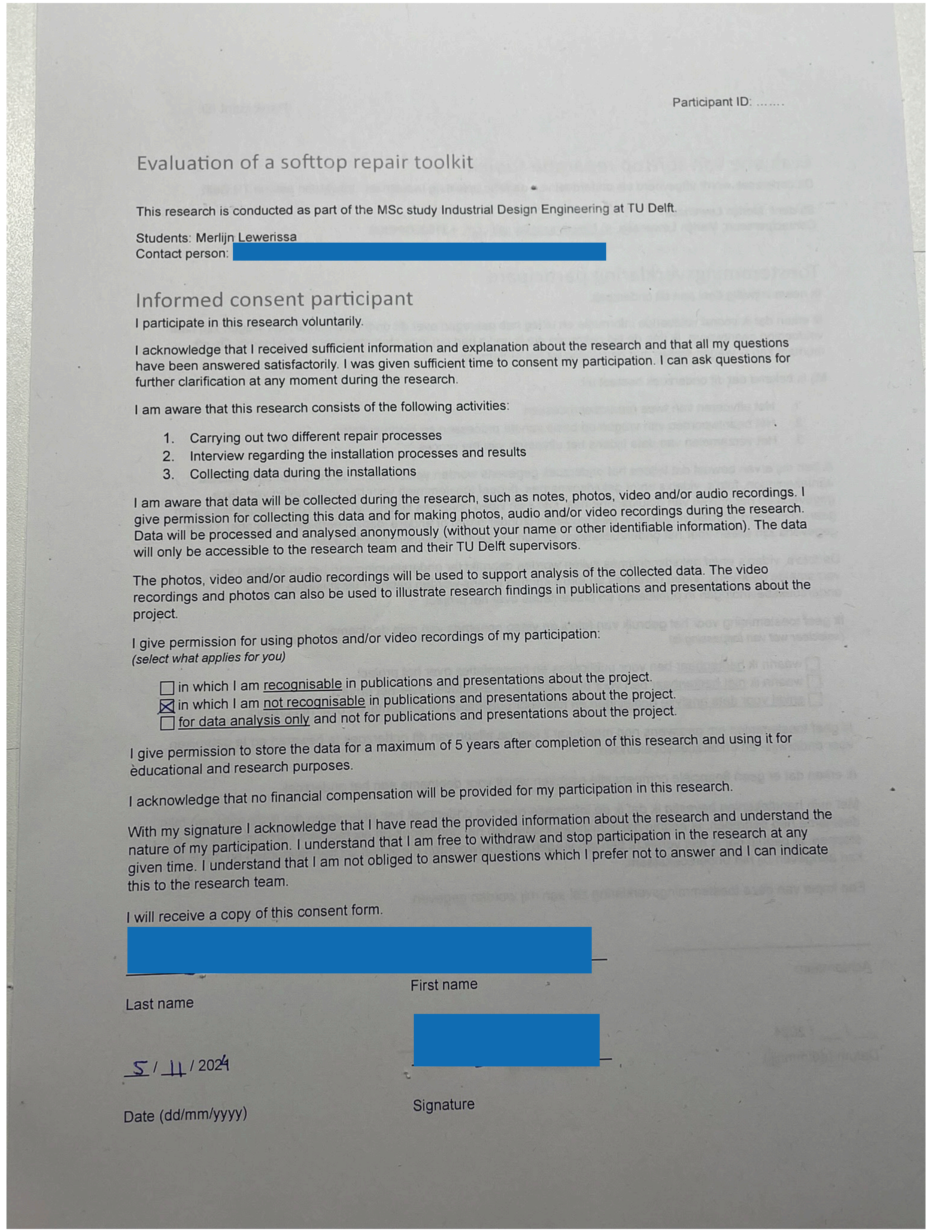
Logistics

COSTPRICE CALCULATION - LOGISTICS							
Part	**Subpart**	**Item**	**Seller**	**Cost**	**Amount**	**Per unit**	**Link**
Transport Level 1	*Price per km/board*			€1.10	70	€0.02	https://detransporters.nl/calculator/
	Price at X km				200	€3.14	
Logistics Level 1	*Storage*	6 month, partial rent		€300.00	70	€4.29	
					Total	€7.44	
					Amount	1	
					Total	€7.44	
Transport Level 2	*Price per km/board*			€0.60	20	€0.03	https://detransporters.nl/calculator/
	Price at X km				600	€18.00	
Logistics Level 2	*Storage*	3 month, partial rent		€150.00	70	€2.14	
					Total	€20.17	
					Amount	1	
					Total	€20.17	

Appendix 9 - Cost price estimation

System

COSTPRICE CALCULATION - TOTAL							
Strategy	**Description**	**Amount**	**Cost**	**Frequency (years)**	**Cost per year**	**Per unit**	**Link**
Production		1	€120.00	1	€120.00		
1 - Repair		6	€16.37	10	€163.74		
2 - Repair+	Level 1	2	€36.73	4	€146.92		
2 - Repair+	Level 2	2	€18.36	5	€91.82		
3 - Refurbish		1	€120.00	1	€120.00		
Logistics	Level 1	1	€7.44	6	€44.67		
Logistics	Level 2	1	€20.17	4	€80.69		
			Total		€767.84		
			Years		10		
			Total per year		€76.78		



Participant ID: ....

Evaluation of a softtop repair toolkit

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Students: Merlijn Lewerissa
Contact person: [redacted]

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

1. Carrying out two different repair processes
2. Interview regarding the installation processes and results
3. Collecting data during the installations

I am aware that data will be collected during the research, such as notes, photos, video and/or audio recordings. I give permission for collecting this data and for making photos, audio and/or video recordings during the research. Data will be processed and analysed anonymously (without your name or other identifiable information). The data will only be accessible to the research team and their TU Delft supervisors.

The photos, video and/or audio recordings will be used to support analysis of the collected data. The video recordings and photos can also be used to illustrate research findings in publications and presentations about the project.

I give permission for using photos and/or video recordings of my participation:
(select what applies for you)

☐ in which I am recognisable in publications and presentations about the project.
☒ in which I am not recognisable in publications and presentations about the project.
☐ for data analysis only and not for publications and presentations about the project.

I give permission to store the data for a maximum of 5 years after completion of this research and using it for educational and research purposes.

I acknowledge that no financial compensation will be provided for my participation in this research.

With my signature I acknowledge that I have read the provided information about the research and understand the nature of my participation. I understand that I am free to withdraw and stop participation in the research at any given time. I understand that I am not obliged to answer questions which I prefer not to answer and I can indicate this to the research team.

I will receive a copy of this consent form.

[redacted]

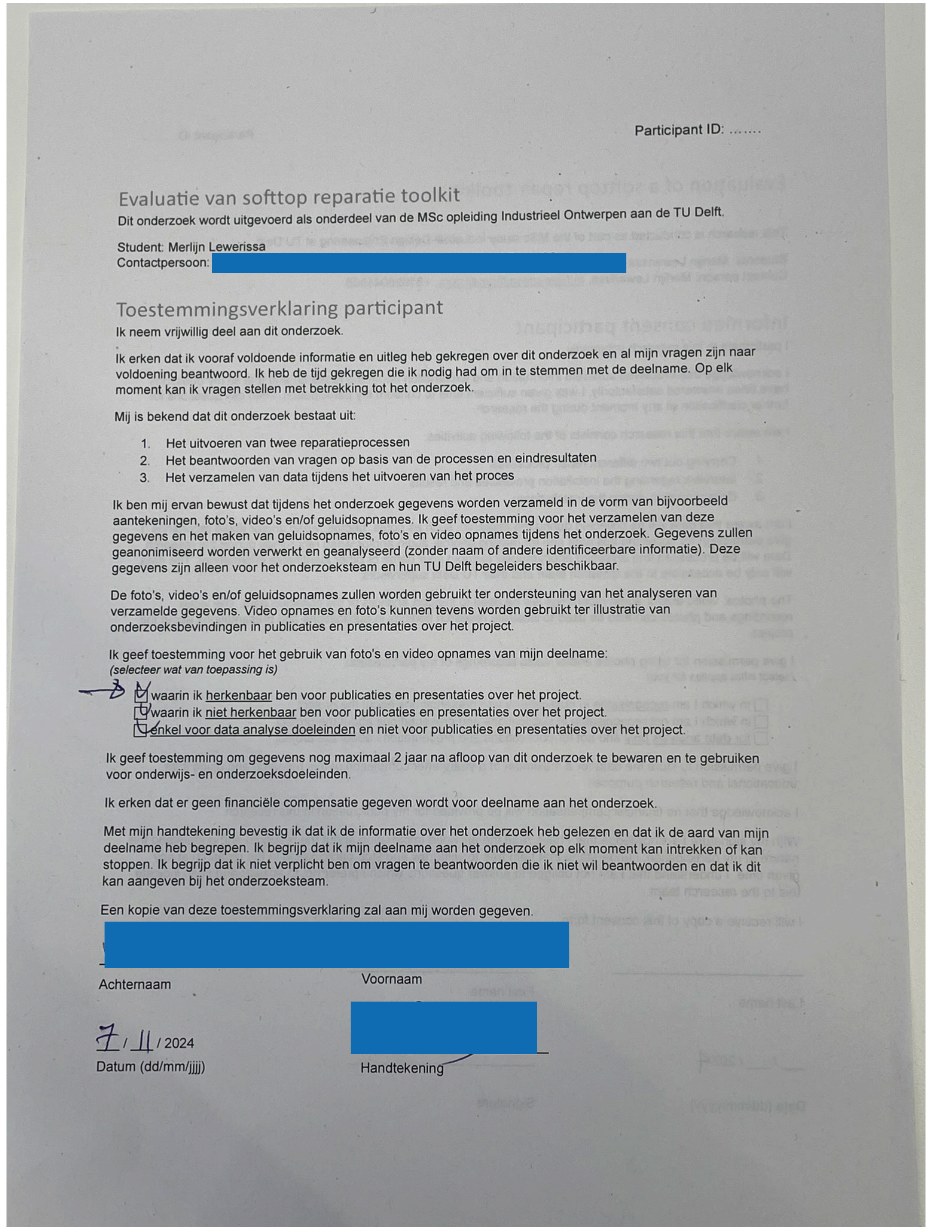
Last name First name

[redacted]

5 / 11 / 2024

Date (dd/mm/yyyy) Signature

Consent forms



Participant ID: ....

Evaluatie van softtop reparatie toolkit

Dit onderzoek wordt uitgevoerd als onderdeel van de MSc opleiding Industrieel Ontwerpen aan de TU Delft.

Student: Merlijn Lewerissa
Contactpersoon: [redacted]

Toestemmingsverklaring participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik vooraf voldoende informatie en uitleg heb gekregen over dit onderzoek en al mijn vragen zijn naar voldoening beantwoord. Ik heb de tijd gekregen die ik nodig had om in te stemmen met de deelname. Op elk moment kan ik vragen stellen met betrekking tot het onderzoek.

Mij is bekend dat dit onderzoek bestaat uit:

1. Het uitvoeren van twee reparatieprocessen
2. Het beantwoorden van vragen op basis van de processen en eindresultaten
3. Het verzamelen van data tijdens het uitvoeren van het proces

Ik ben mij ervan bewust dat tijdens het onderzoek gegevens worden verzameld in de vorm van bijvoorbeeld aantekeningen, foto's, video's en/of geluidsopnames. Ik geef toestemming voor het verzamelen van deze gegevens en het maken van geluidsopnames, foto's en video opnames tijdens het onderzoek. Gegevens zullen geanonimiseerd worden verwerkt en geanalyseerd (zonder naam of andere identificeerbare informatie). Deze gegevens zijn alleen voor het onderzoeksteam en hun TU Delft begeleiders beschikbaar.

De foto's, video's en/of geluidsopnames zullen worden gebruikt ter ondersteuning van het analyseren van verzamelde gegevens. Video opnames en foto's kunnen tevens worden gebruikt ter illustratie van onderzoeksbevindingen in publicaties en presentaties over het project.

Ik geef toestemming voor het gebruik van foto's en video opnames van mijn deelname:
(selecteer wat van toepassing is)

☑ waarin ik herkenbaar ben voor publicaties en presentaties over het project.
☐ waarin ik niet herkenbaar ben voor publicaties en presentaties over het project.
☐ enkel voor data analyse doeleinden en niet voor publicaties en presentaties over het project.

Ik geef toestemming om gegevens nog maximaal 2 jaar na afloop van dit onderzoek te bewaren en te gebruiken voor onderwijs- en onderzoeksdoeleinden.

Ik erken dat er geen financiële compensatie gegeven wordt voor deelname aan het onderzoek.

Met mijn handtekening bevestig ik dat ik de informatie over het onderzoek heb gelezen en dat ik de aard van mijn deelname heb begrepen. Ik begrijp dat ik mijn deelname aan het onderzoek op elk moment kan intrekken of kan stoppen. Ik begrijp dat ik niet verplicht ben om vragen te beantwoorden die ik niet wil beantwoorden en dat ik dit kan aangeven bij het onderzoeksteam.

Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

[redacted]

Achternaam Voornaam

[redacted]

7 / 11 / 2024

Datum (dd/mm/jjjj) Handtekening

Participant ID: ....

Evaluatie van softtop reparatie toolkit

Dit onderzoek wordt uitgevoerd als onderdeel van de MSc opleiding Industrieel Ontwerpen aan de TU Delft.

Student: Merlijn Lewerissa

[redacted]

Toestemmingsverklaring participant

Ik neem vrijwillig deel aan dit onderzoek.

Ik erken dat ik vooraf voldoende informatie en uitleg heb gekregen over dit onderzoek en al mijn vragen zijn naar voldoening beantwoord. Ik heb de tijd gekregen die ik nodig had om in te stemmen met de deelname. Op elk moment kan ik vragen stellen met betrekking tot het onderzoek.

Mij is bekend dat dit onderzoek bestaat uit:

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3. Het verzamelen van data tijdens het uitvoeren van het proces

Ik ben mij ervan bewust dat tijdens het onderzoek gegevens worden verzameld in de vorm van bijvoorbeeld aantekeningen, foto's, video's en/of geluidsopnames. Ik geef toestemming voor het verzamelen van deze gegevens en het maken van geluidsopnames, foto's en video opnames tijdens het onderzoek. Gegevens zullen geanonimiseerd worden verwerkt en geanalyseerd (zonder naam of andere identificeerbare informatie). Deze gegevens zijn alleen voor het onderzoeksteam en hun TU Delft begeleiders beschikbaar.

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(selecteer wat van toepassing is)

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Een kopie van deze toestemmingsverklaring zal aan mij worden gegeven.

[redacted]

Appendix 10 - Repair evaluation
Consent forms

Evaluation of a softtop repair toolkit

This research is conducted as part of the MSc study Industrial Design Engineering at TU Delft.

Students: Merlijn Lewerissa

[redacted]

Informed consent participant

I participate in this research voluntarily.

I acknowledge that I received sufficient information and explanation about the research and that all my questions have been answered satisfactorily. I was given sufficient time to consent my participation. I can ask questions for further clarification at any moment during the research.

I am aware that this research consists of the following activities:

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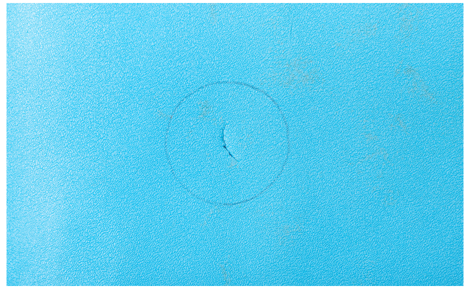
I will receive a copy of this consent form.

[redacted]

Appendix 10 - Repair evaluation

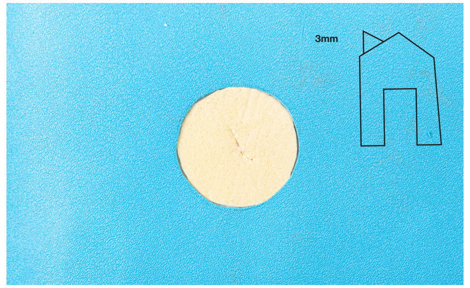
User manual deck

1. Identify leak



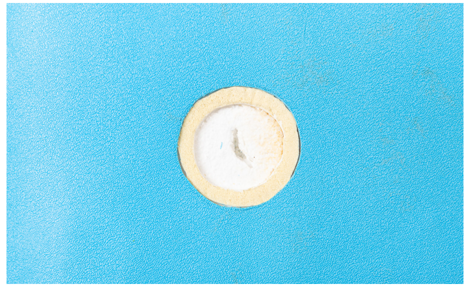
2. Mark the cutting line

Take the largest patch from the repair kit, and place it so that the wound is centered underneath it. Take a pencil and mark the cutting line around the patch.



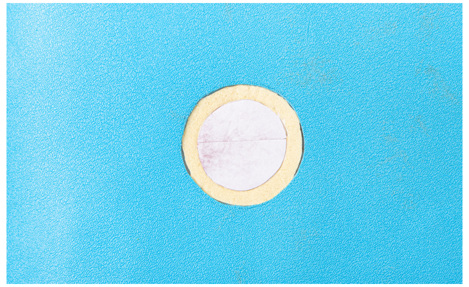
3. Cut first layer

Grab the stanley knife and lock it with the blade 3mm (image for 1:1 comparison) exposed. Cut the foam on the marked circle, keeping the blade at a 45 degree angle. Peel off the outer layer of foam, using your knife or hands.



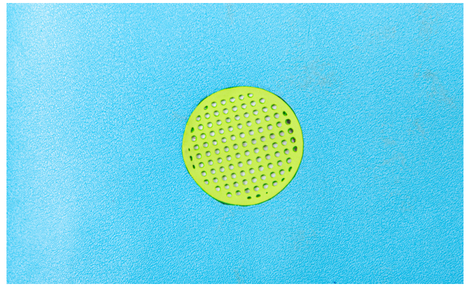
4. Cut second layer

Take the small patch from the repair kit, and trace it on the center of the inner layer of foam. Cut the circle using the knife on the same depth (3mm deep) and peel off the second layer of foam.



4. Place protection pad

Take the protection pad as it is, and place it on the wound.



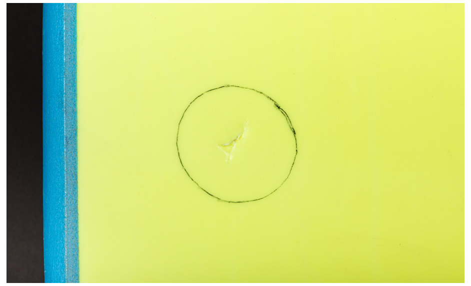
4. Place sealing patch

Peal off the sticker cover and place the foam sealing patch in the opening. Press firmly around the edges of the patch, making sure it adheres well to the foam underneath. The patch should be kept dry for 24 hours, after which it is completely water resistant again.

Appendix 10 - Repair evaluation

User manual bottom

1. Identify leak



2. Mark the cutting line

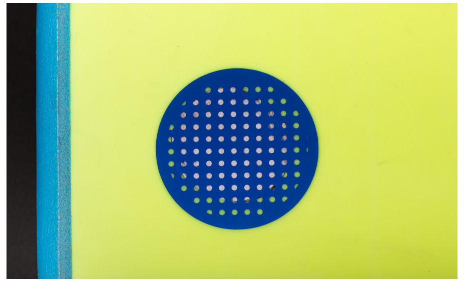
Mark the cutting line. You can also use a marker here, since this is easy to erase from the material.

3. Cut material

Grab the stanley knife and lock it with the blade 6mm exposed. Cut the material (around the circle) all the way to the core. Remove all the material that's layered on top of the EPS.

4. Place protection pad

Take the protection pad as it is, and place it on the wound.



4. Place sealing patch

Take the thin sealing patch, and place over the protection pad. Try to place it centered over the pad. Also keep dry for 24 hours.

Appendix 11 - Surf schools in the Netherlands

Surfschools in NL			
Place	**Name**	**Size**	**Boards**
Domburg	Sportshop	M	60
	De surf club	M	60
Ouddorp	Surflounge	S	30
	Surfkaravaan	S	30
	Natural high	M	60
Hoek van Holland	The Hook	S	30
	Surf School Hoek van Holland	L	90
	Surfschool senang	M	60
Rotterdam	Rif010	S	30
s-Gravenzande	Surfschool Dutch Surf Academy	M	60
	Waves 'N Ripples Surfschool	S	30
Monster	Dreams Surfschool	S	30
Den Haag	Boca Boardriders Surfschool	S	30
	Surf Nature Surf School	S	30
Scheveningen	The Shore	M	60
	Aloha	M	60
	Hartbeach	L	90
	Surf 's Cool!	S	30
Katwijk	Surfschool katwijk	M	60
Noordwijk	Lex Surfschool Noordwijk	M	60
	Surfschool Noordwijk	S	30
Zandvoort	Surfschool Surfana Rapa Nui	L	90
	Pepsports	S	30
	The Spot	S	30
	First Wave/ Surfana Surfschool Noosa	M	60
Wijk aan zee	de Hangout	L	90
	Ozlines	M	60
Castricum	Surfschool castricum	S	30
Egmond aan zee	Backyard	S	30
Camperduin	Hookipa beach	S	30
Callantsoog	Surfschool callantsoog	M	60
Julianadorp	High5	S	30
Texel	Surf center paal 9	S	30
	Surf school texel	S	30
	Surfschool foamball	M	60
Vlieland	Surfana vlieland	S	30
Terschelling	Surfschool gosurfing	S	30
	Surfschool Surfvillage	S	30
Schiermonnikoog	Surfclub Schiermonnikoog	S	30
		Totaal	1800

DESIGN FOR our future

TUDelft

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME
Complete all fields and indicate which master(s) you are in

Family name: Lewerissa [redacted]
Initials: M. F.
Given name: Merlijn
Student number: [redacted]

IDE master(s): IPD ✓ Dfl SPD
2nd non-IDE master:
Individual programme *(date of approval)*:
Medisign
HPM

SUPERVISORY TEAM
Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Conny Bakker	dept./section	Sustainable Design Engineering
mentor	Israel Carrete	dept./section	Sustainable Design Engineering
2nd mentor	Antoine Stohr		
client:	Good, Thanks Surfboards		
city:	Rotterdam	country:	Netherlands
optional comments	Conny Bakker and Israel Carrete both work at the SDE department of IDE, but have different expertise that can both have a positive impact on the project (Israel in material science, and Conny in circular business models and design strategies).		

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Name: Conny Bakker
Date: 13 May 2024
Signature: [redacted]

CHECK ON STUDY PROGRESS
To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total		EC
Of which, taking conditional requirements into account, can be part of the exam programme		EC

[redacted]

Comments:

[redacted]

Sign for approval (SSC E&SA)

[redacted]

Name Rik Ledoux Date 27 May 2024 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

[redacted]

Sign for approval (BoEx)

[redacted]

Name Monique von Morgen Date 28 May 2024 Signature

DESIGN FOR our future

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Personal Project Brief – IDE Master Graduation Project

Name student Merlijn Lewerissa **Student number** [redacted]

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title The Circular Surfboard, a redesign for a service-based business model

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Surfing is one of the most popular water sports globally. An estimated 35 million people surf regularly on our planet. The equipment you need is an important aspect of surfing, which is why in total the global surf industry has an annual revenue of about 22 billion dollars. [1]

The larger part of this surf industry is taken up by the production of surfboards, which is an extremely toxic and wasteful process [2]. Add to this the constant transport of boards across the globe (shipping and surf travel), and you see why the sport is quite unfriendly to our environment.
At the same time, surfing is heavily reliant on nature. Besides the equipment, its only real requirement is the presence of good waves, and the effects of climate change are posing a threat to the sport. Research showed that the effects of climate change (and especially responses to climate change, such as coastal armoring) are harming surf spots worldwide [3]

They call this the Surfers Paradox. Every surfer wants to help preserve the ocean, but surfboards are as polluting as sports equipment can get.

[1] International Surfing Association. (2021). Surfing: A New Olympic Sport. https://isasurf.org/wp-content/uploads/2021/04/ISA-Host-Cities-Presentation-2019_update.pdf
[2] Schultz, T. C. (2009). The Surfboard Cradle-to-Grave. University of California, Berkeley. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=d2430e8cc63c75c92757452b8bc87198b783415b
[3] Sadrpour, N., & Reineman, D. R. (2023). The impacts of climate change on surfing resources. Shore and Beach, 32–48. https://doi.org/10.34237/1009113

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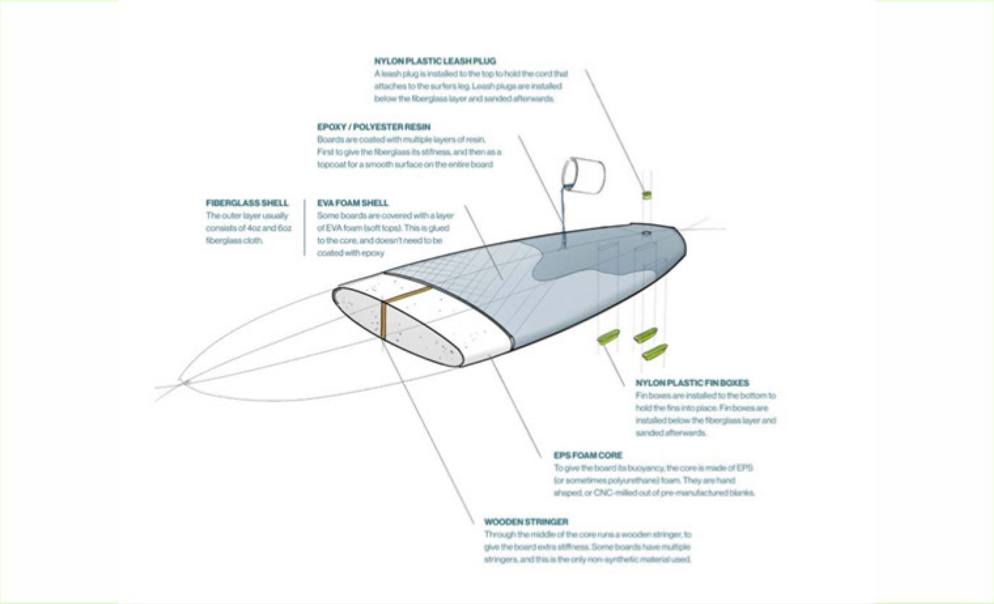

image / figure 1 Current construction of surfboards

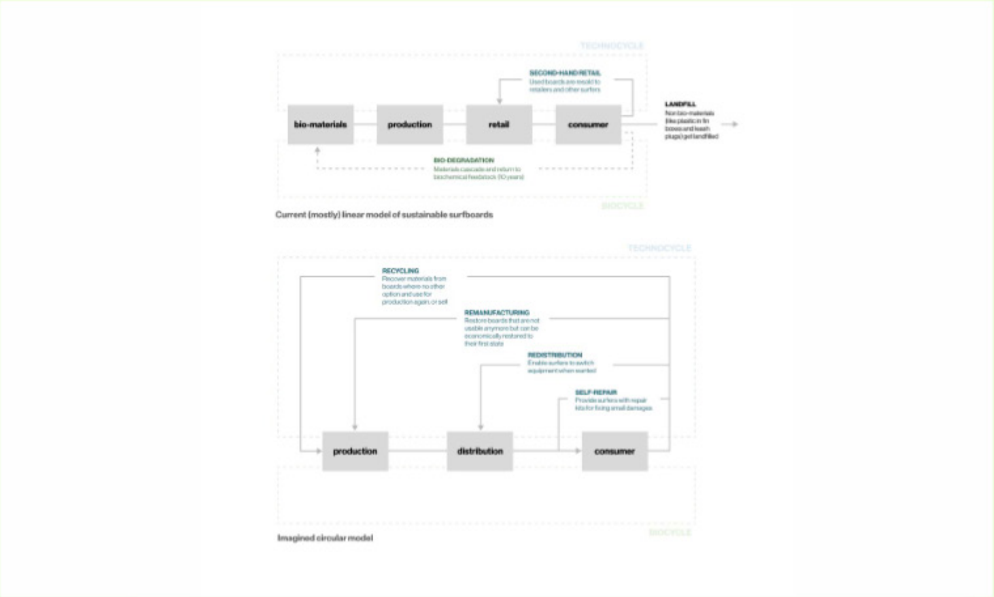

image / figure 2 Imagined product lifecycle: from linear to circular

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

A visualization of how surfboards are usually made nowadays is shown in Figure 1. The environmental issue of surfboards lies in several factors:
- Boards are very polluting. The materials produce a lot of toxic byproducts and components are very hard to separate. This makes it lose most of its value at end-of-life, mostly resulting in incineration as a way of disposal. [2][4]
- They are extremely breakable. Most boards have an outer layer of fiberglass, which cracks and dents easily. This type of board has to be repaired to keep it watertight.
- They lack versatility. Surfers use a different board for every wave condition, which is why you will always find a surfers garage brimming with boards. As a surfer's skill level advances the need for a different board keeps arising.

Current solutions that try to tackle the surfer's paradox focus on trying to reduce toxicity by using bio-based materials. However, when looked at from a circular design perspective (value pyramid), you see that most value is lost during the use phase. This project focuses on recapturing material value, that is lost when boards are landfilled or incinerated. This would allow the company that makes them to implement a more circular (service-based) business model. (figure 2)

[4] Barcelos, R. L., Magnago, R. F., & Lerípio, A. A. (2018). Analysis of the technological impact on industry and its effects on waste production and disposal: a case study of the surfboard manufacturing industry. Ciência E Natura, 40, 49. https://doi.org/10.5902/2179460x31540

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Design, prototype and validate a new surfboard construction that improves repairability, remanufacturability and enables a fitting end-of-life strategy, making it suitable for a more service-based circular business model.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

The first phase of the project will consist of an analysis of different types of surfboard users, and conducting LCA's on different surfboard constructions. The analysis will help me develop a design frame and pick a target group around which I can develop a circular business model. The business model will enable me to use design strategies from the book 'Products That Last', of which 'design for repair' and 'design for disassembly' are the two most relevant ones in my eyes.
In redesigning the surfboard construction, I will use the CATSS methodology [5] to create an understanding of the current material properties of surfboards on different structural levels. This will help me explore potential alternative materials, or find new end-of-life applications (choosing a direction will go hand-in-hand with the development of the business model).
My goal is to make a full-size prototype of the surfboard and test its performance in a real use scenario.
As a foundation for the manufacturing process, I will use a technique used by Good, Thanks Surfboards, a surfboard-making company from Rotterdam. This involves a machine developed and patented by Verdure Surfboards, a company from New Zealand. The machine allows for a more automated production process and reduces waste from CNC-milling foam. Further analysis of the technology will be done when Verdure is in Rotterdam to install the machine in June.

[5] Carrete, I. A., Joustra, J., & Balkenende, A. (2023). Circular applications through selection strategies (CATSS): a methodology for identifying reuse applications for end-of-life wind turbine blades. IOP Conference Series. Materials Science and Engineering, 1293(1), 012011. https://doi.org/10.1088/1757-899x/1293/1/012011

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	29 Apr 2024
Mid-term evaluation	4 juli 2024
Green light meeting	24 okt 2024
Graduation ceremony	28 nov 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:
From 8th of July till 18th of August (between midterm and start of second half of project) the project will be paused because of the summer break.

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I'm passionate about a lot of things, but my main interest in design lies in the Circular Economy. I get energy from designing solutions that not only suit the needs of people, but also limit waste streams as much as possible. For my graduation project, I'm looking to combine this interest with another great passion of mine: surfing. I have been spending my free time at the ocean since I was about 7 years old, which is also why I want to do my part in helping to preserve our planet.

This project will serve as a benchmark for the work I would like to do after my master's program, which lies in circular design. I'm looking to combine what I'm already good at: model making, 3D modeling & graphic design; with topics I would still like to learn more about: bio-design, circular business models & material innovation.