A new generation in the evolution of wakeboarding

The design of a feature within the vision to enrich the experience of Entertainment Enjoyers

TU Delft
Master Thesis Wouter Potma

A new generation in the evolution of wakeboarding
The design of a feature within the vision to enrich
the experience of Entertainment Enjoyers

MSc Integrated Product Design - graduation thesis
Faculty of Industrial Design Engineering
Delft University of Technology

Chair - Em. Prof. Ninaber van Eyben, B.
Mentor - ir. van den Elshout, S. A. J.
Company mentor - Podda, S.

Company - Schneestern GmbH & Co. KG
Cooperating company - Sesitec von Lerchenfeld GmbH

A new generation in the evolution of wakeboarding

The design of a feature within the vision to enrich the experience of Entertainment Enjoyers

Executive summary

Although wakeboarding is increasing in popularity and number of participants, the market of wakeboard features only fulfils the needs of a part of its potential customers. A gap has been determined in the expertise development of riders. Therefore, the focus of this project is on riders that have enough skills to complete a full round on a cable park but are not ready for currently existing features. Additionally, a distinction is made between *Adrenaline Seekers* and *Entertainment Enjoyers*. The latter is focussed on within this project. Based on this target audience analysis, an interaction vision with the qualities of Surprise, Togetherness and Encouraged is developed. This was the starting point for ideation.

In the development phase the minimum viable version of the Pad, a feature that provides a different riding experience than water without the risk for injuries, has been designed. This development is executed by combining the results of a material exploration into prototypes that are realised and tested by riders on a cable park. The evaluation of these prototypes led to the final design of the Pad, which is the first product in the development process of this new generation. According to the vision created, this development process should be continued in order to enlarge the product portfolio and realise this new generation. By enriching the wakeboarding experience of *Entertainment Enjoyers*, a new generation has started in the evolving sport wakeboarding.

Content

0.1 Introduction

Initial starting point of the project
During my time as a student at the faculty of industrial design engineering, I enlarged my passion for designing and realising physical products. Simultaneously, a love for boardsports grew by joining boardsports society DROP in Delft. At the start of 2016, my passion for designing and realising physical products got together with the love for boardsports at the event Flatstyle. At this boardsport event, organised by DROP, I was responsible for the design and realisation of the features on the course. In my search for a graduation project that matched my interests and fitted the graduation guidelines to prove ánd improve my competences, I decided to dive deeper into the world of features for boardsports, wakeboarding in particular.

Schneestern & Sesitec
This project started off individually, by performing a user research and mapping the market of wakeboard feature developers. Contradictory to my expectations, I discovered that the market of wakeboard feature developers consisted of a couple of large players globally, with a large number of small local companies. In order to make an impact with my project, I decided to try to cooperate with a large player in the market. The vision of Schneestern and Sesitec towards the evolving market of action sports seemed to be a perfect fit with my project and therefore they became the client of this graduation project.

Schneestern has been the main client in this project. As being a global developer and manufacturer of features for action sports such as wakeboarding, Schneestern's goal for this project was to discover new possibilities for wakeboard features, leading to a producible new product.
Sesitec, being a global reseller of wakeboard cable systems and parks, cooperated as a second client with a lot of experience and wide network in the world of wakeboarding. Their goal was to be able to offer new and undiscovered features to their clients.
Both companies were of great benefit for the execution of this project. There know-how and experience inspired a lot. This project would not have been where it is know without their constant support.

Figure 1: Main feature at the event Flatstyle in Delft.

Glossary

2.0 System
Cable that runs between two masts at around 5 meters above the water surface to pull a rider back and forward over the water surface individually.

Cable system
A 2.0 system or a Full Size Cable.

Cable water sports
Sports that can be executed on a cable system: wakeboarding, water-skiing, knee boarding and wake skating.

Cable park
A place where cable water sports can be executed by the use of a 2.0 System or a Full Size Cable. This park often contains one or multiple features that can be used by riders to perform tricks.

Feature
Physical object positioned in a cable park to be ridden by riders.

Full Size Cable
Cable that runs in a circle at around 8 meters above the water surface to pull multiple riders over the water surface simultaneously.

Kicker
A feature shaped as a jump. When sliding over this feature as a rider, the athlete will experience a displacement upwards.

Pad
The Pad is the final product designed, which is the result of the execution of this project.

Rider
Term used for wakeboarding athlete (wakeboarder).

Riding
Term used for sliding over the water or over a feature when wakeboarding.

0.2 Project structure

In order to execute a design project efficiently and result with well-considered outcomes, a good structure is desired. The structure of this project is based on the five stages of the Delft Innovation Model (Buijs & Valkenburg, 2005), see Figure 2. The three phases highlighted in blue were part of the scope of this project. These three phases form the chapter structure of this report, followed by a chapter of evaluation.

Figure 3 shows an overview of the process of this project.
1. Strategy formulation
During the strategy formulation an internal and external analysis were executed, as wel as a user research. This formed the basis for 7 search areas, of which on search area was evaluated best.
2. Design brief formulation
In the design brief formulation phase, this search area was further investigated by determining internal bottlenecks and analysing the target audience. In addition to that, an interaction vision was formulated. This formed the basis for idea generation. In the first generation phase, a large number of ideas were generated and evaluated. Three ideas were the starting point of a second generation phase. The design brief of the final product is the conclusion of this phase.
3. Product development
The product development phase started with a broad material and production exploration. The results of this exploration were structured using a morphological chart. The most promosing solutions of the morphological chart were converted into three prototypes, of which two were realised on full scale and evaluated in the wakeboarding context. By combining the best results from these prototypes, the final design was developed. The final design is assisted by a future vision to provide guidance for further development.

Although Figure 3 visualizes the process as a straight process, multiple iterative steps were taken within this process. It is deliberately chosen not to show all these iterations in the structure of this report. In that way, a logical instead of a chronological report is constructed.

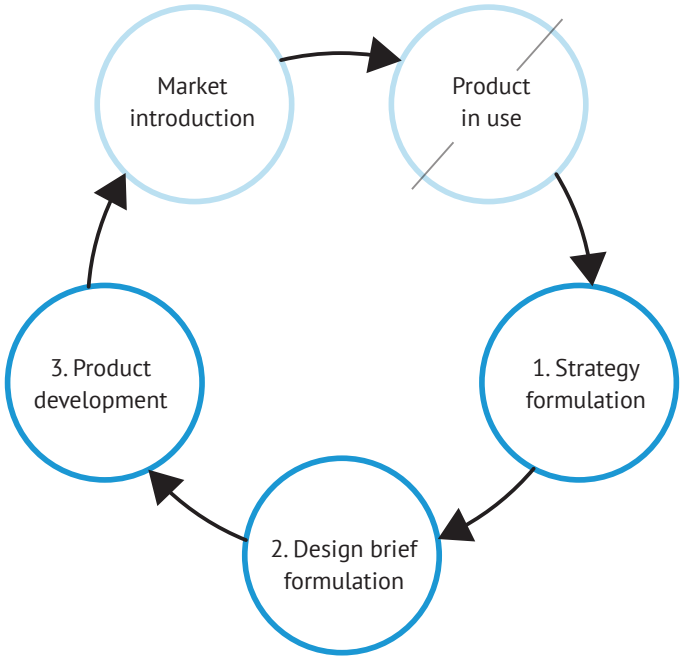


Figure 2: The five phases of the Delft Innovation Model (Buijs & Valkenburg, 2005).

1. Strategy formulation

2. Design brief formulation

3. Product development

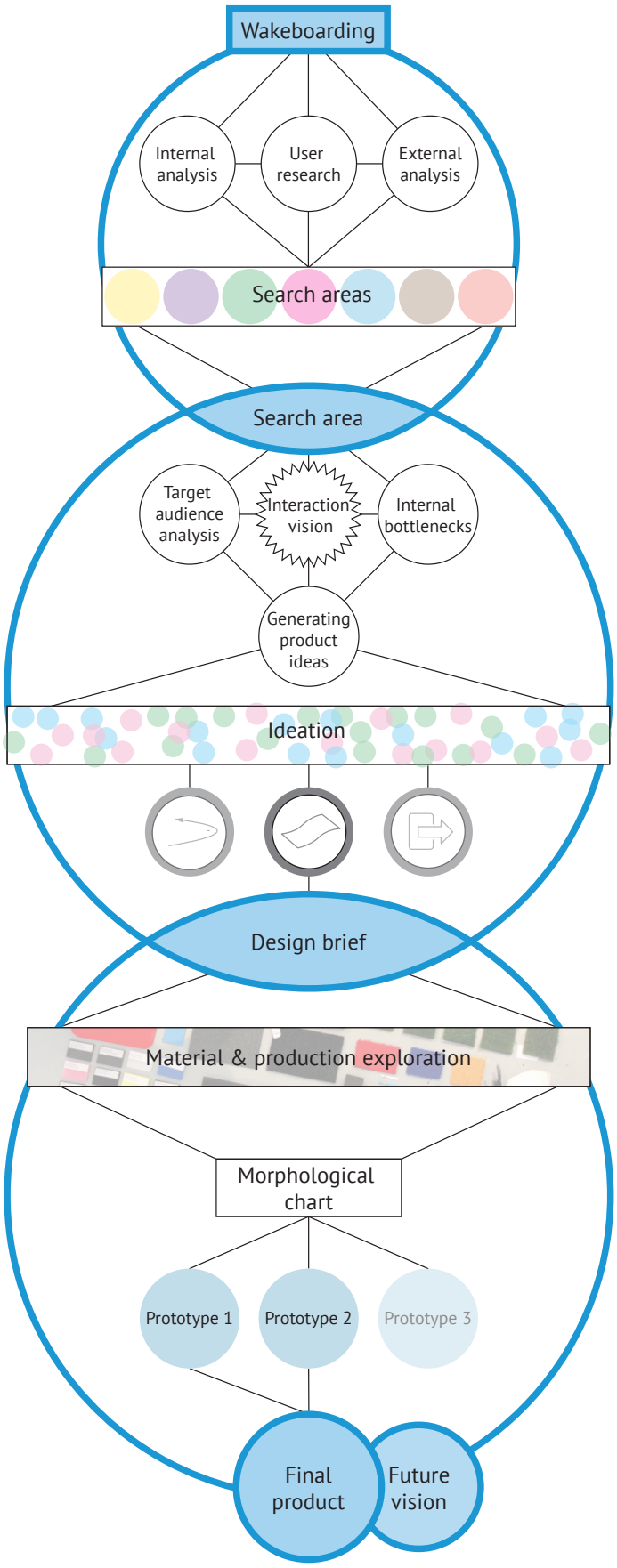


Figure 3: Overview of the process of this project, based on the Delft Innovation Model (Buijs & Valkenburg, 2005).

1 Strategy formulation

The first chapter of this report describes the strategy formulation of the project. It starts by introducing the sport wakeboarding, followed by internal and external analyses of the company Schneestern, Sesitec and their competitors. A user reseach is executed with riders and other stakeholders of the sport.

The results of these analysis have led to the construction of seven search areas. The search area with the focus on beginners and families was considered to have the most potential. Therefore, this search area was the starting point for the design brief formulation.

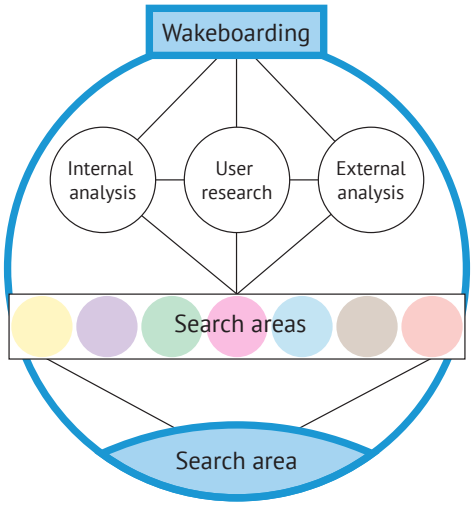


Figure 4: Strategy formulation, steps based on the Delft Innovation Model (Buijs & Valkenburg, 2005).

1.1 Wakeboarding

Wakeboarding is a boardsport that can be categorized as an extreme water sport. Practitioners of this sport, riders, are connected to a board with their feet and get pulled by a handle which makes him/her able to ride (slide) over the surface of the water. The handle is connected to a rope, which is carried by a winch, cable system or boat (Figure 7).

Wakeboarding arose in the late 1970's from a combination of water-skiing and snowboarding (Figure 5). It originates from athletes who got pulled by a boat, which then evolved into performing tricks on the wake of the boat.
The first commercial cable system was build by Bruno Rixen, which introduced new opportunities in water-skiing and wakeboarding (Wakeboarding (2017), The history of Rixen cableways (2013)).
Figure 6 shows an overview of the evolution of wakeboarding. Ever since its existence, wakeboarding has been increasing in popularity. For the Olympic games in 2020, wakeboarding is shortlisted together with 7 other developing sports. At the moment there are more than 350 cableways around the world and the International Waterski & Wakeboard Federation predicts that this will expand to 625 cableways by the time of the Olympics in 2020. (IWWF, n.d.) Statistics about the number of participants and its development are not available.

The learning curve of wakeboarding is steep at the start, when the athlete needs to get up form the water and find the balance and control to slide steadily over the water. After being able to take off, take corners and confidentially slide around on the water, the rider can start practising tricks. These tricks can be categorized in air tricks or feature tricks. Air tricks are executed by increasing tension on the cable which creates momentum to lift the rider in the air. Feature tricks are tricks using physical constructions placed in the water which provide a smooth surface (slider), ramp (kicker) or small strip (rail).

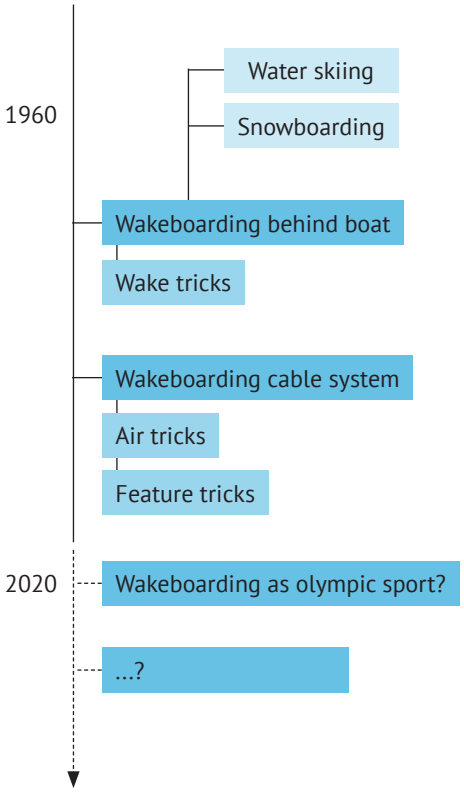


Figure 6: Evolution of wakeboarding.

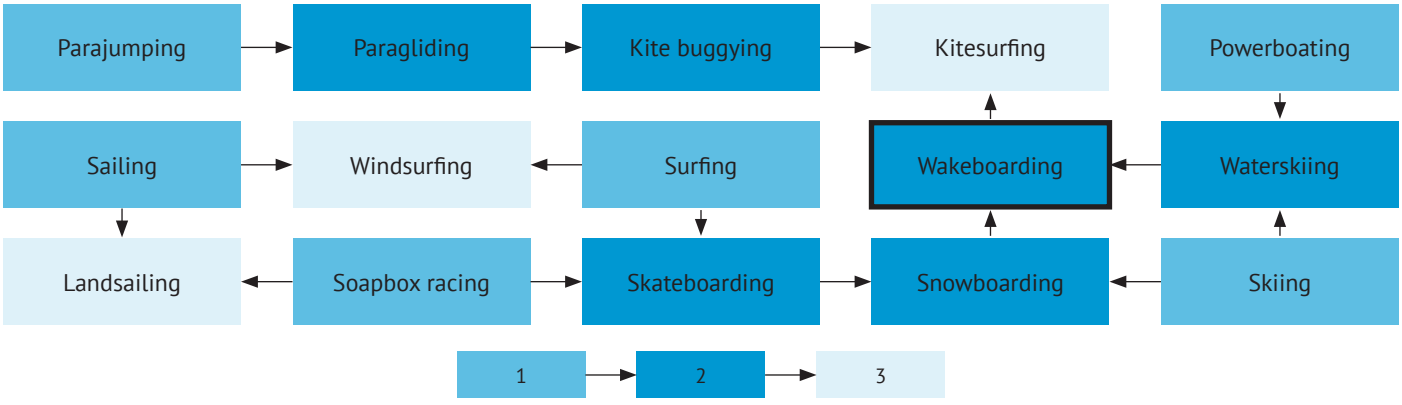


Figure 5: Origins and evolution of major extreme sports (Adjusted from Tavernsenses, 2016).

1.2 Internal analysis

This project is executed in favour of Schneestern, in cooperation with Sesitec. Both companies have a major share in the global market of action sports. Schneestern originates as a manufacturing company for the snow sports but has incorporated more action sports in its product portfolio. Sesitec is global leader in the realisation of cable systems. Schneestern and Sesitec are both located in Allgäu, an area in the South of Germany.

Figure 7: Y. Mampaey wakeboarding at Wet'n Wild.

Schneestern

Schneestern is a company that produces events and parks for extreme sports and was found in 1999. Schneestern's main focus is on the snow market but a shift towards other action sports has arose over the past years. Schneestern beliefs that the popularity of action sports will keep increasing and that in a few years time, the whole action sports sector will become in the middle of our society.
Schneestern has a workshop with welders and carpenters where all equipment is produced. The mother company Schneestern GmbH & Co. KG holds four brands, being Schneestern (snow), Velosolutions (cycling), SKG (skate) and wake. Figure 10 shows the share of each brand within the motherbrand.

Schneestern (snow)
Schneestern offers a wide range of products and services in the snow sector. Nowadays about 40% of the snow revenue comes from services like setting up a snow event or building a snowpark. These events range from snow events in city centres to the Olympic course in 2018. Schneestern also builds and maintains 11 snowparks in the European Alps during the winter season.
60% of the revenue is the result of selling equipment, like rails, boxes, tunnels and other features. Lately, the share of fun and entertaining features has become the largest part of the equipment Schneestern is selling. Schneestern has determined a gap in the market with their focus on fun & entertainment.

Velosolutions & SKG
The brand name of the cycling department is part of a wider brand, where Schneestern's part is responsible for the sales in Germany and Austria. The brand SKG (skate green) is fully owned by Schneestern. Both brands make use of the capabilities of the workshop but also use new ways to build cycling and skate parks.

Wake
Schneestern's wake department is small compared to the other departments and is always looking for ways to expand its offer on the wakeboard market. Currently, all Schneestern's wakeboard features are focussed on professionals.

Figure 8: Snowevent for professionals, produced by Schneestern.

Figure 9: Snowtunnel for beginners, produced by Schneestern.

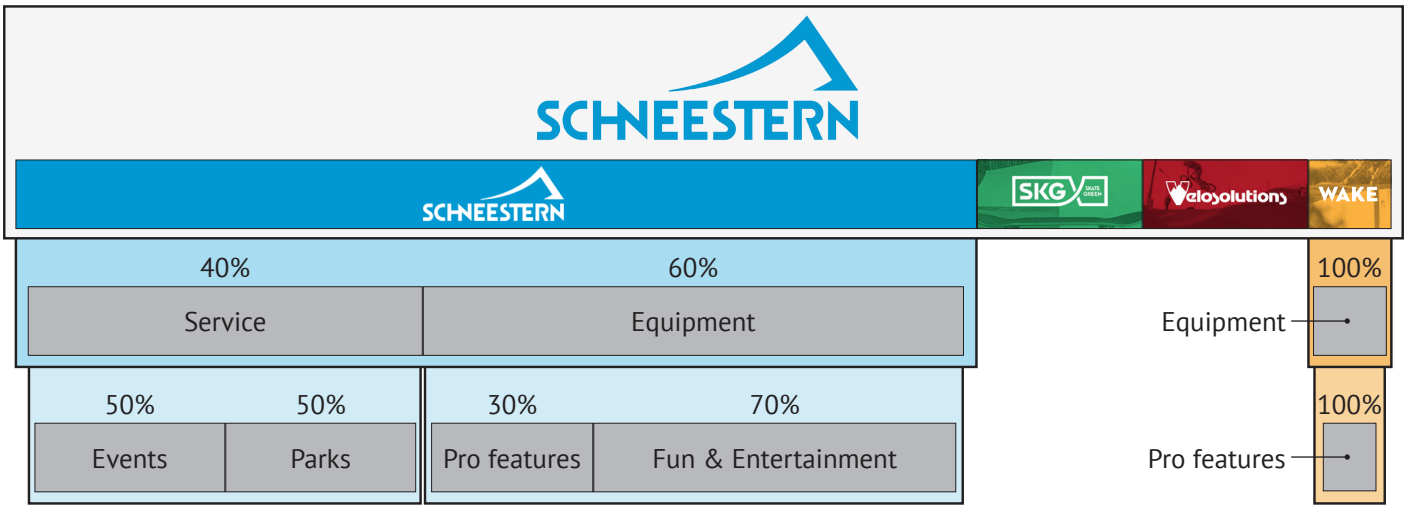


Figure 10: Schneestern and the divisions within the mother brand.

Figure 11: A wakeboard feature produced by Schneestern.

Strengths Schneestern

Experience
- 19 years of experience indeveloping and building snow equipment and executing snow services.
- Large number of distribution channels for snow events all over the world.
- Global market leader in producing snow equipment.

Capabilities
- Large workshop with metal workers and carpenters.
- Pioneers by focussing on fun and entertaining equipment in the snow market.
- Pioneers in building cycling parks, pump tracks and skate parks.

Sesitec

Sesitec is located only thirty minutes away from Schneestern, in the South of Germany. It was found in 1992 as Se-Si-Tec which stands for "Seil-Sicherheit-Technik", and means safe cable technique.
Sesitec produces cable systems that can be used for all kinds of cable water sports like wakeboarding, water-skiing, knee boarding and wake skating. While their main products are the Full Size Cable system and a System 2.0, Sesitec provides a "360-degrees full-service" with their systems. This full-service reaches from the first plans towards the municipality to their customer tracking system Captain POS.
According to Sesitec, the amount of repeating customers at cable water sports is at the moment approximately 10%. In order to increase this percentage, Sesitec is constantly looking for ways to innovate in the cable water sports market.

Full Size Cable
A full size cable (FSC) is a system that can be installed at any lake desired. A cable is stretched between 4 to 6 poles and runs in a circle above the water with a constant speed of approximately 25-30 km/h, powered by a electrical engine (Figure 12). Athletes can be connected and disconnected to this running cable to be carried over the water. Multiple athletes can be connected to this cable at the same time, making this a very efficient way of executing cable water sports.

System 2.0
A system 2.0 is basically a FSC with only two poles (Figure 13). One athlete at the time can use this cable constantly. The advantage of a System 2.0 is that the speed is adjustable, as well as the acceleration. This makes this system very well suited for athletes who participate in cable water sports for the first time. Sesitec offers a regular System 2.0 and a System 2.0 HD. The HD (heavy duty) system is build to be used more intensively by professional users. Since the System 2.0 was launched in 2007, Sesitec has sold approximately 500 systems worldwide.

Captain POS
Since 2016, Sesitec offers a centralized Point of Sale system for cable parks. This system originally only tracked whether customers were still aloud to use the cable systems, considering the time slot they paid for. Now this system is expanded and also linked to all services that can be provided by a cable park like a restaurant, shop or hotel.

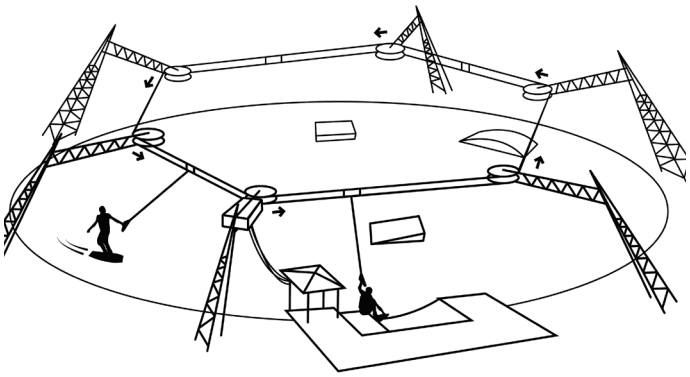


Figure 12: Sketch of a full size cable.

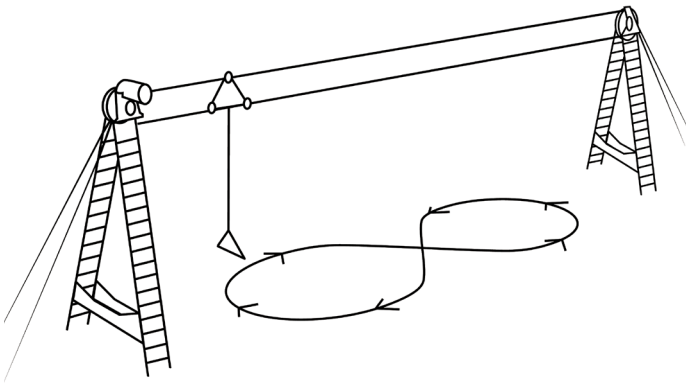


Figure 13: Sketch of a system 2.0.

Figure 14: Sesitec and her divisions, based on number of sales.

Sesitec produces their products mainly in-house in the metal and electronics workshops located under the main office. With partners in different districts around the globe, Sesitec is installing and maintaining their systems globally.

Market share
A lot of smaller sized companies have started selling replicas of the Full Size Cables and System 2.0's all over the world. Nevertheless, Sesitec is the global market leader in System 2.0's by far. Their largest competitor for Full Size Cables is Rixen. Sesitec beliefs that their market share is just over Rixen's, but they do not have any numbers on this.

Strengths Sesitec

Experience
- 25 years of experience in building cable systems and advising cable parks.
- Global market leader of producing System's 2.0 and Full Size Cables.
- Distribution channels and strong relations with cable parks all over the world.

Capabilities
- Large workshop with metal workers, electricians and a cnc plasma cutter.
- Close relations with 20 team riders, professional riders that give input on new innovations.

1.3 External analysis

The external analysis starts with a competitor analysis. An overview of producers of wakeboard features and cable park producers is created. Also, a Porters 5 forces analysis is conducted about wakeboard features. Lastly, the offer of current wakeboard features is described in terms of their construction and appearance.

Competitor analysis

The competitor analysis was conducted on the market of features for the wakeboard market. Because these features are located at cable parks, the cable system suppliers are also incorporated in the company overview. This overview can be found in Appendix 2.

Wakeboard feature suppliers

Within the market of feature suppliers, there are a lot of small sized local companies that produce wakeboard features in their region. The market leader in wakeboard features is Unit.

Cable system suppliers

The main companies that supply cable systems for cable parks are Sesitec and Rixen on a global level. In addition to that, there is a large number of smaller companies that supply cable systems on a national or regional level.

Unit

Unit is the leader in the market of wakeboard features by delivering features that are entirely build from HDPE and filled with styrofoam. Some of the features can be connected and adjusted by a modular system. Unit holds multiple patents related to wakeboarding features (Appendix 1).

In the Netherlands, Unit's feature's can be found at a number of cable parks. Down Under (Nieuwegein) is a cable park that exclusively uses Unit's features. Down Under was visited to discuss and evaluate Unit's features. The cable park manager showed the modular system of the features, where he was very positive about. But, he also explained that changing features of the modular system is a time consuming process. I noticed that this modular system is still limited in the amount of freedom that it provides, since only a couple of features can be rearranged within the same feature but not between different features.

Porters 5 forces

The market of wakeboarding features is summarized according to the five forces of Porter, see Figure 15 (Porter, 1979).

Threat of new entrants

The actual construction of wakeboard features could be performed by a lot of constructing companies that have a proper workshop and a plastic welding extruder. Nevertheless, designing features in the right way is really important. Not only the shape of the curves and other dimensions need to be perfect, also stability, safety and positioning solutions need to be designed perfectly. Therefore, the threat of new entrants that deliver high quality products is low.

Bargaining power of customers

According to the results of the user research, wakeboard features are considered to be a large investment for cable parks. This results in a high urge to bargain for a new product. The limited amount of suppliers decreases the bargaining power.

The industry

Although there are a number of companies that supply wakeboarding features, the quality between these suppliers seems to differ a lot. It is not clear what the market share of all suppliers is. A lot of companies that supply features supply cable systems as well or cooperate with a cable system supplier. Most suppliers are based in and around Western Europe.

Bargaining power of suppliers

The most used building material for wakeboard features is HDPE, see current offer on the next page. The material costs for HDPE result in approximately 60% of the total cost of a feature, according to Schneestern. The price of HDPE is fluctuating influenced by the oil price.
There are multiple HDPE suppliers, which result in a low bargaining power of the suppliers.

Threat of substitute products

A direct substitution of high quality features is not available on the current market. A change in the trend for wakeboarding tricks could be a possible threat, but according to the results of the user research the trend in wakeboarding tricks is moving from air tricks towards feature tricks. In addition to that, the popularity of wakeboarding still expanding.
Nevertheless, customers could consider buying features of lower quality. Low quality features are less durable but could be manufactured by the customer themselves. The user research shows that some cable parks build their features themselves.

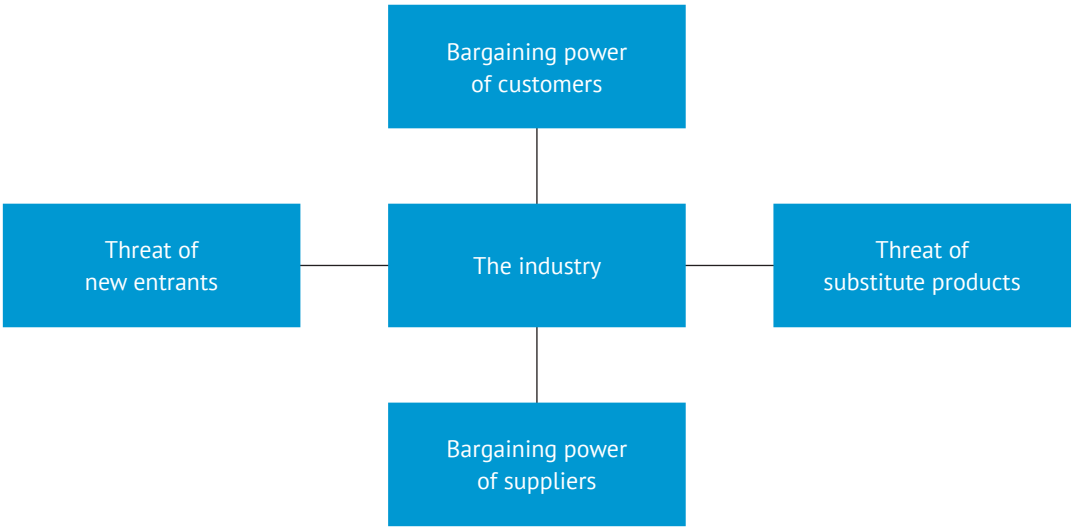


Figure 15: The 5 forces of Porter (Porter, 1979).

Current offer

The offer of wakeboard features on the current market is investigated and explained by its main construction and main type of features.

Construction

The construction and lay-out of all currently existing wakeboard features on the market are roughly the same.
The material of the sliding surface of the features is HDPE. HDPE has perfect sliding characteristics towards wakeboards, is weather resistant and relatively strong. HDPE plates are quite flexible and therefore it needs a stiff construction to become a solid feature. This construction is usually made from HDPE plates too, which are welded together in a grid and filled with Styrofoam to make the whole construction float. One downside of HDPE is its high expansion coefficient due to heat transformations. This should be taken into consideration when welding HDPE plates.

Type of features

The main types of wakeboard features are a rail, a box and a kicker (Figure 16). By varying the dimensions of each feature and combining multiple features, a large number of possibilities arise. Figure 17 shows different type of features from different feature suppliers to show the form language that is used in the current market of wakeboard features.

A standardized system that (re)positions the features in the lake does not exist. Especially at lakes where the water level changes a lot, cable park managers have to control this daily.

Conclusion current offer

Overall, the market of wakeboard features is saturated with large, robust and static features that stay in one spot over a longer period of time.
Most features look clean but unforgiving and seem to be designed to push boundaries, which thrills adrenaline. Feature suppliers present their largest and most difficult features as if they focus only on the professional rider. The features have a similar form language, compiled from geometric shapes and are mostly designed to be rode in one direction.

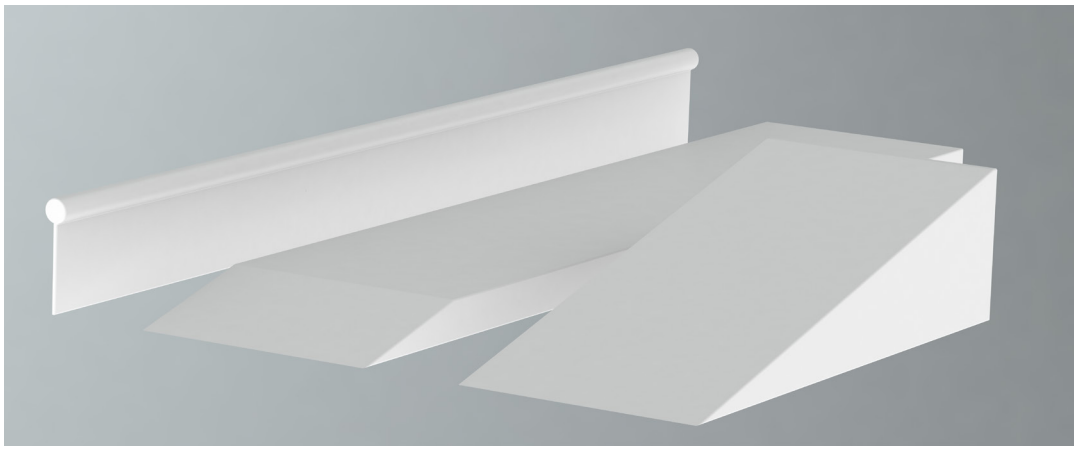


Figure 16: Main type of features: rail, box, kicker.

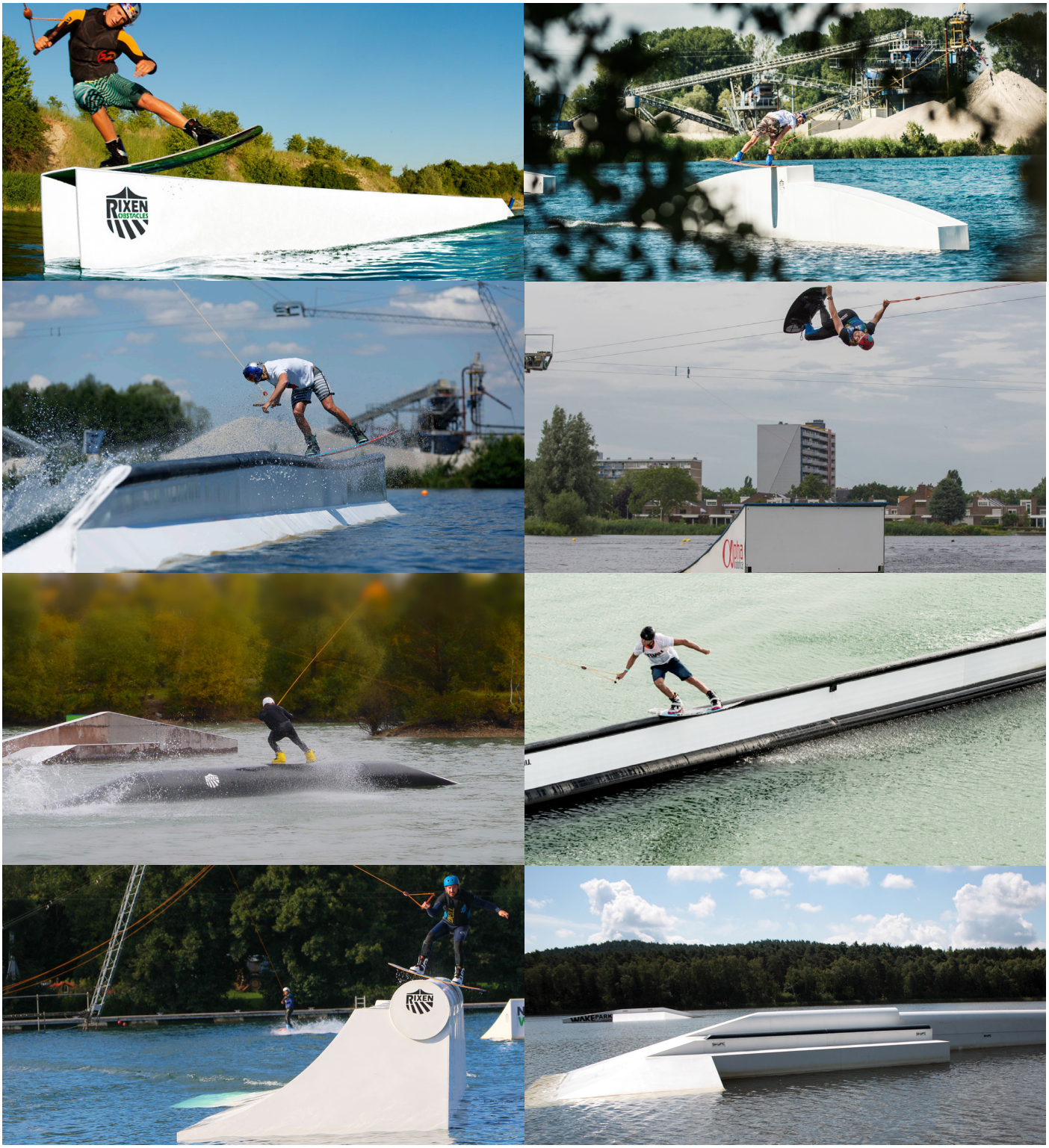


Figure 17: Different type of features. Not all features visualised are designed and constructed by Schneestern.

1.4 User research

A qualitative user research with 26 participants is executed to understand user's motivations to go wakeboarding and the negative aspects of wakeboarding, as well as their opinion about features and wakeboard gear. In addition to that, a broader understanding is gained towards the past and current trends of wakeboarding and different visions towards target groups and the development of wakeboarding are determined. Riders, as well as cable park managers and suppliers have participated to this research.

Objectives

The interviews were conducted to find answers to the following research questions:
1. What are the main motivations of the participants to go wakeboarding?
2. What are the negative aspects of wakeboarding, according to the participants?
3. What is the participants' vision towards the features in a wakeboard course?
4. What is the participants' opinion towards the gear that is used for wakeboarding?
5. How did wakeboarding develop in the past years?
6. What are the current trends in wakeboarding?
7. What is the cable park's target group?
8. What is the cable park's vision towards features in the course?

Participants, Method & Results

The participants, method and results can be found in Appendix 3.

Conclusion

The conclusion of the user research is structured by the 9 categories that arose during the analysis of the results.

1. Positive aspects of wakeboarding
Most participants go wakeboarding for the kick and adrenaline that it evokes. Some riders have the goal to make progression, while others ride to enjoy the atmosphere with friends and being outside on/in the water.

2. Negative aspects of wakeboarding
The main negative aspect of wakeboarding is the limitation to a certain spot. Next to that, external factors like wind, cable tension and other riders are considered to be of negative influence.

3. Trends
Wakeboarding is developing steadily in terms of gear, features and methods and is increasing in popularity. Wakeboarding follows a similar development process as skateboarding and snowboarding do, but is a couple of years behind.
The last couple of years wakeboarding tricks have shifted from air tricks (like raleys) to feature tricks. While features used to be rode in one line (kicker-feature-landing), nowadays more riding possibilities seem to arise with the use of wall rides, street rails and transfers.

4. Target group
Some cable parks target on large groups that visit the cable park only once, and generate revenue from their consumption in the restaurant. Other parks focus on the intermediate and professional boarders and therefore have a drive to bring the sport as a whole to a higher level. The cable parks that focus on the one-time groups value the features less important and invest less in the originality, quality and positioning of their features.

5. Injuries
Although features are considered to be most dangerous by beginners, a lot of injuries happen without the involvement of features.

6. Features

6.1 Importance

Features are very important for a wakeboard cable park. Together with the tension in the cable, this is what differentiates one cable park from another. All wake parks mention the importance of features.

6.2 Quality

High quality features do not only result in low maintenance and a long lifetime for the owner but are also valued high by the riders.

6.3 Costs

All cable parks mention that features are relatively expensive.

6.4 Adjustable

Although positioning features is considered to be difficult and there is a limited amount of spots available on a cable park, rearranging features or parts of features is preferred. It should result in fast progression and stimulate creativity.
One participant sees no need for changing features since it should limit the creativity.
A new, playfuller character is desired by some participants.

7. Gear

The wakeboard binding is the most important part of the gear, since it provides direct control over the board. A helmet is also valued important.

8. Beginners

Some cable parks do not seem to focus on the beginner riders.

9. Other boardsports

Wakeboard cable parks are becoming like skate and snow parks. Kitesurfing is moving towards wakeboarding in terms of feature tricks. A surf-like atmosphere is present at wakeboarding.

Most important insights user research

Riders go wakeboarding for adrenaline and progression or for entertainment and being outside with friends. Wakeboarding is increasing in popularity and follows a similar development process as skateboarding and snowboarding but is a couple of years behind. Cable parks are evolving like skate and snow parks.
Cable parks focus either on progression of their riders and invest in features or focus on one-time customers and focus on restaurant consumption. Features are not the main cause for injuries, although features are considered to be dangerous by beginner riders.

1.5 Search areas

The information gathered in the internal, external and user research led to the description of the strengths and weaknesses of Schneestern and the opportunities and threats in the market. By combining these strengths and weaknesses with the opportunities and threats, search areas were created. Figure 18 visualises the seven most valuable search areas, which will be explained briefly on the next pages.

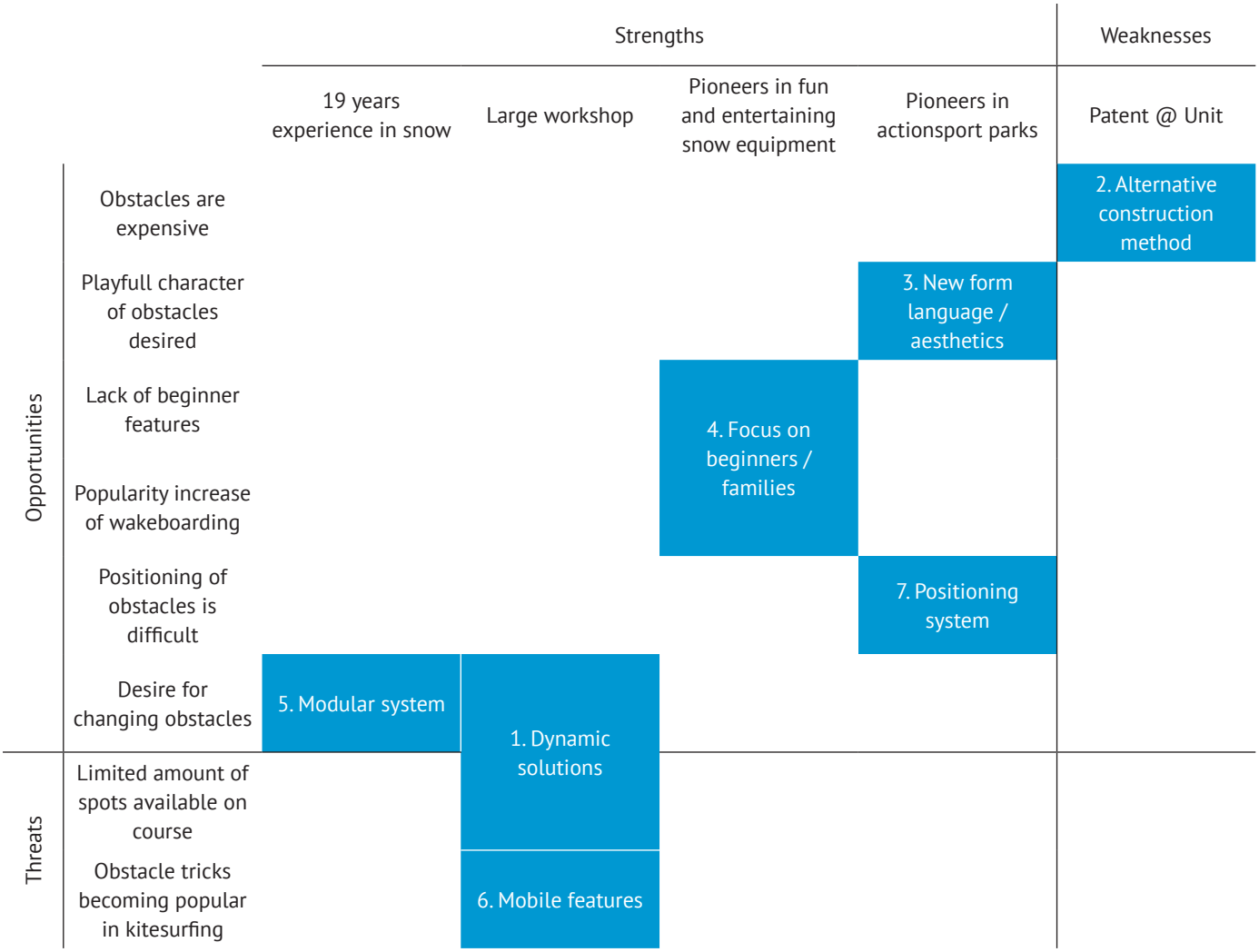


Figure 18: SWOT matrix with the seven most valuable search areas.

1. Dynamic solution

User research: Desire for changing features
User research: Lack of beginner features
User research: There is a limited amount of spots for the features on a cable park

Dynamic solutions will make ultimate use of the limited amount of spots that are available for features on a cable park. By changing (parts of) a feature the feature could change in difficulty or kind of feature. Changing the feature would preferably be executed without any physical activity (i.e. "by the push on a button") and could be executed unlimited times a day.

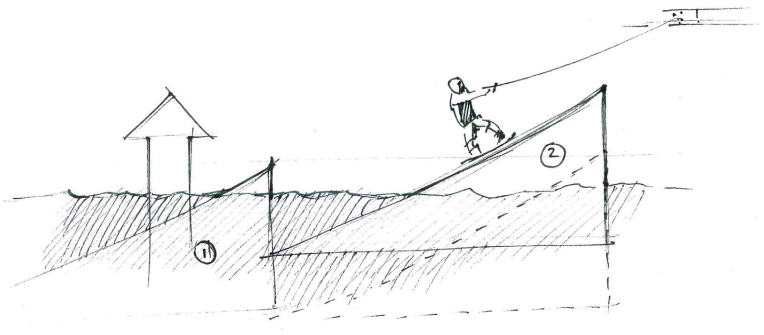


Figure 19: Search area 1. Dynamic solution.

2. Alternative construction method

User research: Features are very expensive
External analysis: Most features constructed from HDPE
External analysis: Unit is holding a patent
Internal analysis: Schneestern has expertise in manufacturing different types of features

Investigating the possibilities in new construction methods, materials and production principals for features, which should conclude with the best construction and manufacturing method for features, while taking the following aspects in consideration: ride ability, cost, form freedom, strength, durability and sustainability.
This solution should be an alternative to the patent that is currently owned by Unit (Appendix 1). Schneestern has a lot of expertise in constructing features for snow, cycling, skate and wake parks, which could contribute to this search area.

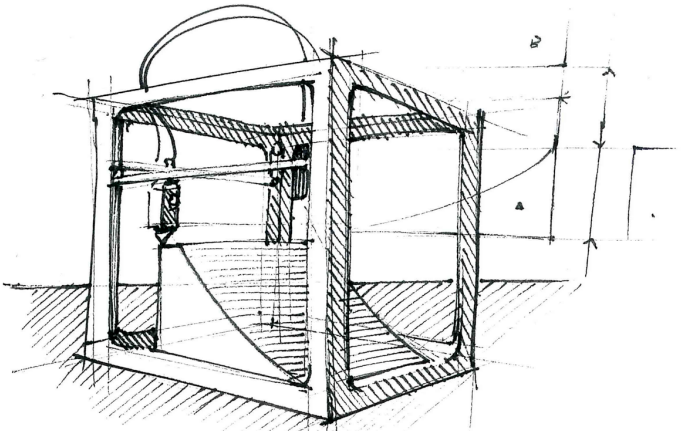


Figure 20: Search area 2. Alternative construction method.

3. New form language / aesthetics

User research: Playfull character of features is desired
External analysis: Features have a similar form language

Introducing a new style in wakeboard features.
These features should introduce new riding opportunities and carry out a new image of wakeboard features.

The external analysis has shown that most features have the same style; they are build up from geometric shapes and have a clean and tight appearance, usually executed in white. A large competitive advantage could be created by exploring the opportunities of a new style of wakeboard features.

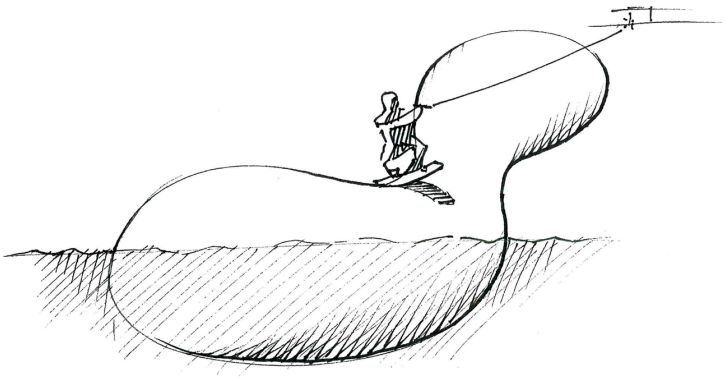


Figure 21: Search area 3. New form language / aesthetics.

4. Focus on beginners / families

User research: Lack of beginner features
User research: Wakeboarding is increasing in popularity (becoming 'mainstream')
User research: Wakebaording is evolving towards snow and skateboarding
Internal analysis: Schneester is experienced in beginner/family focussed snow features
Market research: Focus on pro features

Since wakeboarding is expanding in popularity, cable parks should take beginners and families in their scope as well. A research into the possibilities of features that focus on beginners and families should conclude with a new aspect in wakeboarding which makes wakeboarding an action sport for a wider target audience.

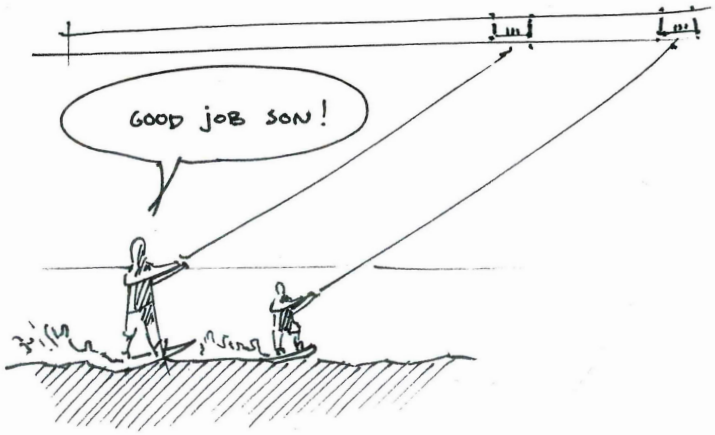


Figure 22: Search area 4. Focus on beginners / families.

5. Modular system

Internal analysis: Schneestern is experienced in modular snow features
User research: Desire for changing features between features
Market research: Unit's modular system is limited in freedom

A modular system should be the ultimate way to change parts of features in unlimited possibilities. Unit is currently offering a modular system but observations showed that there are still a lot of limitations when combining different features. Offering a modular system with more freedom and easier adjusting of features should be an answer to the desire of riders to change features in the cable park.

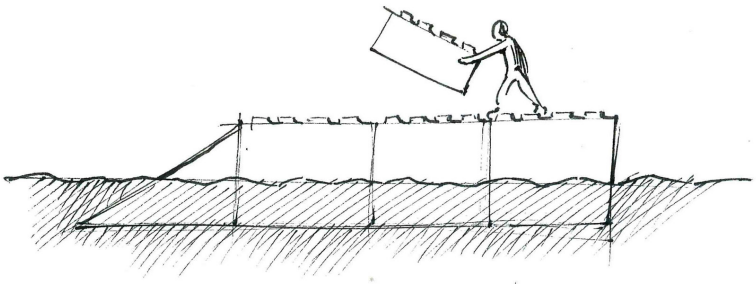


Figure 23: Search area 5. Modular system.

6. Mobile feature

User research: Feature tricks becoming popular in kite surfing
External analysis: Features are static and (semi-)permanent

The current offer of features shows that the features are designed to stay in one place or at one cable park for their entire lifetime. On the other hand, feature tricks are becoming more popular within the sport of kite surfing. A large advantage of kite surfing compared to wakeboarding is the unlimited freedom of spots to go kite surfing. Mobile features should be the answer to bring features anywhere where kite surfing is desired.
These features could also be of great benefit for riders who wakeboard behind a winch and enjoy the freedom to wakeboard on different spots.

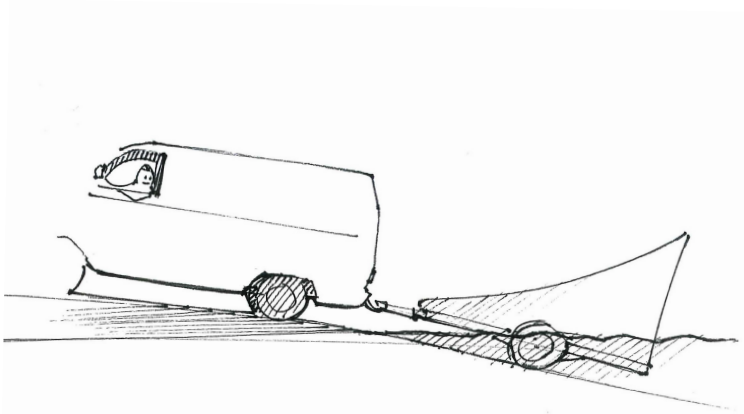


Figure 24: Search area 6. Mobile feature.

7. Positioning system

User research: Positioning of features is a difficult process
User research: Good positioning of features is important
External analysis: No positioning solutions available

Designing a general positioning system for floating features in a lake (optional: with a fluctuating water level).
The user research has shown that positioning of features is a difficult and time consuming process. Besides, riders mention the importance of the position of features. Not only should the feature stay in place all the time (wind, current, riding the featur the features should also be positioned correctly relative to each other and the cable. The external analysis shows that there are r solutions for these problems available on the market yet, which makes it an interesting search area.

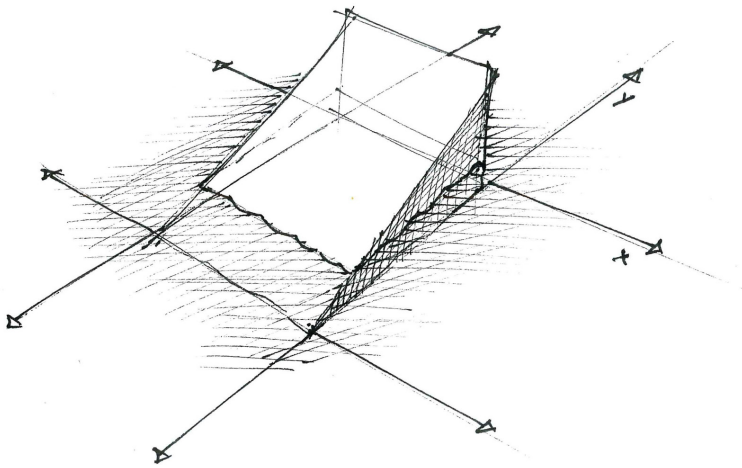


Figure 25: Search area 7. Positioning system.

Conclusion search areas

In consultation with Schneestern and Sesitec is decided to continue with the focus on beginners and families as the search area for this project (search area 4). As the feature building company, Schneestern has experienced a lot of succes by expanding their focus from professionals towards beginners and families in the snow sports. With the current popularity increase in wakeboarding, it is expected that wakeboarding will go through the same development process as the snow sports. This means that the sport will reach beginners and families soon. Since non of the existing wakeboard features focusses on this target audience, it offers a lot of freedom in the execution of this graduation project.

2 Design brief formulation

The previous chapter described the development of the strategy formulation, concluding with the search area for this project: beginners and families. This chapter formulates the design brief. By taking the search area as a starting point, the market and target audience are analysed to formulate a design goal. This goal is substantiated by the vision of desired interaction. Based on this goal and vision, the ideation phase started. This ideation phase is divided into a wide explorative phase resulting in a large number of ideas. Three of these ideas were taken into the second phase of ideation and were developed into concept directions. This chapter concludes with the design brief which will be developed into a product in the next chapter.

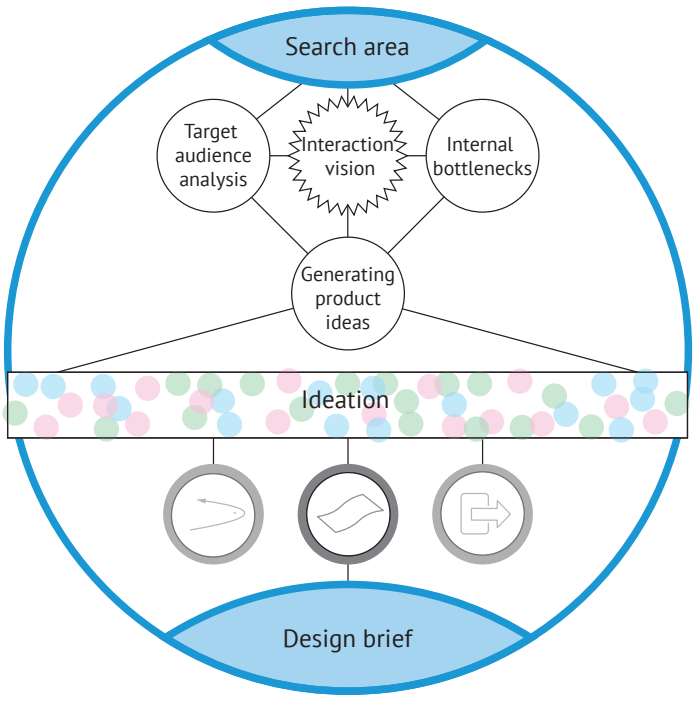


Figure 26: Design brief formulation, steps based on the Delft Innovation Model (Buijs & Valkenburg, 2005).

Original starting points

Opportunities
Wakeboarding, as being part of cable water sports, is increasing in popularity and number of participants. Currently the percentage of repeating customers at these sports is low; approximately 10%. In addition to that, wakeboarding is focussing mainly on the extreme athletes with features that go higher and bigger and provide an increasing possibility in tricks. The less experienced or adventures riders seem to be unserved in the sport.

Strengths
Originating as a company that focussed on extreme snow athletes, Schneestern experienced a successful extension of their scope by including products for beginners and families in their product portfolio. Sesitec, as one of the world's leading cable park system distributor has a lot of experience in the cable water sports market. This experience not only lies within the technical know-how of their own products but reaches a lot further by having a wide network of professional team riders and close contact with cable parks all over the world.

Search area
The focus on beginners and families is further investigated in this chapter in order to develop the design brief.
Although the original starting point is the focus of beginners and families, this focus will be adjusted and reformulated after analysing the target audience.

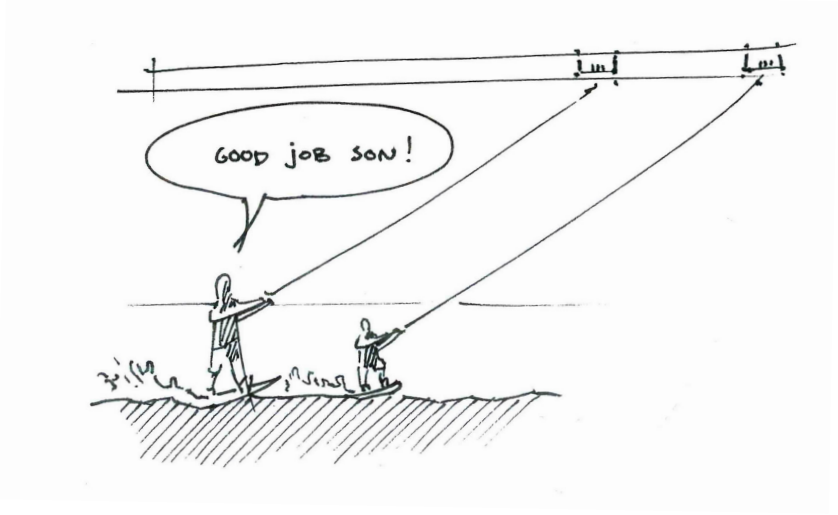


Figure 27: Starting point: focus on beginners and families. To be adjusted and reformulated in this chapter.

2.1 Target audience analysis

Expertise level

Wakeboarding is a relatively complicated sport to learn. Although the learning curve is quite steep, most athletes are able to complete a full round behind a Full Size Cable at the end of the first session. When the athlete is able to complete a full round, he/she should then improve board control and stability before being able and confident enough to try to ride a simple feature. These sessions, between completing a full round and trying a feature are considered to be less exciting. This is determined as "the gap", see Figure 28. The features that will be developed in this project, will be developed to fill "the gap".

When looking at the number of customers at a cable park, only a small amount of all customers rides features (only 10% according to Sesitec), see Figure 29. Since features are a large investment for cable parks, this substantiates the reason too to focus on the non feature riders, the customers in: "the gap".

While this project focusses on the less experienced athlete, the expertise level of the athlete will increase by participating. As a consiquence, this might lead to a larger participation of feature riders in the future.

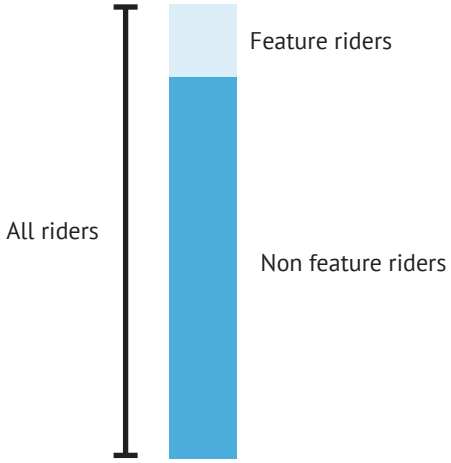


Figure 29: Amount of feature riders relative to non feature riders (approximation).

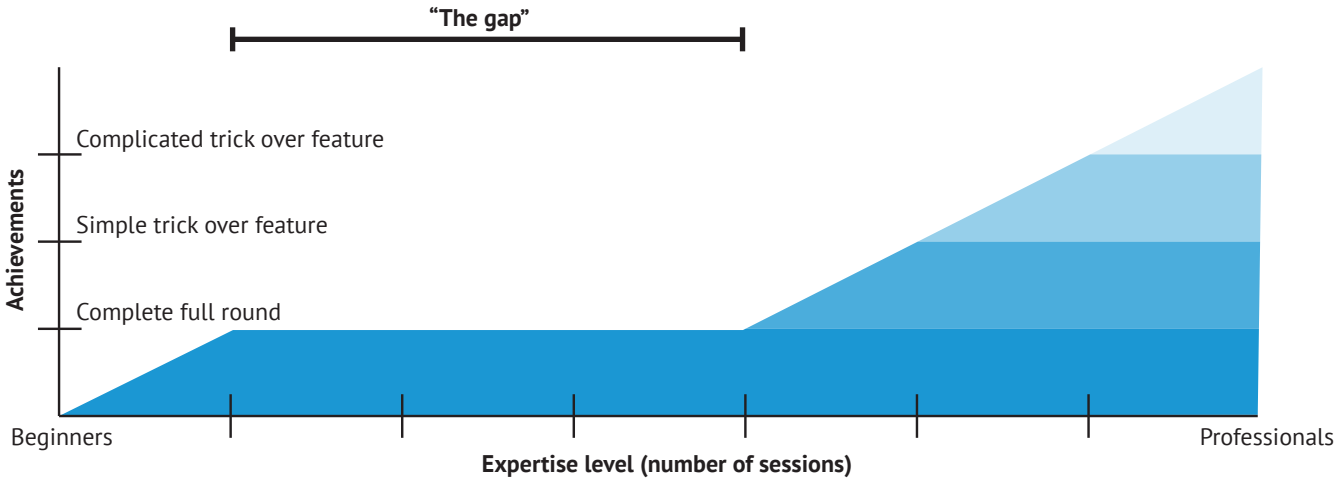


Figure 28: Learning curve of wakeboarding. Expertise level relative to the achievements.

Customer segment

According to the user research in chapter 1, the two main motivations for participants to go wakeboarding are to gain adrenaline or to gain entertainment. Therefore, a distinction was made between two types of customers: the *Adrenaline Seeker* and the *Entertainment Enjoyer*.
The *Adrenaline Seekers* come for the kick that wakeboarding evokes. They are willing to learn new tricks and seek for progression. They will push their boundaries most.
The *Entertainment Enjoyers* come to the cable park to spend their leisure time. The enjoyer likes to play on the water and brings friends or family over to play with. The goal of being on the water is to have fun, instead of gaining progression. Figure 31 on the next page shows an impression of these two customer segments.

The market of wakeboarding features seems to be saturated with features that are targeting the *Adrenaline Seekers*, but no features seem to exist that focus on the *Entertainment Enjoyer*. Therefore, the focus will be on the *Entertainment Enjoyer*. Figure 30 shows the focus area for the project related to the customer segment and their expertise level.
Note that the focus area has shifted from beginners and families towards beginning *Entertainment Enjoyers*.

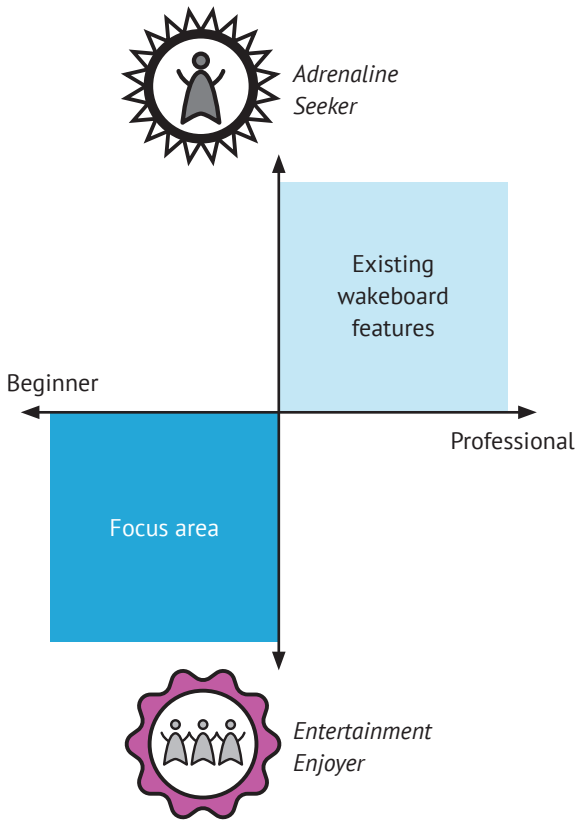


Figure 30: Focus area in relation to the customer segment and the expertise level.

Adrenaline seeker

Entertainment enjoyer

Figure 31: Impression of the two customer segments: the Adrenaline Seeker and the Entertainment Enjoyer.

Demographics

Customers can be segmentated in different types of segments. The choice to segment the target audience based on psychographic characteristics (activities, interests) instead of demographic characteristics (age, gender, race) was made deliberately. Because ultimately, this product should not be more relevant to customers who differ in age, gender, income, religion or race (Bhasin, 2017). With that being mentioned, there is one important factor that makes a 'demographic' distinction within the customer segment and that is physical capability. In order to perform cable water sports, athletes need to have a physical strength to be able to transfer the force of the 25-30 km/h running cable during the execution of the sport. Unfortunately, there is no data available about the age of children relative to their physical strength. Sesitec uses the guideline that children should be able to swim before they can start performing cable water sports (also because of safety reasons). According to Sesitec, athletes should have the age of 14 when they can start riding features that can cause high impact, like big kickers, but this does not apply to this project.

Therefore, the target audience of this project is not limited by age, nor other demographic characteristics.

Health of sports

It is commonly known that practising sports contributed to the health of the practisioner. According to Eime et al. (2013), sports can contribute to three types of health specifically: physical health, psychological health and social health.

In order to determine which sport contributes to which type of health, a distinction is made for all sports over two variables. According to Eime et al., these variables are the level of participation (individual vs. team) and the level of structure of the sport (organised vs. informal). As shown in Figure 32, all types of sport contribute to the physical health, while organised and team sports also contribute to psychological health and social health.

Although wakeboarding is executed individually, there is a large social aspect within the sports which does not make it fully individual. Therefore, wakeboarding is categorized in the middle between individual and team sports.
The extent to which wakeboarding belongs to informal or organised sports mainly depends to the individual athletes. When he or she follows a training programme, it can be considered as an organized sport, but when these sports are played inconsequent and less frequent, it can be considered as an informal sport. Most probably, the latter will be the case for this target audience.

Therefore, wakeboarding is determined as being informal, see Figure 32.

By shifting wakeboarding towards a more organised or team sport, wakeboarding will also contribute to social and psychological health. Making wakeboarding more organised does not match the customer segment of *Entertainment Enjoyers*, but changing wakeboarding more into a team sport matches the target audience. This will be incorporated in the interaction vision.

Conclusion target audience analysis

Within the expertise development of riders, a gap is determined after being able to ride a full round and before being confident enough to start riding features. In addition to that, the audience of riders is segmented into *Adrenaline Seekers* and *Entertainment Enjoyers*. A decision is made to focus on *Entertainment Enjoyers* with an expertise level in the gap.
The original search area to focus on beginners and families has shifted towards beginning *Entertainment Enjoyers*. The target audience is not limited by demographic characteristics.
In order to make wakeboarding contribute more to social and psychological health, wakeboarding should develop towards a teamsport.

Based on the conclusions of the target audience analysis, a design goal is formulated. This will be the central goal for future development throughout this project.

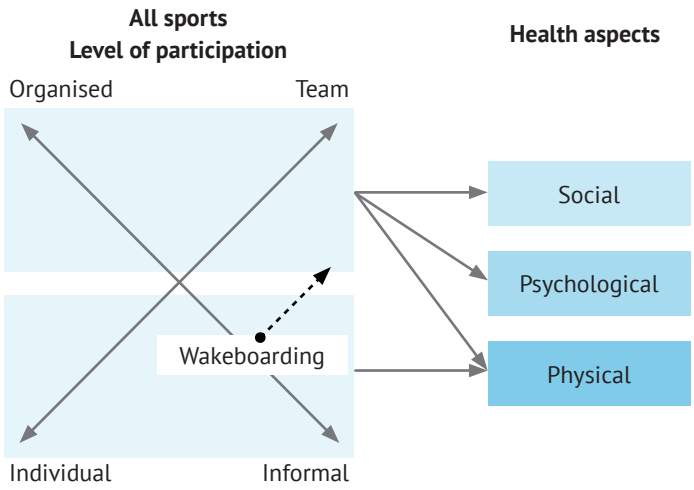


Figure 32: Contribution of sports to different health aspects. Simplified and adjusted for wakeboarding (Eime et al., 2013).

Design goal

"Develop a feature for Entertainment Enjoyers that are wakeboarding on a Full Size Cable with an expertise level determined within 'the gap'."

2.2 Interaction vision

According to the target group analysis, an interaction vision has been developed which communicates the desired interaction between the user and the product. This vision will be guiding for further development for this target audience. Schneestern could apply this vision not only within the wakeboarding department, but throughout all their departments of action sports for this target audience.

Interaction vision

"An interaction vision represents the intended qualities and characteristics of the interaction with your new design. This vision should fit the design goal and will be used as an addition to this goal" (cited from Mulder and Pohlmeyer, 2015).
The vision is introduced by a metaphor and described using three interaction qualities. These interaction qualities are then translated into product qualities, specifically for the wakeboard context. The structure of the interaction vision is visualised in Figure 33.

Metaphor

"I can remember myself as being a little boy, visiting the old farmhouse of my grandparents every once in a while. The farmhouse was full of hidden gems and had a large attic full of interesting treasures. Once, I discovered an old toolbox, full of tools that I had never seen before. I was so excited that I invited my little nephews up on the attic and together we spend the whole weekend up there, trying all different tools over and over again."

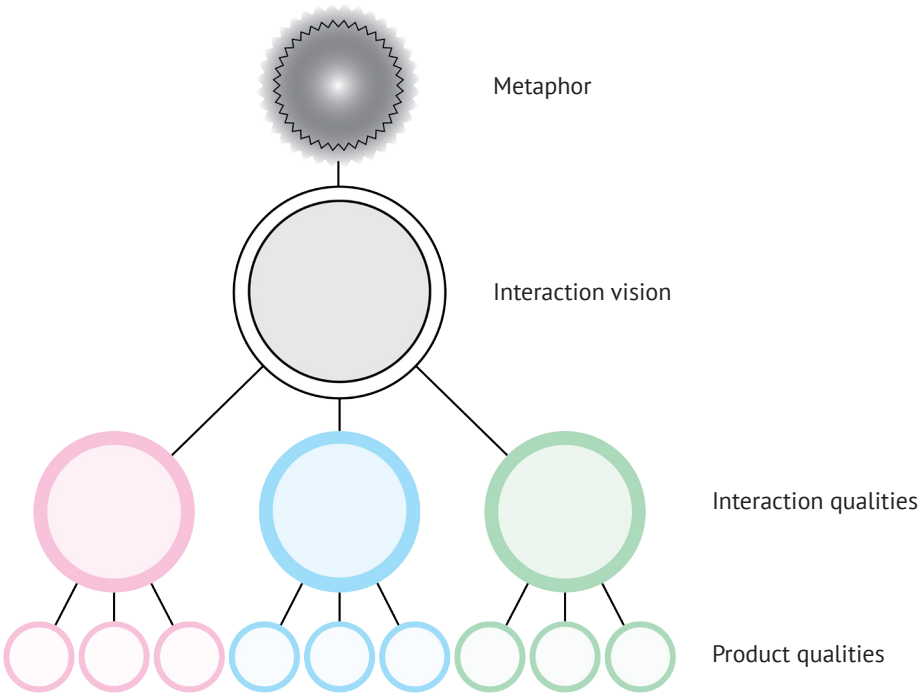


Figure 33: Structure of the interaction vision

Interaction vision

"Like discovering an old toolbox on the attic of my grandparents' farmhouse, excited to discover all the possibilities together with my nephews."

Interaction qualities

Within the interaction vision, the following interaction qualities are determined.

(inviting) Surprise
Although I knew that the treasure hunt on the attic could lead to something cool, the discovery of the toolbox came as a surprise. The product to be designed should therefore have an inviting character that leads to a surprise.

Togetherness
I was so stoked about the discovery of the toolbox, that I shared it immediately with my little nephew's. Together, we had an amazing time on the attic. This feeling of togetherness should be a result of the product.

Encouraged (stoked)
The positive surprise that the discovery of the toolbox provoked, made me stoked to try all the features of every tool over and over again. It encouraged me to keep coming up on the attic for new discoveries.

Stoked
"To be "stoked" is to be completely and intensely enthusiastic, exhilirated, or excited about something. Those who are stoked all of the time know this; being stoked is the epitome of all being. When one is stoked, there is no limit to what one can do." (cited from Stoked - Urban dictionary, 2004)

Product qualities

The product qualities describe possible ways to translate the intended interaction qualities into a product. The product qualities are generated with respect to wakeboard features.

Surprise
The surprise quality could be achieved by visual appearance, sound effects or by using water splashes.

Togetherness
The feeling of togetherness could be created by making the feature available every rider, no matter his/her expertise levels. Also, teasing riders could result in the feeling of togetherness. Togetherness could as well be created by providing the opportunity to cooperate.

Encouraged
Riders could become encouraged by using a positive approach, responding to achievements or by enlarging achievements.

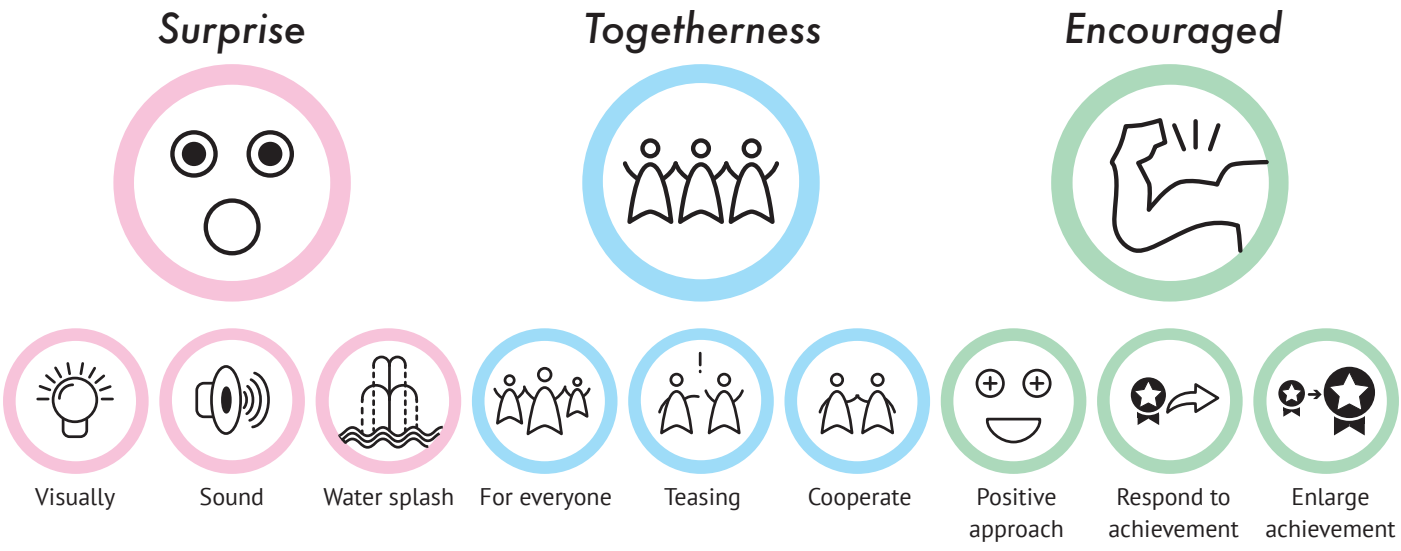


Figure 34: Interaction qualities and their product qualities.

2.3 Internal bottlenecks

Safety

Risk of injury

Wakeboarding can be categorized as an extreme sport, with a high risk of injury. On a cable system the athletes get pulled over the water with a speed ranging between 25 and 30 km/h. The wakeboard, fixed to the feet of the athlete functions as a thin (±3 cm) and stiff separation between the athlete and the water. When keeping the board in the right angle relative to the water surface, the rider will slide over the water smoothly. Nevertheless, when this angle changes negatively with respect to the water surface, the movement of the board will be blocked by the water, causing the athlete to decelerate drastically with the risk to fall with high impact on the water surface. Needless to say, this risk increases in turns and when performing tricks. When performing tricks, riders steer sideways in order to get a higher speed relative to the (constantly) moving cable, which increases the impact at a possible crash.

Limited scientific data is available about the type and number of injuries caused by which aspect of wakeboarding or occurring at which kind of trick. Nevertheless, the user research concluded that most serious injuries are caused by athletes who are turning or landing incorrectly which causes the board to block movement. The robust features seem not be the direct problem for injuries, although could indirectly cause an incorrect landing.

Since wakeboarding is increasing in popularity, I recommended to execute a research to gather scientific data regarding this topic.

Responsibility

Legal responsibility

From a legal perspective, the owner of the cable park and the athlete are both responsible for the negative consequences caused by the execution of the sport. The cable park should provide a sufficient explanation and maintain its material regularly. The athlete should take the risks of performing the sport in consideration (explained by the cable park) and behave according to his/her personal capabilities.

Two action sports companies were consulted to understand their vision regarding the legal responsibility within action sports (Boulder hall Campus, Den Haag & wakeboard cable park Wet'n Wild, Alphen aan de Rijn). Some action sport companies ask their participants to sign a waiver, others not. Whether athletes have signed a waiver or not, the responsibility of an injury remains always doubtful and can not be assigned fully to the athlete nor the company. Although signing a waiver might not have direct impact on the legal responsibility, it does make the athletes more aware of the possible risks involved in the sport.

Ethical responsibility

As a designer and producer of wakeboard features, the ethical question arises whether you should support the execution of a sport with a high risk of injuries, possibly enlarging this risk by the product you designed. I think one should answer this ethical question for themselves, and so I did too.

> Personally, when I go wakeboarding, I am aware of the fact that wakeboarding comes with a high risk for injuries but I enjoy executing it so much that I take this risk for granted. I know my personal boundaries when it comes to riding wakeboard features and I assume that other athletes will set these boundaries for themselves too. As a rider I assume that all features are constructed and maintained sufficiently and I think that every designer should design all features as safe as possible.

By designing for *Entertainment Enjoyers,* I deliberately chose not to focus on gaining adrenaline, usually by increasing risks, but to focus on entertainment. Nevertheless, riding any feature increases the risk compared to riding straight through the water. I think that every rider should set up his/her own boundaries concerning which features to ride. Therefore, the feature's appearance should match its risks. In other words, if the feature looks simple, it should be easily ride able and not have a very difficult or tricky part which needs a lot of skills. This is formulated in requirement 4.4 (List of requirements Appendix 6) which states that the appearance of the product should match its difficulty level. Needless to say, the product should match Schneestern's guidelines for constructing safe wakeboard features, requirement 6.1. In addition to that, it is required (requirement 1.3) for the product to have a substantial lower risk for injuries compared to the currently available features.

Guidelines Schneestern
The current wakeboard features that Schneestern produces try to avoid any injury that is caused by the design or production of their features. Therefore, Schneestern uses a couple of design rules.

Minimize mounting parts
The number of mounting parts should be limited and where used, hidden for possible contact with the rider. Therefore, most features are completely constructed from welded HDPE plates which need no additional mounting parts. The use of screws or bolts on top of the sliding surface is forbidden.

Risk of getting trapped
All features should be designed in a way that there is no risk to get trapped behind any part of the feature. The feature can not have any cracks or sticking out form. The anchor lines are always attached to the bottom of the feature so there is no possibility for the rider to get trapped in a line.

Minimum depth
Major injuries could occur if the rider gets trapped underneath the feature when approaching the feature. Therefore, Schneestern uses a rule of thump for the minimum depth of the features.
The side(s) where the rider can approach the feature should be minimal 20 cm underneath the water surface. On the other sides, the minimal depth is 10 cm.

Production
Based on the current number of sales per feature and number of wakeboard cable parks globally (625 predicted in 2020 (IWWF, n.d.)), the product should be designed for a total number of sales ranging between 50 and 500.

Nowadays, Schneestern usually produces every product to order. This product should preferably be produced in orders of 20 pieces at once to be sold from stock until the stockpile runs empty. The product is preferably produced by making optimal use of the product capabilities of Schneestern's workshop, but is it possible to produce parts of the product externally. Another wish is to design (parts of) the product to be customizable. Preferably, the main construction is constant through all pieces, but some aesthetic features are customizable according to the client's preference.

These wishes and requirements are formulated in the list of requirements in Appendix 6.

2.4 Ideation

The ideation development is divided into two phases.
The first ideation phase kicked off in cooperation with the employees of Schneestern and Sesitec with very wide and explorative idea generation sessions. This resulted in a large number of valuable ideas, which were evaluated and concluded with three concept directions for continuation. These concept directions were further elaborated upon in the second phase with regard to the interaction and product qualities. After evaluating these concepts, the minimum viable version of the Pad was chosen to realise and test physically.

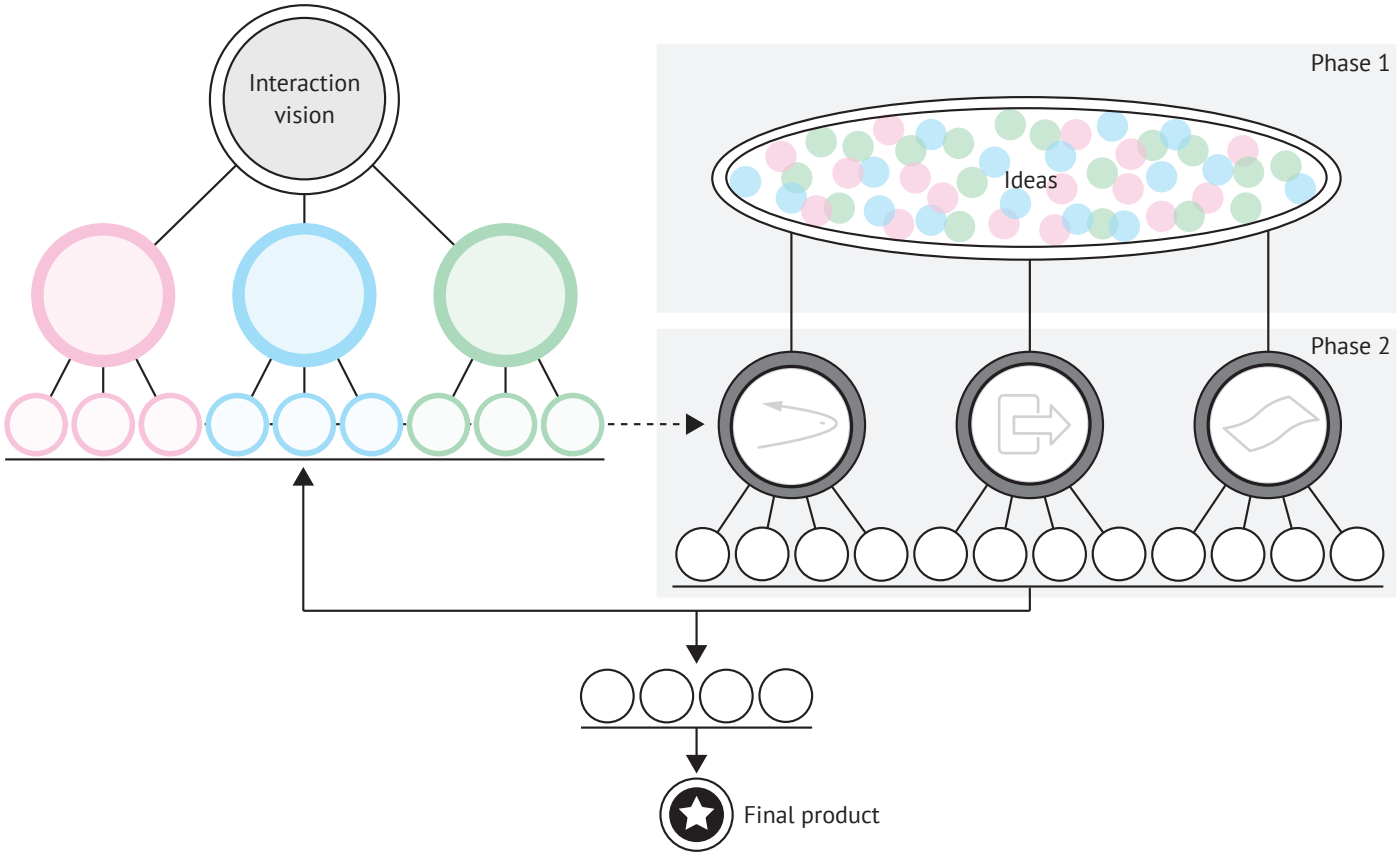


Figure 35: Structure of the ideation phases.

Ideation phase 1

At the offices of Schneestern and Sesitec, three creative sessions were executed in order to use the expertise and experiences of the client optimally. In each session, different employees from different departments and with expertise levels in wakeboarding were invited in order to get insights from different perspectives. The sessions were structured and executed based on the creative facilitation methods of Buijs & Meer (2014) and Tassoul (2009).

Stimulus

As inspirational stimulus two types of cards were used. The PLEX cards from Lucero & Arrasvuori (2010) representing 22 categories of playful experiences and the positive emotional granularity cards, which distinguish 25 types of positive emotions that a product can evoke (Desmet, 2012). Desired, as well as undesired experience and emotional cards were used as inspiration.

Based on feasibility, relevance for the design goal and relevance for this graduation project, a selection of 35 ideas was made, visualised in Appendix 4. These ideas were clustered into the following five clusters.

Interactive

These ideas focus on the interaction between users or between users and the product.

Water features

All kinds of ideas that use water as a building block of the feature.

Routing

Different approaches to provide routing for the users. Routing could be used to make a slalom course, but could also show the perfect route to go through a corner or approach a feature.

Prepare for features

These ideas are based on existing wakeboard features, but are a lot easier and less dangerous.

Exit features

When there are a lot of users at the cable system at the same time, users are limited in the amount of laps to ride before exiting the cable system. This is experienced as a negative aspect by users. Therefore, new ideas came to existence to “make lap limits great again” (quote Janik von Lerchenfeld, Sesitec).

Evaluation ideation phase 1

The 35 most valuable ideas (Appendix 4) were evaluated together with the clients Schneestern and Sesitec. The choice for continuation of ideas was based on producibility, viability and feasibility.

Producibility Schneestern

Schneestern's goal of this project is to produce the final design of this project and to use it as a starting point for development of other products. The knowledge gathered in this project could be used in the future development of other products. Therefore, Schneestern's wish for this project is to develop a product that matches their production capabilities.

Viability Sesitec

Sesitec's role is to participate as the main sales partner in this project. They have a lot of connections to (professional) riders and sales channels to cable parks all over the world. Sesitec wishes a viable product that is innovative, yet fitting in the current market of wakeboard features.

Feasibility graduation project

As a graduation project, this project is limited by the amount of work that can be done within the timespan of the project by an individual. Nevertheless, the project should be challenging enough to show and develop competencies gathered as an integrated product designer.

Conclusion ideation phase 1

After discussing these topics, a decision was made to develop three ideas into concept directions in the second ideation phase. These ideas are the Lines, the Pad and the Exit feature.

Lines

For unexperienced riders, the turn in the corner is valued as a difficult manoeuvre. The lines will provide guidance for the rider in these corners. These lines can be positioned in the water in any shape desired. The lines could also be used to show the optimal riding line for specific tricks or mark a slalom course.

The Pad

The Pad is a soft feature that floats on top of the water. It provides a different riding experience than water, which entertains the rider. Because of its softness, the Pad is accessible for riders from all expertise levels. As a consequence, it could motivate unexperienced riders to start riding larger features.

Exit feature

The exit feature is chosen as a whole cluster to take into the second idea generation phase. The goal of this feature is to make the limitation of the number of laps on the cable park fun. Different opportunities could be developed to realise these exit features.

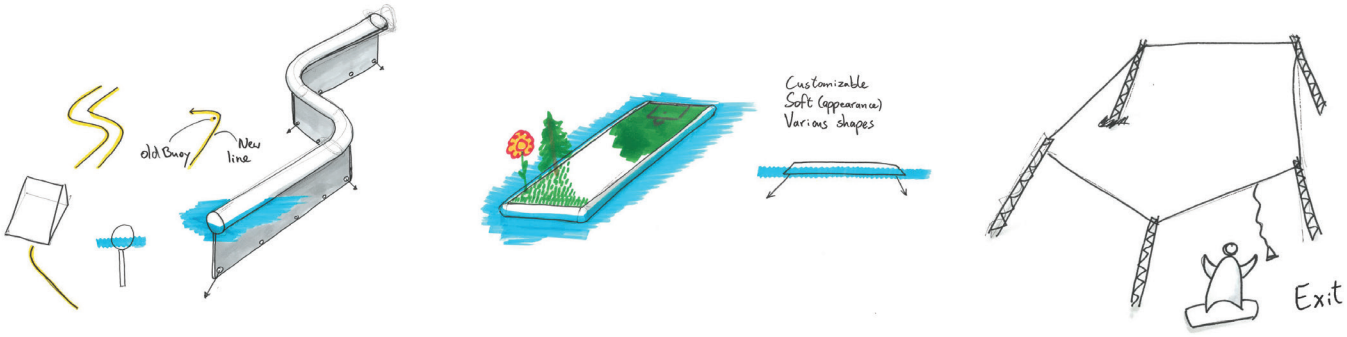


Figure 36: The ideas Lines, the Pad and Exit feature.

Ideation phase 2

The second idea generation phase started with the three ideas as concluded from the first evaluation. These ideas are visualised in the context of a cable park in relation to a rider. Thereafter, they are exposed towards the interaction and product qualities from the interaction vision. Appendix 5 visualises the results of this elaboration.

Figure 37: Visualisation of the Lines in the context with a rider.

Figure 38: Visualisation of the Pad in the context with a rider.

Figure 39: Visualisation of the Exit feature in the context with a rider.

Evaluation ideation phase 2

Figure 40 shows an overview of the concept direction elaborations with regard to the product qualities. The grey marked concept elaborations show which elaborations contain all three interaction qualities. These concept directions should be realised in order to match the interaction vision best.

Minimum viable product

The project timespan for product development was limited. Therefore, the decision was made to continue with a minimum viable version as a first step in the product development process.

The minimum viable product (MVP) is the version of a product with the minimum amount of features, realised to gather validation of the product. This version of the product will be used to obtain feedback from the target audience and can be the starting point for integrating more features in the future.

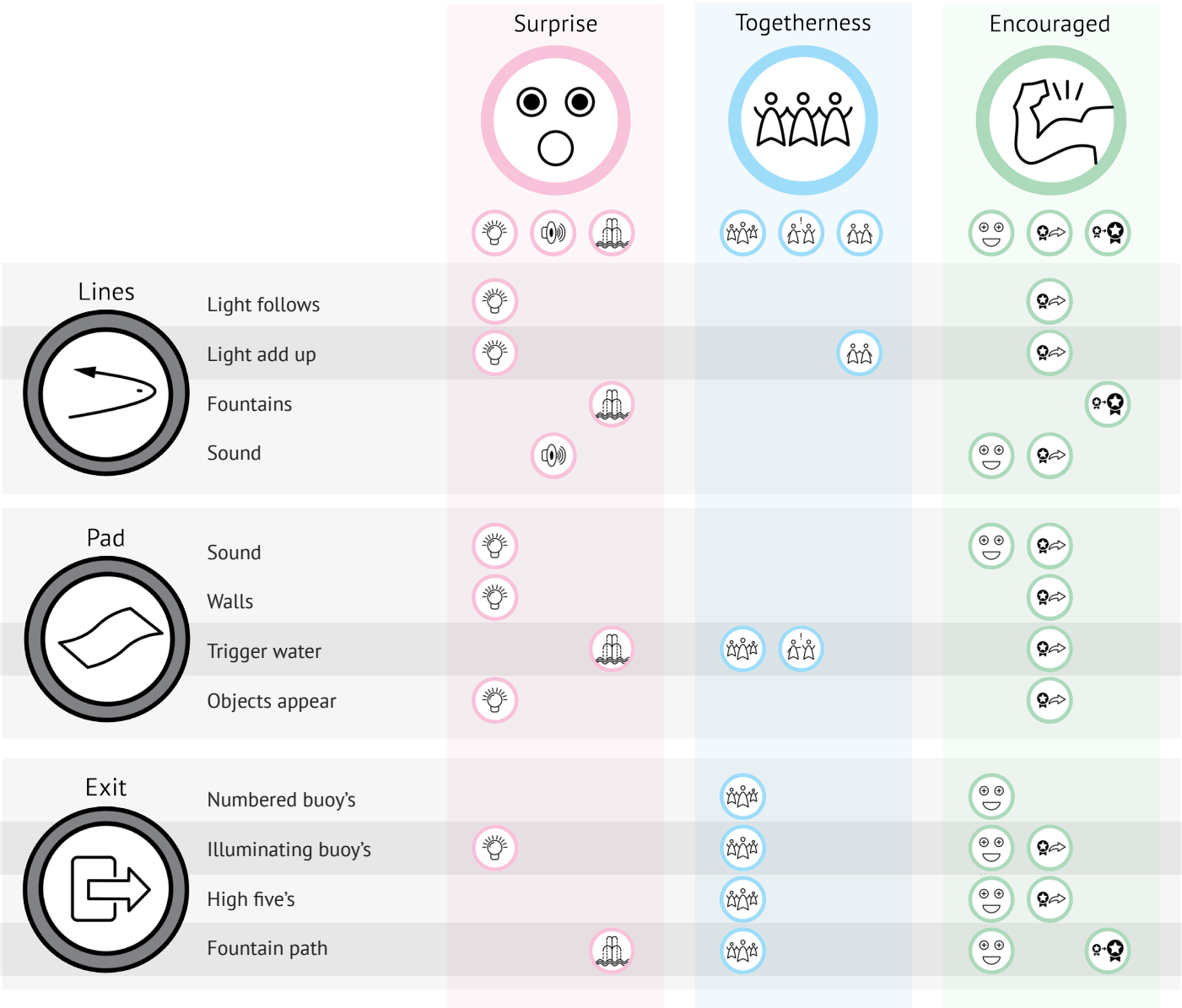


Figure 40: Overview of the concept direction elaborations with regard to the interaction vision. The grey marked elaborations contain all three interaction qualities.

Conclusion ideation

The minimum viable version of the Pad was chosen to take for further development into the product development phase. Leading in the decision making process was Schneestern's preference for this product.

The realisation process of the MVP of the Pad will be described in the next chapter of this report. The MVP opens a lot of opportunities for integrating other features in the future, as visualised in the second ideation phase.

2.5 Design brief

This chapter started off with the search area of 'beginners and families'. In this chapter the target audience is analysed and defined in order to reformulate this as unexperienced *Entertainment Enjoyers*. The design goal is formulated and an interaction vision is developed. Multiple idea generation sessions and evaluations have led to the decision to develop the MVP for the Pad. To summarize this chapter, the design brief is presented by answering the questions Who? What? Where? When? Why? and How? The list of requirements and wishes can be found in Appendix 6.

Who?
This product will be targetting on riders with an expertise level determined in 'the gap'. These riders now how to ride a full lap but do not have the skills or motivation to start riding features. The target audience is segmented as *Entertainment Enjoyers*. This target audience goes wakeboarding to find pleasure and be together with friends or family.

What?
The Pad. A floating feature that can be ridden like existing features but without the risk of injuries. The feature can be realised with different top surfaces, shapes and themes.
The feature possesses the qualities 'Surprise', 'Togetherness' en 'Encouraged'. The Pad will be the first product of a series of wakeboard features targeting the unexperienced *Entertainment Enjoyers*, based on this interaction vision. The minimum viable version will be developed as a first version of this product.

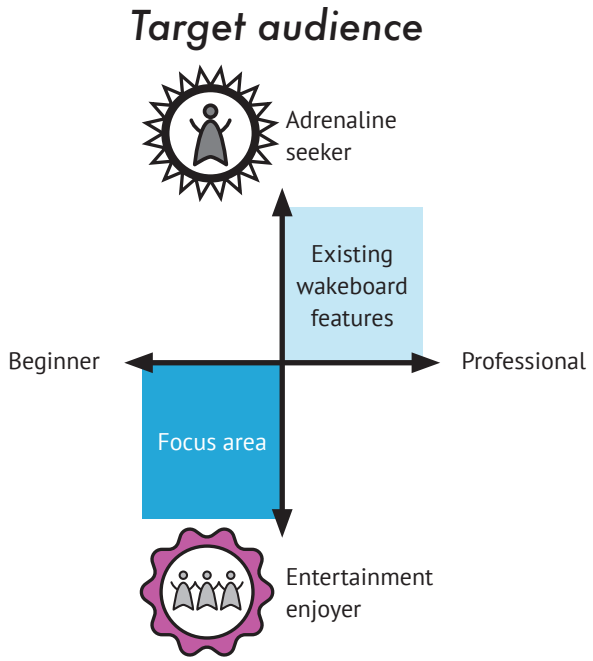
Where?
The feature will become available for wakeboard parks all over the world. Sesitec will be the main partner for distribution. The product will be produced at Schneestern in Germany.

When?
During the execution of this project, the MVP of the Pad will be designed. This product won't be saleable on its own and therefore a future vision will be developed as an addition to this design. More products should be developed simultaniously that match the design goal and interaction vision to be presented towards potential customers as one product portfolio. A vision will be created to provide guidance for further development. The development of more products that contribute to this product portfolio is not within the scope of this project, therefore the timespan is depending on the planning of Schneestern and Sesitec.

Why?
Because wakeboarding is rising in popularity and number of participants. It is expected that wakeboarding will evolve in a similar way as snowboarding, which means that the target audience of the sport is expending. Soon, this target audience will be including *Entertainment Enjoyers* next to the already existing audience of *Adrenaline Seekers*.
Besides that, a 'gap' was identified in the expertise development of riders. After being able to complete a lap, the next step is to start riding features, but there is a gap before you reach that expertise level.

How?
By making optimal use of Schneestern's production capacity and Sesitec's distribution channels. The next chapter will describe the development process of the Pad.

Figure 41: Visualisation of the possible appearance of the Pad.



Design goal

"Develop a feature for entertainment enjoyers that are wakeboarding on a Full Size Cable with an expertise level determined within 'the gap'."

Interaction vision

"Like discovering an old toolbox on the attic of my grandparents' farmhouse, excited to discover all the possibilities together with my nephews."

Figure 42: Overview of the design brief formulation chapter.

3 Product development

This chapter describes the process of the product development of the Pad as defined in the design brief in the previous chapter.

A wide range of possible solutions were explored. Multiple companies and experts were consulted and visited at their production facilities. The results of this exploration are clustered and visualised by a morphological chart. The division of sub-problems within this chart is used as guidance for the structure of the first part of this chapter.

By combining the most promising sub-solutions from the morphological chart, three prototypes were developed, of which two were realised and evaluated. This chapter concludes with the final design of the minimum viable version of the Pad, assisted by a future vision that guides the way for future development.

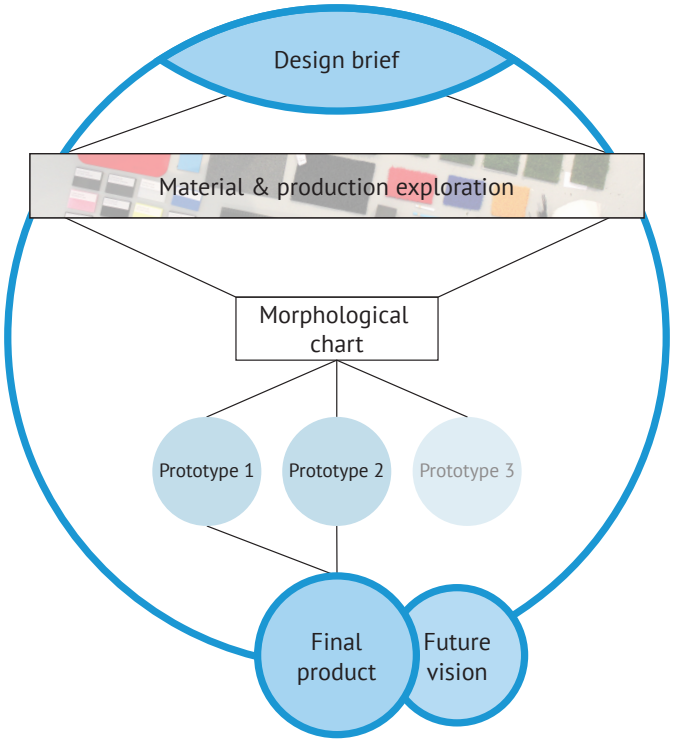


Figure 43: Product development phase.

3.1 Material & production exploration

A wide and indepth material and production exploration has been executed. A large number of companies have been consulted and a couple of company visits have been made. A lot of samples have been requested to be tested and get inspired. Figure 44 shows an overview of most of these samples.
Appendix 7 contains an overview of contacted companies and information about their contribution to this project. Appendix 8 contains reports of some of the company visits.
A test was set up to investigate the frictional resistances of different material samples towards a wakeboard (Figure 45). This test is described in Appendix 9.

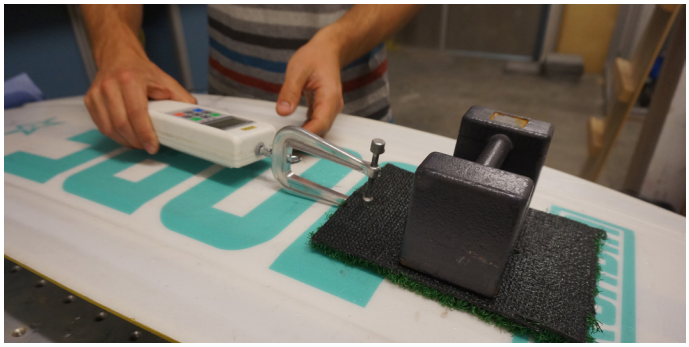


Figure 45: Measuring the frictional resistance towards a wakeboard.

Figure 44: Overview of most of the samples received to be tested and inspired.

3.2 Morphological chart development

The design problems of the Pad are split up into six divisions. During the material & production exploration, multiple solutions were found for each division. The conclusions of each division are described on the next pages. More information about the research within each division leading to the conclusions can be found in Appendix 10.

The Pad is split up into the following divisions:
Base
Makes the product float and form the base for optional cover layer(s).
Cover
Positioned on top or around the base layer. Multiple cover layers could be used together.
Configuration
Possible configurations of the product regarding the flexibility and permeability of water.
Form
Possibilities of the (top-view) layout of the Pad.
Start
Possibilities to realise a smooth transition from the water to the Pad.
Anchoring
Possibilities to anchor the product.

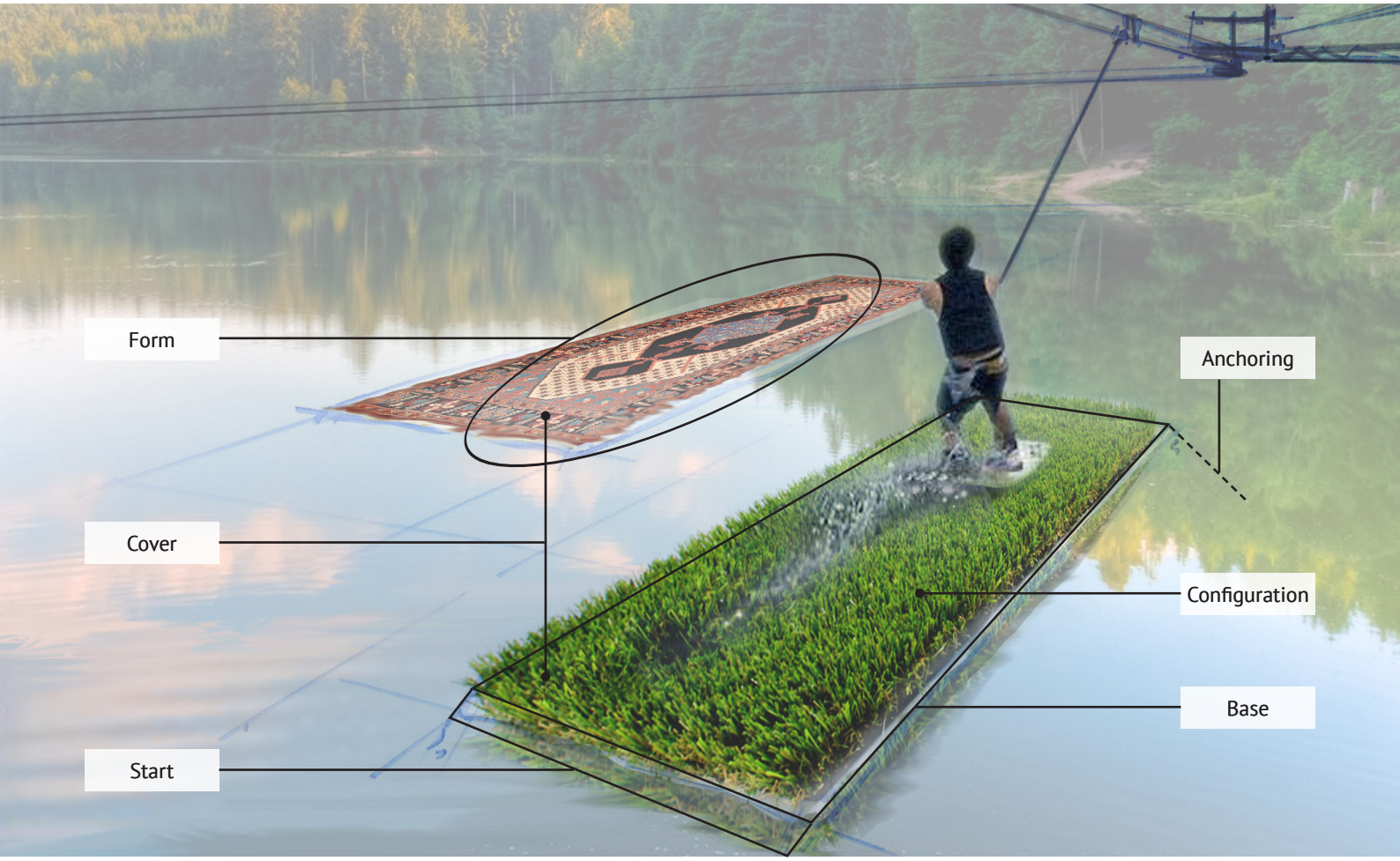


Figure 46: The Pad is split up into six divisions.

Base

The possible solutions that could function as a base are grouped in the following categories:
- Solid base
- Inflatables
- Foam

Conclusion solid base

Schneestern is expert in producing products constructed from HDPE plates. Therefore, this will be used as a base in combination with another cover material(s).
The main advantage of closed solid bases is that they create their own buoyancy, which is adjustable by changing the amount of air inside the body. This is not applicaple in the MVP version of the Pad and therefore not chosen for further development.

Conclusion inflatables

The buoy's, nor the dropstitch material will be used as a base for this product. Although the buoy's could become interesting when integrating dynamic features, they provide to little form freedom. The dropstitch material is criticized too fragile for this application.

Conclusion foam

The most suitable foam for the application in this product is PE foam.
Expanded polypropylene only becomes viable when large quantities are going to be produced. EVA rubber is relatively strong, but its frictional resistance is too high to be used without an extra top layer. With an extra top layer, the foam does not have to have the strong qualities that EVA rubber possess and could be replaced by the more affordable PE foam.
The foam should not be exposed directly to the wakeboard due to its high firctional resistance. In that way the foam can become a base layer or should be covered by another cover layer.
In order to determine which density and thickness of PE foam should be used, tests should be executed and evaluated.

Cover

The possible solutions that could function as a cover layer are grouped in the following categories:
- PVC
- Artificial grass
- Brushes

Conclusion PVC

As a final cover layer, the PVC floor from [supplier] has a lot of potential. It has a transparent PVC layer with a print on the

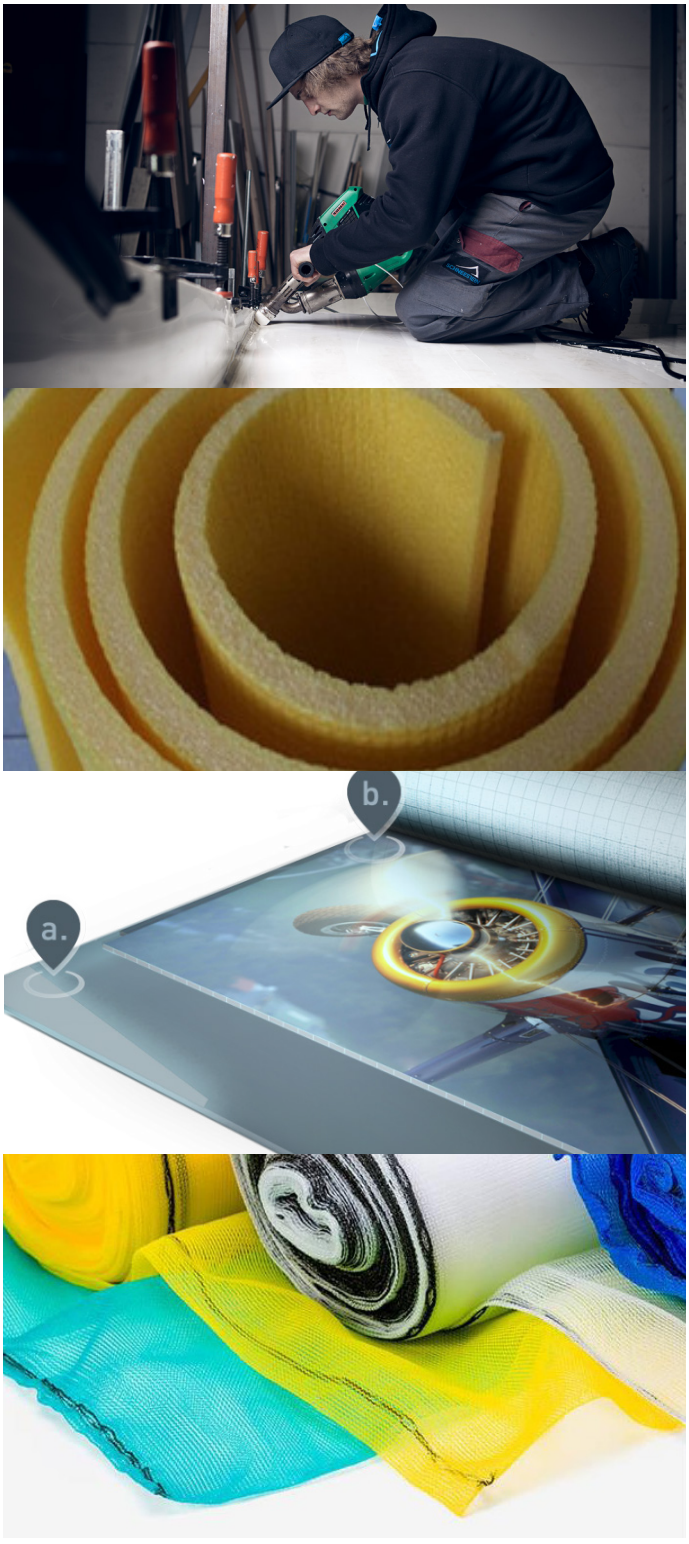


Figure 47: Constructing with HDPE plates.
Figure 48: PE colsed cell foam.
Figure 49: PVC floor.
Figure 50: PVC netting.

backside, which makes it very durable. PVC canvas is valued not durable enough to function as a final cover layer. PVC canvas and PVC netting could both be used as a construction material, for example between the base and the final cover layer.

Conclusion artificial grass
In consultation with L. Hulsman (Ten Cate) was decided that grass used for hockey fields and soccer fields should be best suited for this application. The material of the fibres of these fields is PE, which is the same type of plastic which is currently used as a sliding surface of wakeboard features.

Conclusion brushes
Based on my own experience, I concluded that the brushes of Everslide are to stiff and unappealing to be suitable for this product. The solution of long brushes produced by [supplier], as developed with B. Lambers is viable and should be investigated in the next step.

Configuration
Different types of configurations are possible to realise the Pad, with varying flexibility and permeability. These configurations should be tested and evaluated in order to gain insights about its riding experience.

Form
In contrast to the currently available wakeboard features, which are usually straight in one line, the Pad's top-view layout could have all kind of forms.

Start
The start of the product is the side of the product where riders will enter the product. It is important that the transition from water to the product is smooth at the start, in order to reduce the risk of falling at this transition.
The possibilities to realise a smooth transition from the water to the product are a solid start, a weighted flange or filling the product with water. The best solution for the start of the Pad is depending on which materials are going to be used.

Anchoring
Possible solutions to connect an anchor to the Pad are by using a ring in flange, hole through the material or a hook. Like the start solutions, the best solution is depending on which materials are going to be used.

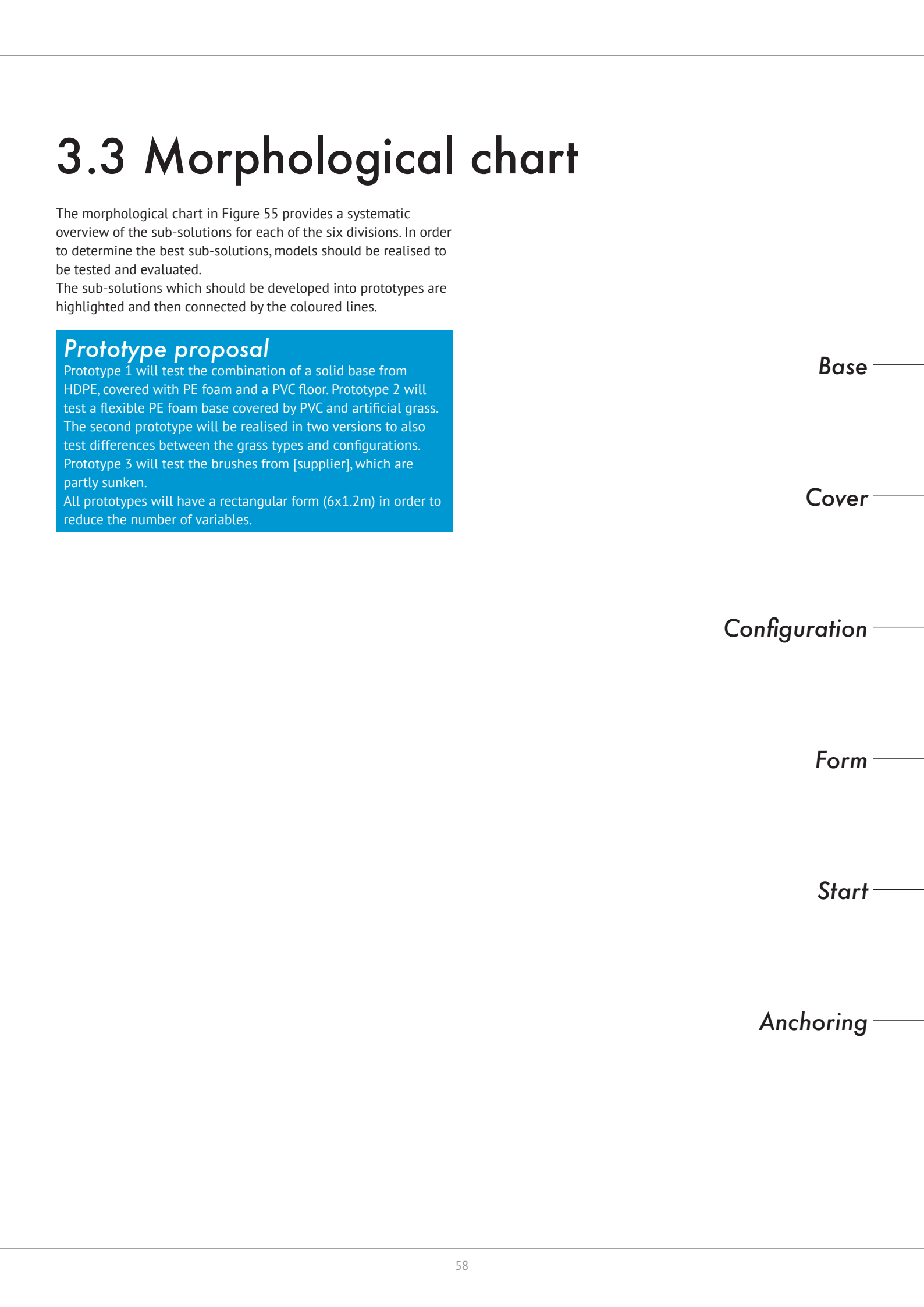
Figure 51: PVC canvas.
Figure 52: Artificial football grass
Figure 53: Artificial hockey grass.
Figure 54: Industrial brush.

3.3 Morphological chart

The morphological chart in Figure 55 provides a systematic overview of the sub-solutions for each of the six divisions. In order to determine the best sub-solutions, models should be realised to be tested and evaluated.
The sub-solutions which should be developed into prototypes are highlighted and then connected by the coloured lines.

Prototype proposal

Prototype 1 will test the combination of a solid base from HDPE, covered with PE foam and a PVC floor. Prototype 2 will test a flexible PE foam base covered by PVC and artificial grass. The second prototype will be realised in two versions to also test differences between the grass types and configurations. Prototype 3 will test the brushes from [supplier], which are partly sunken.
All prototypes will have a rectangular form (6x1.2m) in order to reduce the number of variables.



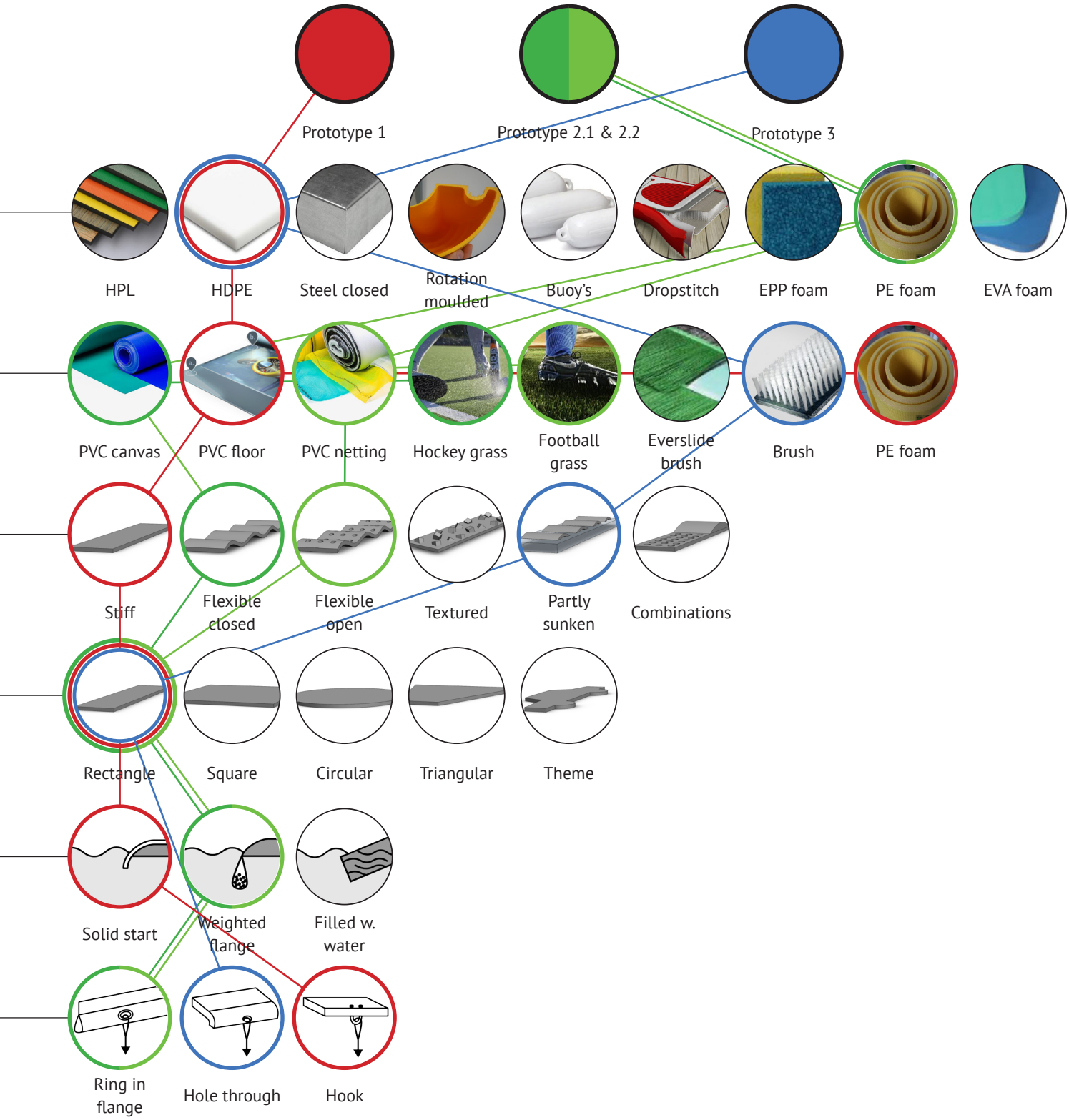


Figure 55: Morphological chart.

3.4 Prototype development

Three prototypes were designed to be realised and evaluated. Prototype 1 and 2 were actually realised, tested and evaluated. Due to a delayed delivery time of [supplier], prototype 3 couldn't be realised in full scale within the timespan of the project. A scale model has been realised, which is discussed in Appendix 8.

First, the objectives for realising these prototypes and the actual design are described, followed by the realisation of these prototypes.

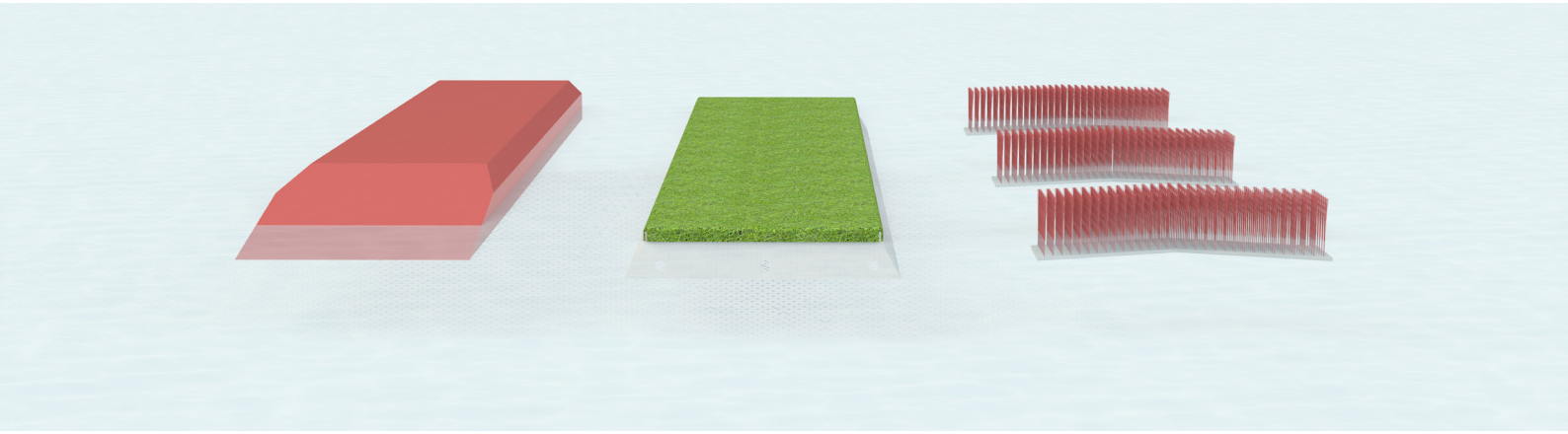


Figure 56: Prototye 1, 2 and 3.

Prototype 1

Prototype 1 is focussed on riding a customisable feature by making use of a printable PVC top layer. This top layer will be supported by a PE foam layer that covers the solid base. This base will be an open base, constructed similar to the current construction of Schneestern's features with adjusted dimensions to match the target audience' expertise level. The edges will become chamfered to give a softer appearance.

Although explicitly left out of the minimum viable product scope, this is also a first step in testing the possibilities of a dynamic closed base since the combination of PE foam and printable PVC could also be applied on top of the solid closed base, if viable.

Experience objectives

1.1 Evaluate the experience of sliding over a flexible PVC cover layer.
1.2 Evaluate the experience of sliding over a PE foam layer combined with a solid base.
1.3 Evaluate the visual appearance of the printable PVC from a distance and close by.
1.4 Evaluate the experience of the dimensions and chamfered edges of the prototype.

Physical objectives

1.5 Evaluate manufacturing of a solid HDPE base with chamfered edges.
1.6 Evaluate the attachment of the PE foam on the HDPE base.
1.7 Evaluate the attachment of the PVC layer on the HDPE base with PE foam in between.

Construction

The base of this prototype will be a solid slider, constructed from cnc cutted HDPE plates and welded together. This base is constructed with multiple ribs and acquires its buoyancy by Styrofoam located in the base. A layer of 60 mm closed-cell PE foam with a density of 28 kg/m^3 will be glued on top of the plates by CRC Power Stick. See Appendix 11 for the determination of the glue. The PVC layer will be cut and welded into a cover and is attached on the bottom of the base by a strip of HDPE which is connected to the side walls. Stainless steel hooks will be attached on the base to position the prototype by anchors.

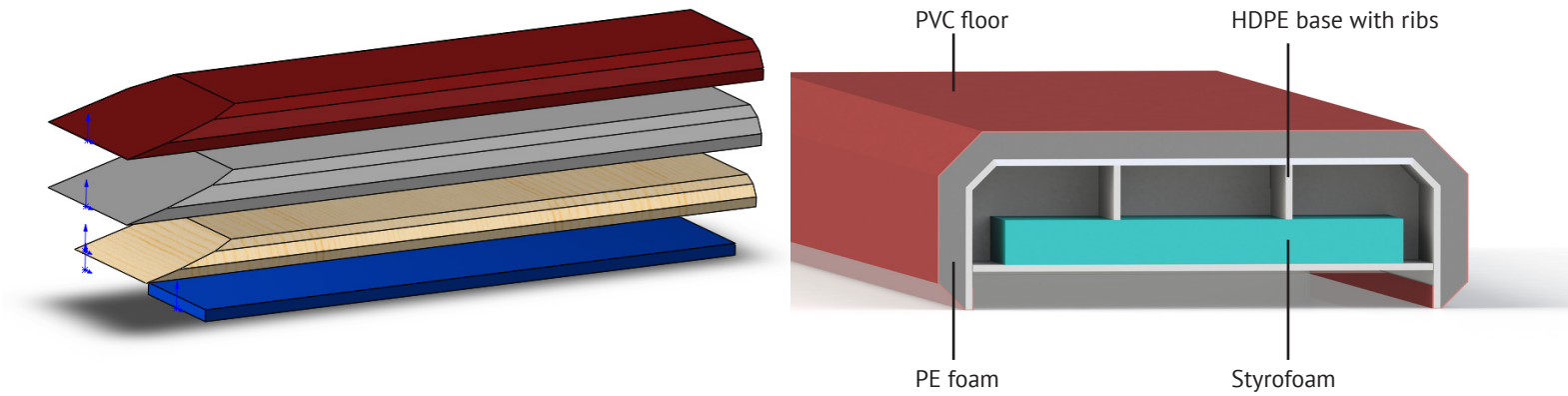


Figure 57: Visualisation of prototype 1.

Prototype 2

Prototype 2 is a combination of artificial grass on top of a flexible base. PE foam will be used as a base, placed in a cover. Artificial grass is connected to the cover.

Experience objectives

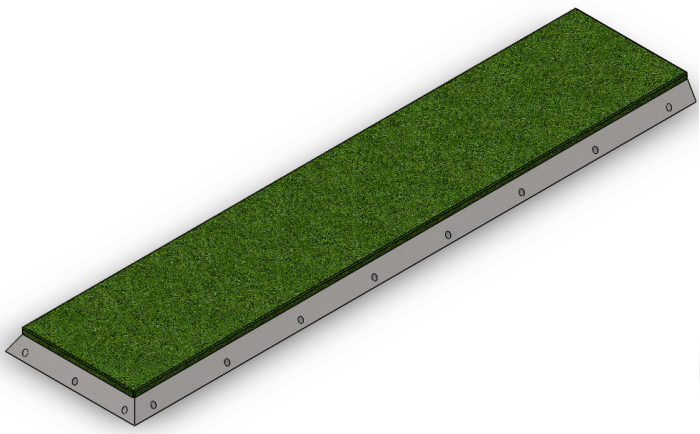
2.1 Evaluate the experience of sliding over artificial grass.
2.2 Evaluate the experience of sliding over a flexible base, with holes and without holes.
2.3 Evaluate the visual appearance of artificial grass from a distance and close by.
2.4 Evaluate the experience of the dimensions of the prototype.

Physical objectives

2.5 Evaluate the construction of a flexible base with a stitched cover from PVC netting and PVC canvas.
2.6 Evaluate the attachment of artificial grass to the flexible cover.
2.7 Evaluate the positioning of the feature.

Construction

The base of the construction is 60 mm PE foam, with a density of 28 kg/m^3, and therefore has a high buoyancy. PVC netting is chosen to construct the cover since this material is strong, though and affordable and water can flow through it. Half of the PE foam is perforated with holes that let water through the prototype when sliding over it, to test this effect. The top layer of this prototype is artificial grass, which is stitched onto the cover.



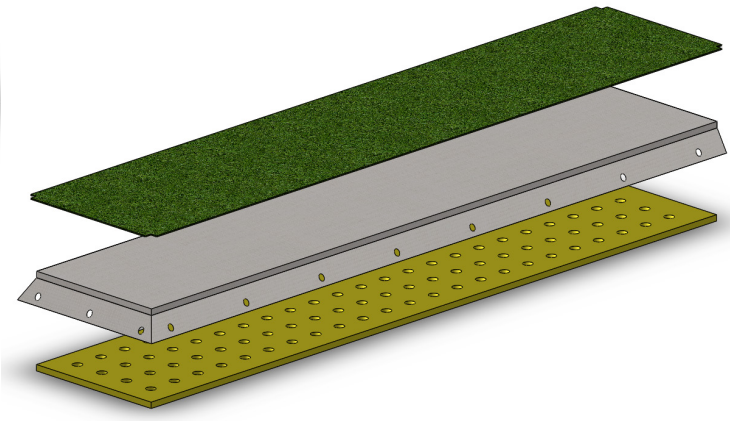


Figure 58: Visualisation of prototype 2.

Prototype 3

Prototype 3 is a combination of the sunken base and the industrial brushes of [supplier]. The high brushes are inspired by running through a field of high grass, though realised from high quality material. As discussed in Appendix 8, the best solution to introduce the brushes of [supplier] into a viable product is to lower down the base underneath the water level. Since the manufacturing costs of the brushes are relatively high, the amount of brushes used is minimized. Therefore, prototype 3 consists of three separate areas of brushes, shaped in the form of an arrow.

Experience objectives

3.1 Evaluate the experience of riding through the brushes.
3.2 Evaluate the visual appearance of the brushes.
3.3 Evaluate the experience of the form of an arrow and different areas of brushes.

Physical objectives

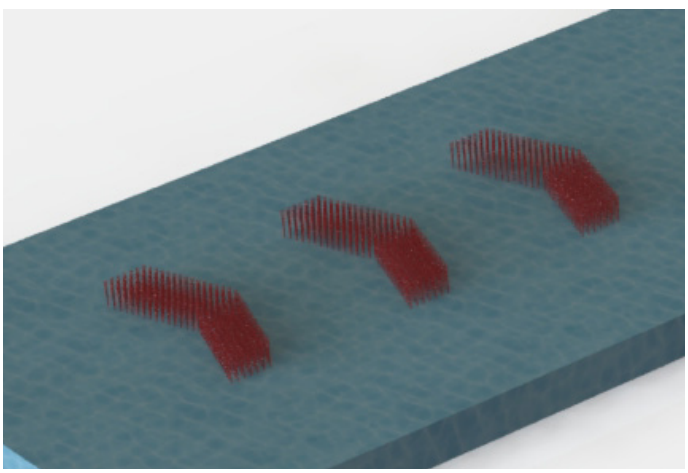
3.4 Evaluate the positioning system of the sunken base.
3.5 Evaluate the desired height of the base.
3.6 Evaluate the desired dimensions and type of the brushes.

Construction

The main construction is a HDPE plate, with brushes inserted in the form of an arrow, every 50 mm. In consultation with B. Lambers (Supplier), the following brush characteristics were determined:

Material	PBT
Fibre diameter	1.2 mm
Length	285 mm (max standard size)
Number of fibres per brush	20

In order to make keep this prototype under the water level, the model should have a buoyancy which is more than water (density < 1 kg/m3) and should be pulled down by a connection to the anchors. After receiving the arrows from [supplier], the best construction to position the prototype on the right height will be determined.



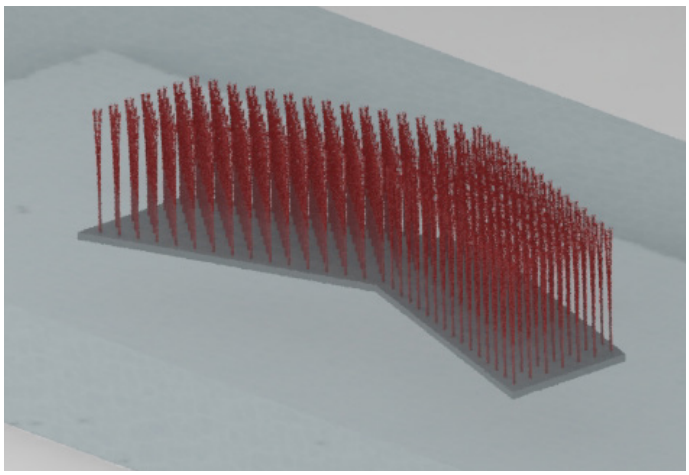


Figure 59: Visualisation of prototype 3.

Prototypes realisation

Quotes from all potential suppliers were requested in order to estimate the costs of the prototypes, see Appendix 12. After discussing this cost estimation and the construction of the prototypes with S. Podda (Schneestern) was decided to realise all prototypes. Unfortunately, [the supplier] was not able to deliver the prototypes within the time for prototyping within this project. Therefore this prototype was only realised in two small versions and evaluated, see Appendix 8. Appendix 13 contains pictures of the steps taken in the realisation of the prototypes.

Prototype 1

Prototype 1 was realised according to the original plan. Welding the chamfered HDPE corners turned out to be more difficult than expected, since Schneestern did not have the sufficient tools available to fixate the plates (Figure 60). Cutting the PE foam turned out to be very convenient, although welding the foam was a tricky process which produced nasty gasses. With the help of F. Haas, the PVC floor was cut and welded to shape (Figure 61).

Prototype 2

Because of the high expectations of this prototype and the collaboration of Ten Cate, two versions of this prototype were realised. Ten Cate made two pieces of artificial grass available which were sufficient to realise two full scale versions. Prototype 2.1 consists out of a foam base which is perforated by holes. This prototype's cover is made out of PVC netting with a top layer of artificial football grass. Protoype 2.2 consists out of a closed foam base. The cover is constructed from PVC canvas, covered by artificial hockey grass.

The design of prototype was partially adjusted according to the expertise of F. Haas, who thereafter realised the covers by stitching and welding without any problems. His suggestion was to keep the bottom of the cover open- and closeable by using rings and a rope.

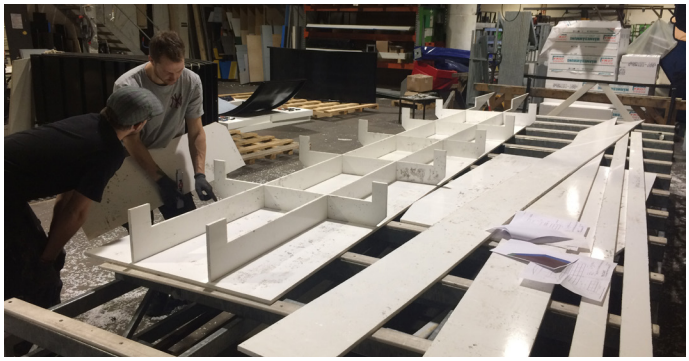


Figure 60: Welding the HDPE base of prototype 1.
Figure 61: Welding the PVC floor of prototype 1.

3.5 Evaluation prototypes

In April 2018 prototype 1, 2.1 and 2.2 were transported to cablepark Inselsee in Blaichach and lifted into the lake of this cable park (Figure 66). After placing multiple anchors in the lake, the prototypes were positioned right under the cable.

In order to evaluate the prototypes with riders that had no prior knowledge of the project, the initial plan was to leave the prototypes in the water over the weekend and ask visitors of the cable park to participate in this evaluation. Therefore, evaluation forms were prepared that focused on the experience as well as the physical objectives. These evaluation forms can be found in Appendix 14. Unfortunately, is was not possible to expose the prototypes to riders that were not involved in the project in order to protect the intellectual property of the prototypes. After securing the intellectual property, the evaluation forms can be used to evaluate with riders without prior knowledge of the project.
As a consequence, the prototypes were only ridden by four riders: Sebastian Podda (Schneestern), Tobias Luitz (Sesitec), Claudius van Derschau (Inselsee) and myself. Tobias and Claudius were asked to fill in the evaluation forms, but because of the small number of participants these forms were not statistically evaluated. Their feedback contribution is taken into account in the overall evaluation.

The prototypes were evaluated according to the experience objectives, physical objectives, interaction vision and cost. The results and conclusions concerning the experience and physical objectives are the results of a thorough evaluation meeting with employees from Sesitec and Schneestern who attended the testday.

Figure 66: The prototypes were lifted into the lake using a crane.

Figure 62: Testing the prototypes.
Figure 63: Prototype 1.
Figure 64: Prototype 2.1.
Figure 65: Prototype 2.2.

Results experience objectives

According to the objectives set in chapter 3.4.

Prototype 1

1.1 Sliding PVC

The sliding characteristics of the PVC top layer were evaluated excellent. The PVC gave little to zero extra resistance, especially when wet. This makes it good to ride, also for unexperienced riders.

1.2 Sliding PE foam combined with solid base

The rider did not experience negative nor positive effects due to the PE foam when sliding. This means that the density of the foam was high enough to be able to slide, in combination with the thickness and thoughness of the PVC.
The foam absorbed the impact for a possible fall drastically compared to the current features, but the rider could not see or feel this when wakeboarding.

1.3 Visual appearance PVC

The quality of the print on the PVC top layer was excellent. From a distance participants could hardly see the print on the top of the prototype due to the viewing angle, although the sides of the prototype were good to see. Colours with more contrast to the water and surroundings could be used to attract more attention. Although attached when stretched, the top layer stretched and blow up due to the radiation of the sun. From close by, this looked unappealing but this was not noticed from a distance nor when used while wakeboarding.

1.4 Dimensions

"The only problem about prototype 1 is that it is too short." (Claudius von Derschau, Inselsee) The angle of approach, width and height of the prototype were right for unexperienced riders. The chamfered edges gave the feature a harmless appearance. The length of the prototype was to short to be able to perform lots of tricks, nevertheless the length of the prototype was evaluated right for unexperienced riders.

Prototype 2.1 & 2.2

2.1 Sliding artificial grass

The sliding characteristic of the artificial grass was not smooth enough. Because the participants knew that the prototypes might not work perfectly yet, they were prepared to expect possible resistance. Nevertheless, we evaluated this resistance to high to be ridden by unexperienced riders. There was no significant difference in resistance experienced between the grass of prototype 2.1 and 2.2.

2.2 Sliding flexible base

The sliding characteristics of the flexible base were excellent. The participants experienced the sliding characteristics as if the prototype had a solid base. Most probably, this was due to the speed of the running wakeboard cable. Different speeds were used, varying between 25 and 30 km/h. There was no difference experienced between the prototype with and without holes. The flexible base resulted in a safe appearance when falling on the prototype.

2.3 Visual appearance artificial grass

The visual appearance of the artificial grasses was evaluated positive. Especially from close by the grasses looked really appealing. The grass of prototype 2.1 was most appealing and gave a softer appearance. In order to attract more attention from a distance, colours with more contrast to the surroundings could be used.

2.4 Dimensions

The length and width were right for unexperienced riders. The height, which was almost equal to the water level, gave the prototype an easy appearance.

Figure 67: Flexibility of prototype 2.2.

Results physical objectives

Prototype 1

1.5 HDPE base with chamfered edges

The main construction of the HDPE base was executed with the same approach that Schneestern uses to construct the current wakeboard features. The chamfered edges caused a lot of difficulties since these edges could not be kept in place by using the accessories Schneestern uses for perpendicular edges. This resulted in curvy edges due to the heat deformations caused by the welding extruder. The plastic welding extruder also did not have a 45 degree mount which made welding even more difficult. Investing in the right accesories to keep the plates in place and the right extruding mount should solve these problems.

1.6 Attachment PE foam

Sawing the PE foam plates in miter was carried out easily on a table saw. Before attaching the foam to the base, the foam plates were welded together. The process of welding was difficult and had to be done by two persons. A negative mould in the right corner would have made this process more convenient. Air suction was needed to filter the released gasses. Sanding the HDPE to prepare for gluing and the actual gluing was executed easily.

1.7 Attachment PVC layer

Attachment of the PVC to the HDPE box, first by staples and therafter secured by a HDPE strip, was executed easily. With the help of F. Haas, cutting and welding the PVC into the right shape was executed easily too.

Prototype 2.1 & 2.2

2.5 Flexible base with stitched cover

The manufacturing process of the cover was executed by a professional sewer (F. Haas) and did not result in any problems There was no difference between sewing the PVC netting or canvas. Keeping the cover open and closable was convenient for transport.

2.6 Attachment artificial grass

Sewing the grass onto the cover was not a problem for the sewer. Nevertheless, the sewing line was clearly visible. A better method should be found to carry out this attachment method.

2.7 Positioning of the feature

Pulling the start of the prototype down to the anchors worked very well and resulted in a smooth transition from water to grass. Unfortunately, the sides of the artificial grass floated more than expected, see Figure 68. The sides of the mat therefore did not match the prescribed safety guidelines. If a rider would get trapped under the mat with his board, the risk of injuries becomes too high. Therefore, the sides of the mat should be made heavier in order to make them sink.

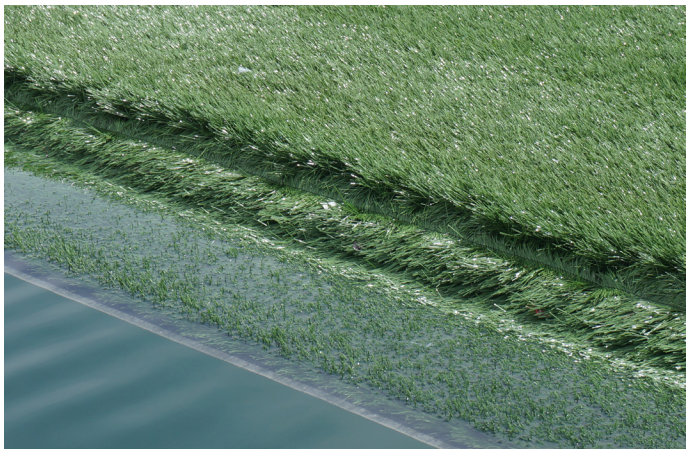


Figure 68: Floating sides of prototype 2.1.

Evaluation interaction vision

In order to truly evaluate intended interaction and product qualities, as described in the interaction vision, an independent participant group should test the prototypes. A research was set up to execute this evaluation with unexperienced entertainment enjoyers at the Inselsee cable park, but unfortunately this research was not executed. Schneestern valued the prototypes very high and possibly wants to capture (parts of) the prototypes for intellectual property. Therefore, the prototypes can not be exposed towards the public yet.
The test forms, as part of the research set-up can be found in Appendix 14.

The interaction vision contains the interaction qualities surprise, togetherness and encouraged (chapter 2.2). The evaluation towards these qualities is carried out based on the evaluation together with the clients.

Surprise
The surprise effect came best to existence in prototype 2.1, due to the long fibres of the artificial grass. By making better use of the print of [supplier], this surprise effect could be enlarged in prototype 1. Examples are the print of photorealistic prints of textures (stones, grass, sea, etc) or printing an image in a realistic perspective (a hole in the water for example).

Togetherness
By making all prototypes available for all riders, all prototypes contribute to an increased value of togetherness.
One of my concerns was that the features were too simple/boring for experienced riders but during the evaluation this concern was taken away. One of the pro riders mentioned his excitement to try to jump completely over prototype 2, since landing too short wouldn't be a problem due to the flexibility of these prototypes.

Encouraged
To what extent unexperienced entertainment enjoyers would feel more encouraged is something that should really be tested and evaluated with real test persons.

> Personally, when I tested the prototypes I felt really encouraged, but that was because a major milestone in the project was reached.

Evaluation cost

An overview and evaluation of the costs for the prototype realisation can be found in Appendix 15. Prototype 1 turned out to be considerably more expensive than prototype 2.1 and 2.2. These cost were the result of expensive materials used and a more labour intensive manufacturing process.

By taking the results of the experience objectives in consideration, it is suggested to use a flexible base (objective 2.3). This base offers a similar sliding experience compared to a solid base but will cut down on costs a lot.

Conclusion evaluation prototypes

The overall evaluation of the prototypes is structured according to the 6 divisions of the morphological chart. The conclusion of this evaluation is used as a starting point for the final design.

Base

HDPE

The base constructed from HDPE functioned really well. The chamfered edges were a good first step to make the edges look less dangerous, although this made production more complicated. The production process of the base is labour intensive and therefore costly.

PE foam

The PE foam worked really well as a base. The foam was stiff enough to be ridden by a wakeboard and at the same time flexible enough to reduce the impact of a possible crash. The holes in prototype 2.1 had no effect on the riding experience compared to the base without holes in prototype 2.2.

The base constructed from PE foam is more affordable than the base of HDPE due to the labour intensive process of construction. The PE foam is therefore valued best as the base of the Pad.

Cover

PE foam

The PE foam as a cover between the HDPE base and PVC floor resulted in good sliding characteristics. The impact reduction at a possible crash was sufficient, but can become higher. This could be realised by using foam with a lower density, but it is questionable how this will effect the riding characteristics.
The foam was really well able to cut in the right shape, even though welding the plates together was a tricky process which produced hazardous gasses. The attachment of the foam to the base by the glue was sufficient.

PVC canvas and PVC netting

Using these materials as a cover of the foam worked really well. Both materials are strong, flexible, relatively affordable and good to process by welding and sewing.

PVC floor

The quality of the print of the PVC floor was extremely high. This opens a lot of opportunities for customizing the print. Not only could photo realistic and prints in perspective be realised, also branding could be integrated.
The sliding characteristics of the PVC were perfect.
The blow-up effect due to the sun's radiation should be minimized by fully gluing the floor or making small holes in the PVC.

Football grass & hockey grass

Although both types of grass were valued really positive by their visual appearance, especially the long fibred football grass, the sliding characteristics were not good enough. Further research should be done to find a better solution.

Configuration

The flexible open and flexible closed configurations were really engaging to stand on, but when wakeboarding over prototype 2.1 and 2.2 this flexibility was not noticed. The type of configuration has no significant impact on the riding experience.

Form

Only the straight form was used in this test in order to reduce the amount of variables and build the prototypes as efficient as possible. In order to step away from the geometric geometry that is used in the current wakeboard features, organic shapes should be taken into account in further steps.

Start

Both types of start worked well with the prototypes. The sides of prototype 2.1 ann 2.2 floated more than expected. When approaching this feature from the sides, this could have been dangerous, as discussed in the result 2.6. The sides should be weighted if this type of mat finds an application in the future.

Anchoring

Both methods to connect the anchors worked sufficient.

Conclusion evaluation prototypes

As it turns out, a combination of both prototypes is the best method to realise the minimum viable version of the Pad. The base from PE foam with a cover of PVC canvas will be used from prototype 2, covered by the PVC floor from prototype 1. The production of a HDPE base is too labour intensive and therefore too costly. The artificial grasses do not have sufficient sliding characteristics.
In order to distinguish the feature from the current geometric designs in the wake park, the form should become organic. The start can be pulled down by a weighted flange with hooks to connect the anchor lines.

Additional value prototyping

Inspiration

Apart from providing insights about experience and physical objectives, the prototyping phase had wider contribution within this project. During the design and realisation of the prototypes, by placing the models in the water and by riding them, a lot of - unmeasurable - inspiration was gained. This inspiration has contributed a lot to the final design and future vision, although hard to capture in a report.

Further research

Suggestions for further research regarding the prototypes that have been tested.

PE foam

In order to gain the effect of (partly) sinking through the flexible base, it should be investigated what the effect of more holes, larger holes, a thinner plate or smaller density of PE foam would be.
Also, it should be tested how the riding experience is influenced if thicker or thinner foam could be used and if transitions in thickness can be ridden.

PVC floor

The PVC floor should be tested for a longer period of time on the wakeboard course to test the effect of frequent use with a wakeboard. This should also determine the effect of weather conditions, especially the materials' tolerability towards UV. Schneestern is currently investigating the possibilities of placing prototype 1 in a wakeboard park over the summer of 2018, to test these qualities.

To solve the problem of the balloon that arose due to heat transformations, more research should be done (Figure 69). Finding the right glue to attach the PVC floor to the PE foam is one option to solve this problem. After consulting [supplier] is decided to test 'eurocol 640' as a first step in this development. Another option is to perforate the PVC on the top to let the air out, but the effect on the riding experience should be tested and evaluated.

Figure 69: The PVC floor blew up like a balloon because of the radiation of the sun.

Artificial grass

The types of grass that are used in prototype 2.1 and 2.2 are not suitable to be ridden by the target audience but the experience of riding through a floating grass mat is really encouraging. Further research should be executed to find artificial grass with better sliding alternatives. In consultation with Ten Cate, it was decided that the first step would be to evaluate grass types with defibrillated tape fibres made from PP and from PE.
When a feasible type of artificial grass is found, the effect of algae development should be tested. If the development of algae has a negative influence, it is suggested to further investigate the use of algae exterminators used in hockey fields.

Form

As mentioned, possible constructions and riding experience of organically shaped Pad's should be investigated in order to distinguish the Pad more compared to the currently existing features.

3.6 Final design

The Pad

Based on the conclusions of the prototype evaluation, a final design of the minimum viable version of the Pad was constructed. The Pad has a soft base which reduces the risk for injuries without handing in on the sliding characteristics. Although designed specifically for beginning *Entertainment Enjoyers*, it can also be ridden by other wakeboarders. The Pad is organically shaped and because of the different heights different riding lines can be ridden. The Pad can be printed in every theme desired, fitting the preference of the cable park. Prints could range from realistic forest, underwater or meadow landscapes to colourful animated designs or brand logo's.

Form & dimensions

The Pad is organically shaped, to have a less dangerous and masculine appearance. It also distinguishes the Pad from other existing obstacles in the cable park.
The Pad is designed to be ridden using different riding lines by riders from varying expertise levels. The most accessible way to ride the Pad, is to ride the left side ([1] in Figure 70). The dimensions of this part of the Pad are similar to prototype 1, which was valued to be very accessible for all expertise levels. If a rider is able to ride line [1] and [2] and is looking for a new challenge, he/she can try to approach the Pad from different sides and use it as a kicker or slide diagonally ([3] & [4] in Figure 70).

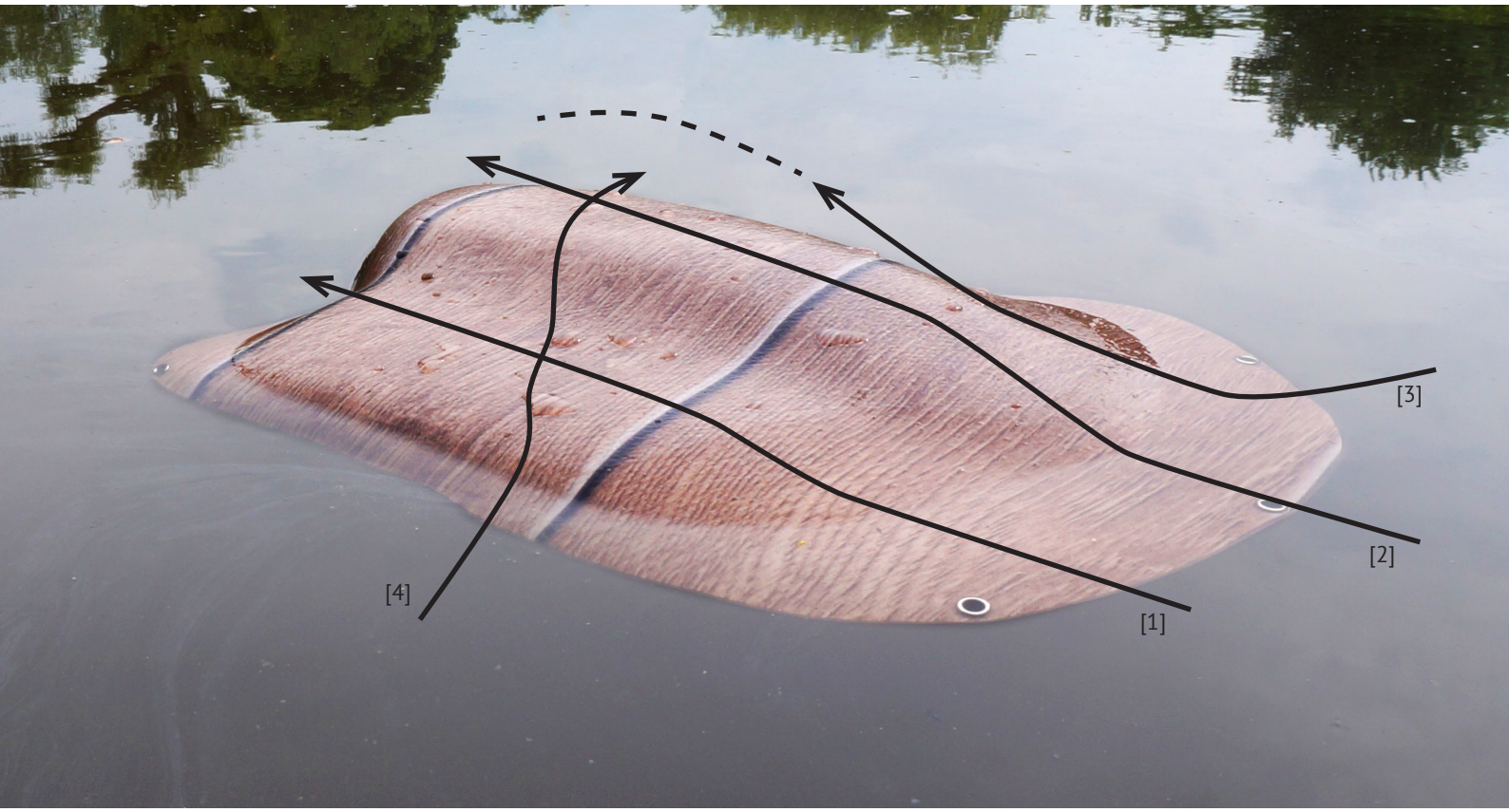


Figure 70: The Pad and some different riding line opportunities.

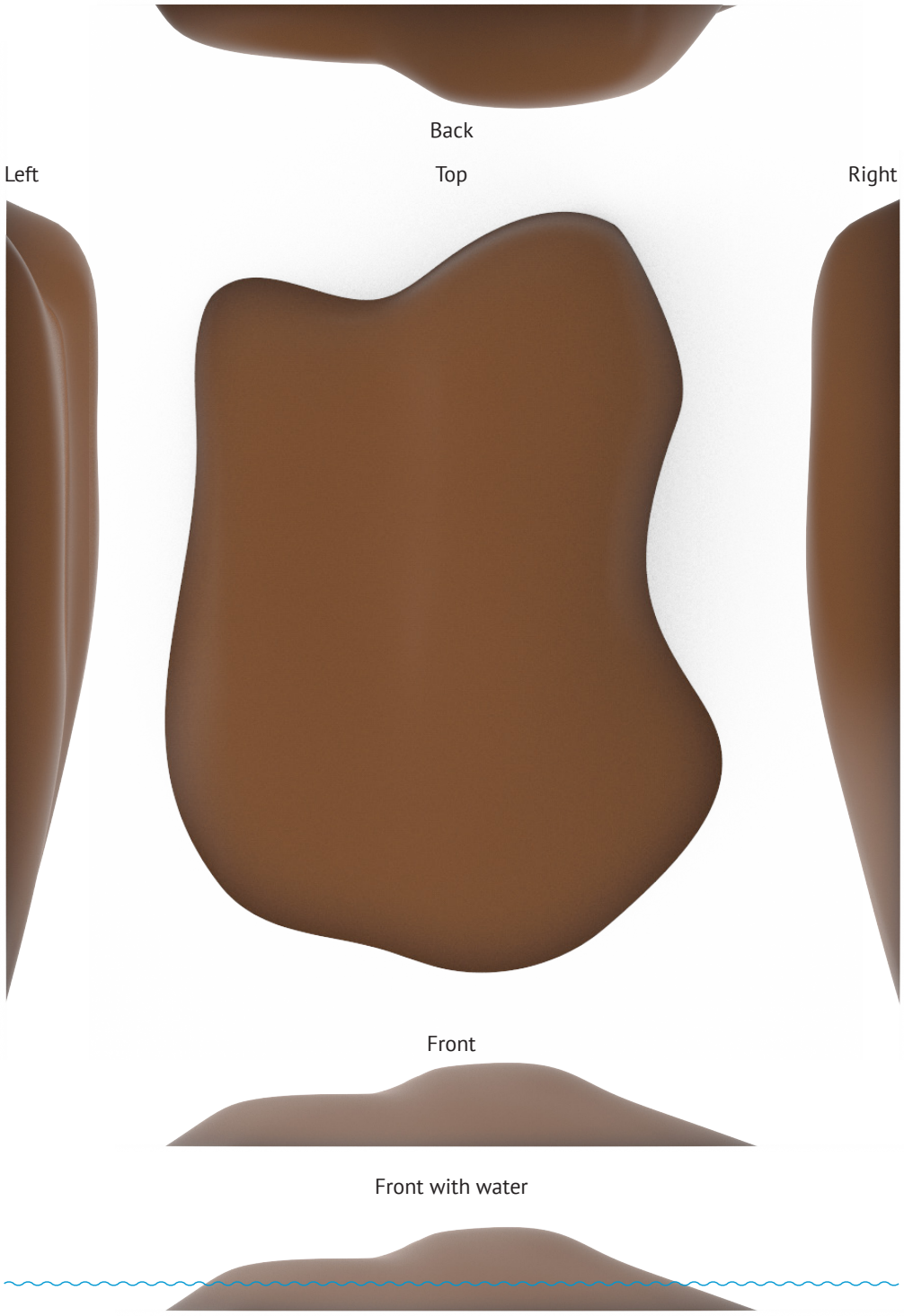


Figure 71: The Pad.

Materialisation & manufacturing

The Pad will be constructed from a combination of PE foam, PVC canvas and PVC floor. Figure 72 shows a systamatic exploded view of the Pad.

Base

The base will be constructed from multiple layers of PE foam. Schneestern has a close connection with a cutter who cuts using a 5-axis cnc waterjet. They will cut all layers of foam in the scape desired. The layers will be welded together to form a solid base. The PE foam with a density of 28 kg/m2, used in prototype 1 and 2, is suitable for this application according to the test results and will be used.

Cover

The base will be completely covered by PVC. The top layer will consist of PVC floor, the bottom layer of PVC canvas. The PVC floor will be produced and printed by [supplier]. The PVC floor will be stretched and heated over a mould (thermo formed) to plastically deform in this shape without any cutting lines. A scale model is produced in order to validate the manufacuring principle, see Appendix 16. On the full length of the side of the floor (the part that is under water), a flange will be stitched. Inside this flange a stainless steel chain will be enclosed to make sure the floor always stays under water. Stainless steel rings will be enclosed in this flange to connect the Pad to anchors in the lake. After positioning the foam base in the PVC floor, the Pad will be closed by a PVC canvas bottom sheet. Canvas will be used since the bottom part doesn't need to have the high quality of the top layer and is more affordable. The PVC canvas and floor will be welded together, which is possible due to the same base material of both layers. It is suggested that the Pad will be realised in cooperation with sail maker [supplier], a company that Schneestern cooperates closely with in the realisation of their current product offer.

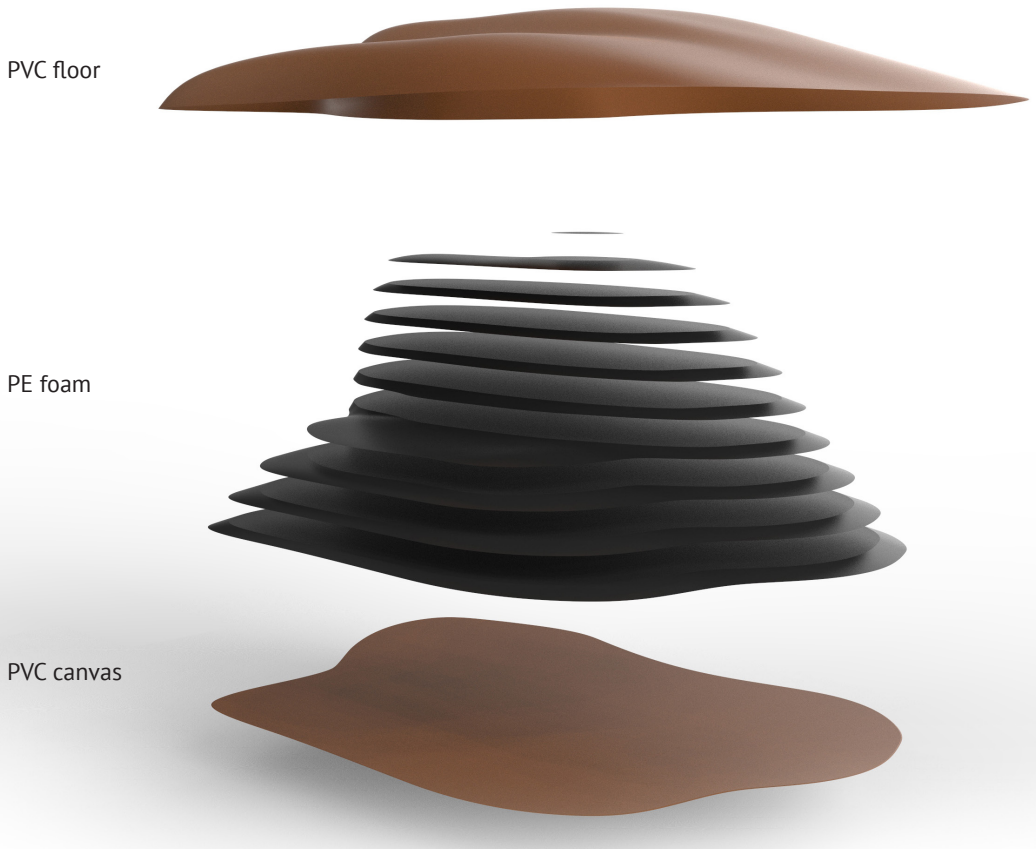


Figure 72: Exploded view of the Pad.

Safety

The complete feature will consist of flexible materials, with a base entirely out of foam. This will make the base safe for impact when falling on top of the feature. The sides of the Pad will continue for 250 mm under the water surface, all around. This is 50 mm more than prescribed in the guidelines for features from Schneestern. The end of the feature deliberately does not have the small slope of the start, since that would result in a higher chance to get blocked when the front of the board hits the water.

Cost price

The total costs for the Pad is estimated at approximately € 4000,- per product (Figure 73). This estimation is based on the production of one product and is expected to become lower is the number of products will be increased. This estimation is based on the cost evaluation of the prototypes. No actual quotes have been requested yet, so please note that these prices are all based on assumptions.
The main costs of the Pad are a result of the large surface of PVC floor and large volume of PE foam. It is expected that purchasing this large quantity of PE foam would result in a price advantage, therefore this is estimated at € 20,- per square meter. Further research should determine if 60 mm thick foam is actually the best type of foam plate to use, maybe the Pad can be realised using thicker plates. Before making the cost estimation more realistic, the number of products for the first edition should be determined, since producing multiple products at once will result in a price advantage.

End of life

A deliberate choice was made not to glue the base and cover together since both parts consist out of a different type of plastic. The base consists out of PE and the cover – the floor as well as the canvas – consists out of PVC. At the end of life of the Pad, these parts can be easily separated for recycling.

	Quantity	Unit	Price / unit	Price
Materials				
PE foam 60 mm	70	m^2	€ 20	€ 1400,00
PVC floor (custom print)	30	m^2	€ 60	€ 1800,00
PVC canvas	20	m^2	€ 6	€ 120,00
Rings anchor	6	rings	€ 1,28	€ 7,68
Chain (weight)	15	m	€ 1,50	€ 22,50
Manufacturing				
CNC waterjet PE foam				€ 200,00
Forming PVC floor	4	hours	€ 39,50	€ 158,00
Welding PE foam plates	2	hours	€ 19,60	€ 39,20
Welding cover PVC floor + canvas	2	hours	€ 39,50	€ 79,00
Total cost				**€ 3826,38**

Figure 73: Cost estimation the Pad.

Next steps the Pad

A couple of small tests should be performed and a full scale model should be realised before finalizing the design and making this product ready for production.

Small scale tests

Foam

The design of the layers of foam should be presented to the waterjet cutter in order to discuss the possibilities and limitations. The design should possibly by slightly adjusted according to this meeting. Also, the thickness of the foam plates used should be reconsidered according to the cutting possibilities.

PVC floor perforated

To eluminate the blow-up effect of the PVC floor due to heat differences, the PVC should either be perforated with small holes or should be glued to the foam. In order to keep the PE foam and PVC floor recycleable, it is undesired to glue the materials together. Tests should be executed to find the best way to perforate the PVC in a way that doesn't negatively influence the riding characteristics nor the durability.

As a backup plan, both materials could be glued together (although undesired). According to the supplier, the floor should be good attachable to the foam by using 'eurocol 640'. This should be tested and evaluated.

Forming PVC floor

Tests should be performed to investigate the best way to form the floor in the organic shape desired. The scale models (Appendix 16) validated that the PVC floor is thermo formable, but the best way to do this on full scale has not been determined yet. If possible and affordable, the full cover should be formed in one piece. Otherwise, multiple pieces should be welded together after forming. Additionally, the effect on the proportions of the print because of the deformation of the cover should be investigated. Design rules for the design of the print should be determined based on this evaluation.

Full scale tests

Foam – multiple layers

The full scale model should provide insights about the riding experience in this configuration, with multiple layers of foam instead of one (in both prototypes). According to the evaluation of these tests, foam with another density could be tested.

Print of top layer

Multiple designs should be made in order to set up a first collection of prints. According to the manufacturing principle to form the floor into the final shape, this print should be adjusted. If the floor can be completely plastically deformed without cutting, the design of the print should be different printed than if the floor will be cut and welded together.

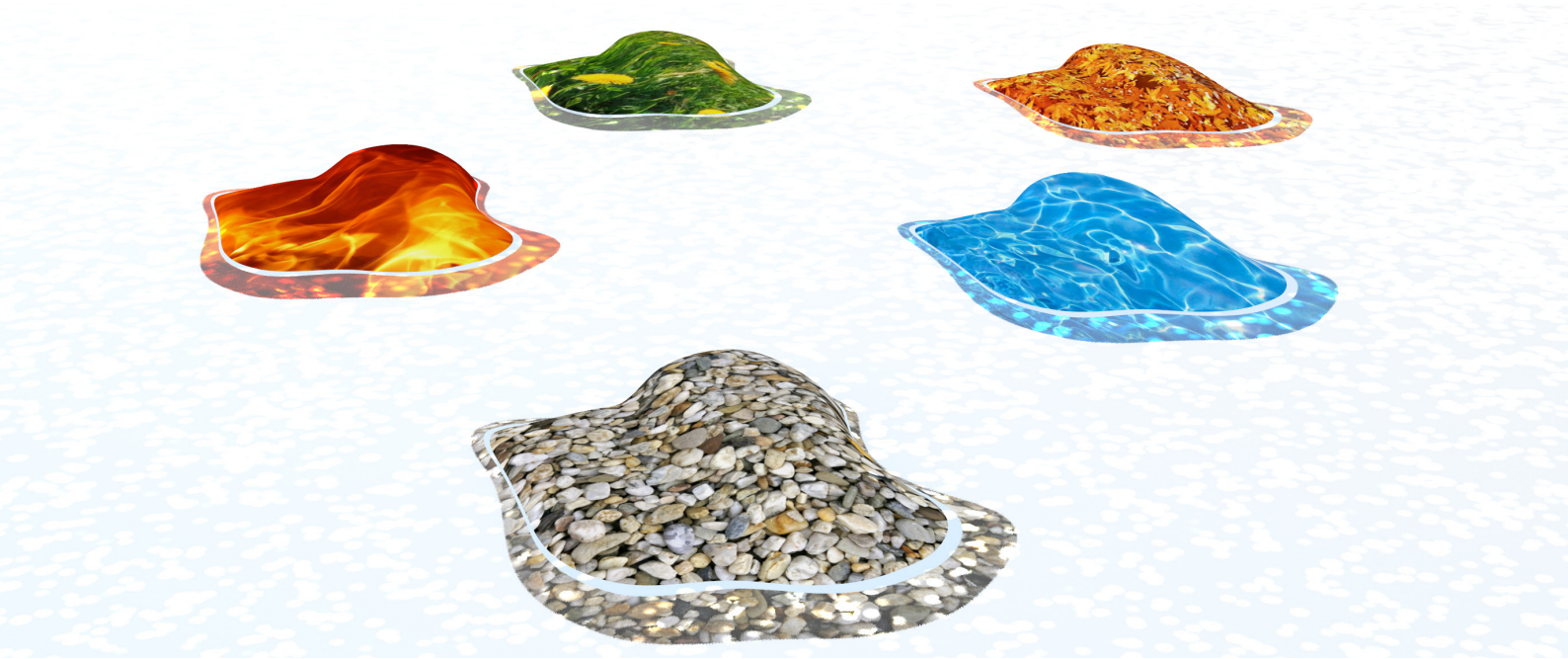


Figure 74: Suggestion for prints of the Pad.

Figure 75: The Pad in relation with a wakeboarder (photoshop from scale model).

3.7 Future vision

The final design of the Pad represents the minimum viable version of this product. The goal of this product is to gather feedback from customers and validate the working principle. This product can be the starting point for further development and integrating more features.

The Pad is not a product on it's own. Multiple products should be developed that match the determined target audience and interaction vision of the Pad. In that way, cable parks have the opportunity to combine multiple features that match a common theme or desired layout of the cable park.

Nevertheless, the development of this range of products will take time. Therefore, a future vision of what a cable park could look like in the future is developed in order to provide guidance for future development.

Wakeboarding landscape of 2030

The cable park in 2030 will be filled with all kinds of harmless and surprising features. Based on the slopes of a dune landscape, all features are organically shaped and have different top surfaces, textures and buoyancies. This creates an enormous amount of riding opportunities for riders of all expertise levels to explore together. The landscape possesses multiple hidden gems that trigger actuators in different places of the landscape, surprising the rider over and over again. Some trigger the waterfall or the fountains, while others make some slopes change angle or make a whole 'island' disappear. Within this landscape riders will never get bored but are encouraged, stoked, to get back as soon as possible.
The landscape consists of multiple separate features that create a whole together. In that way, park managers can shape their own perfect landscape using the provided building blocks. It also gives them the opportunity to invest in only a couple of features every season and does not need a full investment at once. The visual on the next page, Figure 76, shows a conceptual drawing of what a landscape in this cable park could possibly look like.

Next steps future vision

The first steps for future development in the direction of the wakeboarding landscape of 2030 are as follows.

The Pad

The final design of the minimum viable version of the Pad should be realised en tested over the period of at least one season. A second evaluation of the condition of the product after this period should be executed. This experience can be used in the further development of the landscape.
The Pad should also be used to test the viability of the complete concept. This product, as well as the complete concept should be subjected to possible clients (cable parks) and riders in order to gain insights into the viability and change the concept according to their input if necessary.

Textures

The texture of artificial football and hockey grass have been tested but were not found to be sliding perfectly yet. It should be investigated which other textures provide a surprising and smooth riding experience to be integrated in features of the landscape.

Actuating features

The first actuating feature to be realised should be the water feature. Different options of realising fountains, sprays and waterfalls should be evaluated after developing and realising these features.

Dynamic features

What is the best way to make features change shape or disappear and appear out of the water? This should be investigated and tested by developing different solutions.

Sensory features

The possibilities of triggering sensors by riders in the cable park should be investigated. How can these sensors be located in the cable park or integrated in features? What are the opportunities to make these sensors personal? Can individual achievements be tracked or can the feature respond different after a number of times?

Next page:
Figure 76: Conceptual drawing of the future vision with the Pad incorporated.

4 Evaluation

The process of this graduation project is evaluated on multiple levels. First on project level, the recommendations and project evaluation are described. These evaluations are followed by a personal reflection and conclude with acknowledgements to everyone who contributed to this project.

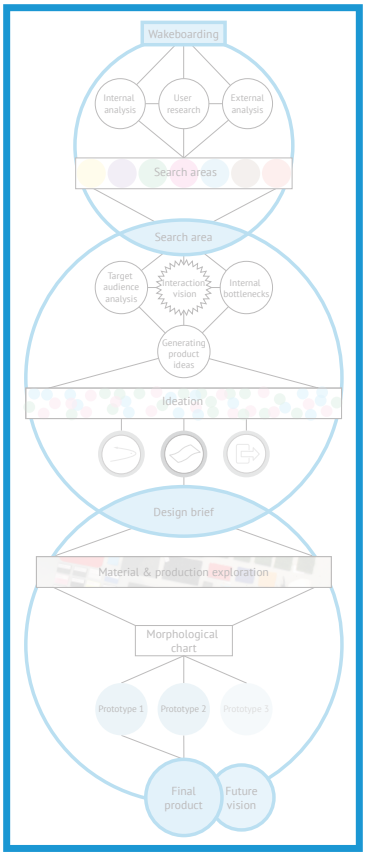


Figure 77: Evaluation of the project.

4.1 Recommendations

First one part of the process that has not been incorporated into this report will be explained, followed by shortcomings that lead to future suggestions for improvement.

Rotation moulding
After my second visit to Schneestern and Sesitec, just before Christmas, I arrived back in Delft with a large number of potential ideas to work on. I took a dive into the world of materials en production techniques and at the suggestion of multiple professors at the faculty I visited a rotation moulding company called Dragon Plastics. I became enormously enthusiastic about the possibilities of this (relatively) low scale and affordable production technique.
Looking back at this moment, I realise that I lost track of the design goal of this project and this is also what the feedback was when I – convinced and excitedly – presented this production technique to my clients. Let's not go into detail about how this feedback was presented. I decided to take a big step back in the process and restarted by defining a vision, the interaction vision, before re-entering the material and production phase. Although the negative feedback was very demotivating, I can now say that it was a valuable moment in the process, which contributed positive to the final result of the project.
Simultaneously, I am satisfied with my gained knowledge about rotation moulding and I am sure that I can use this knowledge somehow in my future career.

Evaluation interaction vision
When setting up any goal or vision for a product to be developed, it is important to evaluate this afterwards in order to conclude whether this goal is reached. Unfortunately, it wasn't possible to evaluate the interaction vision the way I planned due to short-term changes. Schneestern decided that it was to risky to leave the prototypes in the water longer than a day in order to protect the intellectual property of the designs. This made it impossible to evaluate the prototypes with participants who were not involved in the project. I evaluated the vision together with my clients, which didn't provide a completely unbiased result. It is suggested to execute this research as soon as the intellectual property of the designs has been secured.

Form the Pad
All prototypes were limited to the same top-view layout and dimensions. It is assumed that the Pad will also be rideable in the layout and dimensions as designed, but further research should be executed to determine whether this is actually the best form in terms of rideability. Manufacturability could also influence the optimal form of the Pad after evaluation with all stakeholders.

Safety
In my research towards the safety aspect of wakeboarding, chapter 2.3, I discovered that valuable data about risks and injuries within wakeboarding hardly exists. Taking the increasing popularity of the sport in consideration, I think it would be valuable to execute an in-depth research about the main risks of the sport. This research could be the starting point for redesigning (parts of) the sport in order to reduce the number of injuries, if applicable and desired. Since part of the 'fun' of wakeboarding is caused by its risk, especially for *Adrenaline Seekers*, it would be a challenge to make the sport safer without reducing the excitement created by risks.

Minimum viable product
The minimum viable product of the Pad has been designed. After short- and long-term evaluations of this product, more features could be added to this design. Possible starting points for future development are:
Dynamic features
Blow up features, hide and disappear (parts of) features, activate water jets, showers, fountains etc.
Personality features
Integrate currently existing technologies and sensors (like NFC) in order to make features respond and track individual riders.

Sustainability
The environmental impact of the Pad, and wakeboard features in general, has not been part of the scope of this project. Looking back at this project, I feel like I should have incorporated this in the project to a larger extend. Before further development, I would recommend to calculate the environmental impact of the Pad in order to evaluate whether design changes should be made based on this impact.

Apply construction in more features
With the development of the Pad, a new way of constructing wakeboard obstacles has been developed. Further research should be executed to investigate the potential for other features to be constructed by a combination of PE foam, PVC floor and PVC canvas.

4.2 Project evaluation

Goal and vision
In the design brief formulation, the following goal and vision were formulated:

Design goal:

"Develop a feature for entertainment enjoyers that are wakeboarding on a Full Size Cable with an expertise level determined within 'the gap'."

Interaction vision:

"Like discovering an old toolbox on the attic of my grandparents' farmhouse, excited to discover all the possibilities together with my nephews."

Design goal
With the final design of the Pad, this design goal is clearly met. The Pad is a feature with optimal sliding characteristics but has a soft base, making it suitable for riders with an expertise level determined in 'the gap'. The organic shape and unlimited freedom in aesthetic appearance makes it fit the target audience: the *Entertainment Enjoyers*. By providing multiple riding lines, the Pad is also made suitable for riders with a higher expertise level than 'the gap'.

Interaction vision
As discussed in the previous chapter, recommendations, the interaction vision has not been evaluated by an independent participant group so an unbiased evaluation is hard to give. The vision is evaluated in chapter 3.5 with regard to the prototypes based on evaluation with the clients.
Together with the final design of the Pad, also a future vision is designed. This future vision incorporates more sensory and actuating features in order to fit the interaction vision better in the future.

Clients & supervisory team
Although my initial plan was to execute this project without a client, I discovered that my project would have more potential right of existence if I would cooperate with a company. Schneestern and Sesitec were therefore a perfect match, with a similar vision towards the action sports market and a large global market share.
Sometimes, it was hard to mediate between all stakeholders involved in my project. Especially by having not one, but two clients involved in the project. As described in chapter 1.3, external analysis, Schneestern and Sesitec have a complicated relation towards each other in the market of wakeboarding. This sometimes made it difficult for me be in the middle of these companies. I have tried to realise a cooperation with my clients and supervisory team where I updated all members regularly, at the same time leaving enough space for myself to independently choose my trajectory and make decisions.

This project was also my first cooperation with a non-Dutch company. Although I wasn't expecting any differences – it was just our neighbour Germany – I noticed more remarkable differences than expected. Especially in the decision making process, I experienced a hierarchic structure within the company that I have not experienced before. The CEO of the company usually had the last word. Although I do not want to criticize this structure, it was something that I had to get used to during the project. Off course you can not say that no Dutch and all German companies have this hierarchic structure and so I will not state that this is true. Nevertheless, these are my personal experiences based on this project.
Working for two large companies that are executing a lot of global projects simultaniously, resulted in the fact that my project was not always on their top priority. Sometimes, this caused some frustration from my side, but off course we were always able to solve these issues.

Follow up
Both clients were satisfied with the results of this project as a large first step in this new direction. At the same time, they realise that the Pad on its own is not ready for the market yet. More time and effort should be invested in order to develop a portfolio of multiple products matching this target audience and interaction vision which can be presented to potential customers as a whole. The future vision and determination of the goal and vision can be used as guidance in this development process. Schneestern and Sesitec haven't communicated any details about their plans for further development yet.
Prototype 1 is planned to be positioned at the cable park of Inselsee over the summer of 2018 as soon as the intellectual property has been secured. This would be the first long-term test of the use of PE foam in combination with PVC floor.

4.3 Personal reflection

Personal goal
Additionally to the goals set by the university for the execution of a graduation project I set a goal to myself to realise a full scale wakeboard feature and ride it before the end of the project. During the prototyping phase, I realised three models that I have been testing in a cable park in order to evaluate. During the realisation of these prototypes I realised that the actual production of physical products, contact with distributors, the workshop, managers, etc. is something that I really like doing. I am satisfied that I was able to incorporate this personal goal into this project.

Autonomy
Since the finalisation of my Bachelors degree, this was the first project to execute completely solely. Because of this, I rediscovered my love for cooperation. Although I enjoyed the fact that I knew every single thing about the project and that I didn't have to rely on the quality of team members' work, I missed discussing how to approach certain problems or phases during the project. I also noticed again the great benefit of working in a multidisciplinary team where every team member works on a part of the project that he/she enjoys most. Luckily, there were lots of (study related) friends to discuss certain approaches and tackle problems with.

Mood and complications
The execution of this graduation project didn't come without setbacks. Figure 78 visualises my average mood during the process of this project. Right after the start of this project a fall during kitesurfing, one of the other board sports I enjoy, resulted in a fracture in my fibula. Although mainly impractical physically, it slowed down my process due to my immobility and recovery time. Right before the end of my project, I received news that made all goals in life become insignificant. One of my close friends was brought to the hospital with a life-threatening injury. Without going into detail, I couldn't leave this moment out of my personal evaluation since this news had an enormous impact on my mood and motivation during the final stage of the project. At the time of writing it is uncertain how he will recover from this injury, so I wish Berend all the best!

Focus – distraction ratio
When executing a large project with a lot of responsibility, it is hard not to think of anything else than the particularly project. Before you realise you start dreaming about it, and lets just hope they will be sweet dreams. Although the pressure to deliver under time was present, I noticed the importance to also seek distraction. Although these moments of joining a party or holiday weekend seem useless, they are usually of great benefit and could deliver important inspiration. I would like to show Figure 79, which is the toilet door of a nightclub that I visited on Kingsday, as an example of how you can become inspired during the moments of distraction. Please note the similarities between this door and the landscape described in the future vision.

Future plans
I am looking forward to produce more tangible products in the future by being involved in the design, as well as the production process. Although I will definitely consider the steps that I have learned to take in the development process of a product, I will enjoy that I don't have to spend a large part of my time reporting all these steps. I am pleased that I have been able to spend the last exciting years as a student, but now I am ready to finish a chapter in my life and start a new one!

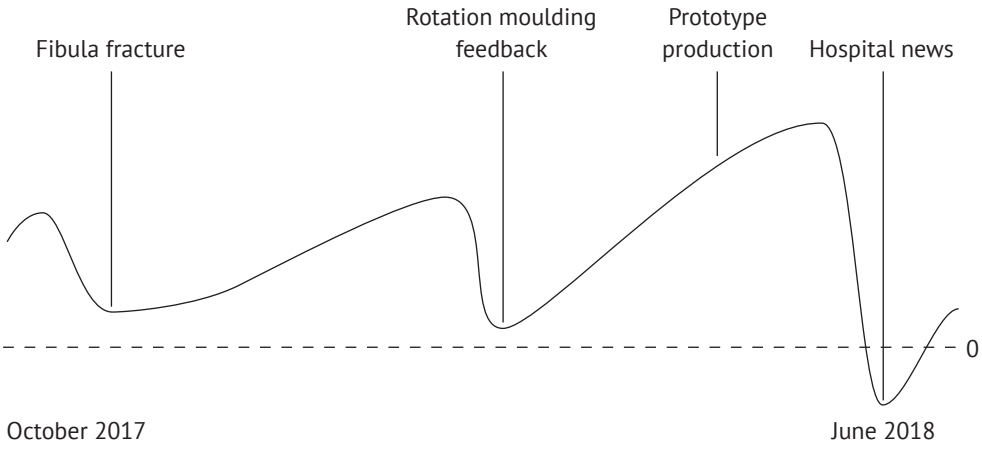


Figure 78: Mood visualization during the process of this project.

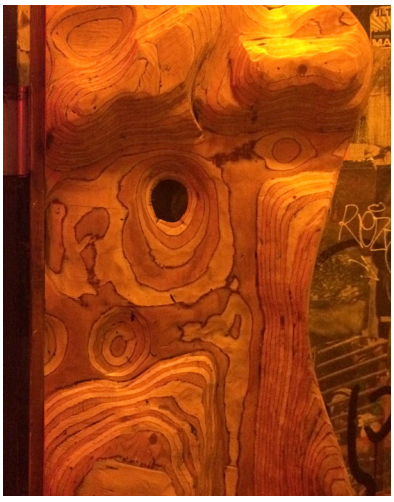


Figure 79: Inspirational door of a nightclub.

4.4 Acknowledgments

First of all, an indescribable thanks to the never-ending support from my parents, the ones who made it possible for me to be where I am today.
I would like to thank my chair, Bruno Ninaber van Eyben, for his sometimes indistinct but always beneficial advises. My coach, Sebastiaan van den Elshout for his approachability and coaching on a very personal level.
Thanks to Schneestern and Sesitec for giving me the opportunity to execute this project and providing me all the tools required.
Special thanks to Basti Podda, who was always super helpful during my times down in Durach.
I would also like to thank Walt, for helping me to translate the visuals from my mind to paper.
Last but not least, I would like to thank all my kind friends who have supported me by sparring about problems and motivating me when I felt lost in the process. I would also like to thank my friends who helped me to step away from the project and contributed by realising the perfect focus-distraction ratio.

I really couldn't have done it without all your support!

Figure 80: Ir. Potma in his natural habitat.

5. References

Referred to in this report
Sources

Bhasin, H. (2017, September). 4 types of Market segmentation and how to segment? Retrieved December 05, 2017, from https://www.marketing91.com/4-types-market-segmentation-segment/

Eime, R. M., Young, J. A., Harvey, J. T., Charity, M. J., & Payne, W. R. (2013). A systematic review of the psychological and social benefits of participation in sport for children and adolescents: informing development of a conceptual model of health through sport. International Journal of Behavioral Nutrition and Physical Activity, 10(1), 98. doi:10.1186/1479-5868-10-98

German Utility Model. (n.d.). Retrieved November 08, 2017, from http://www.wh-ip.com/germany/german_utility_model.html

Buijs, J. A., & Meer, H. V. (2014). Professioneel wyberen. Den Haag: Boom Lemma uitgevers.

Buijs, J., & Valkenburg, R. (2005). Integrale productontwikkeling. Utrecht: LEMMA.

Foam - Oxford Dictionaries. (n.d.). Retrieved May 11, 2018, from https://en.oxforddictionaries.com/definition/foam

Hostetler, S. G., Hostetler, T. L., Smith, G. A., & Xiang, H. (2005). Characteristics of water skiing-related and wakeboarding-related injuries treated in emergency departments in the United States, 2001-2003. The American journal of sports medicine, 33(7), 1065-1070.

Lucero, A., & Arrasvuori, J. (2010). PLEX Cards: a source of inspiration when designing for playfulness. In Proceedings of the 3rd International Conference on Fun and Games (pp. 28-37). ACM.

Mulder, I. & Pohlmeyer, A. (2015) Course manual Exploring Interactions

Porter, M. E. (1979). How competitive forces shape strategy.

Sanders, E., & Stappers, P. (2012). Convivial design toolbox. Amsterdam: BIS.

Stoked - Urban dictionary. (2004). Retrieved March 3, 2018, from https://www.urbandictionary.com/define.php?term=stoked

Tassoul, M. (2009). Creative Facilitation. VSSD.

The history of Rixen cableways. (2013). Retrieved November 1, 2017, from https://www.rixen-cableways.com/en/investors/history/history/rixen-cableways

IWWF (n.d.) Wakeboarding 2020 vision. Retrieved November 1, 2017, from http://www.wakehq.com/files/Cable-2020-Vision-Brochure.pdf

Whelan, T. (1994). Polymer technology dictionary. London: Chapman & Hall.

Experts

B. Lambers (supplier)
F. Haas (supplier)
L. Hulsman (TenCate)
M. de Wit (De Wit)
S. Podda (Schneestern)
W. van Mansum (Urban Arrow)

Not referred to in this report
Sources

Alger, M. (2017). Polymer science dictionary (3rd ed.). Dordrecht, The Netherlands: Springer.

Allender, S., Cowburn, G., & Foster, C. (2006). Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. Health Education Research, 21(6), 826-835. doi:10.1093/her/cyl063

Brennan, S. M., Kollár, L. P., & Springer, G. S. (2003). Modelling the mechanical characteristics and on-snow performance of snowboards. Sports Engineering, 6(4), 193-206.

Brymer, E. (2009). The role of Extreme Sports in lifestyle enhancement and wellness. In Proceedings of the 26th ACHPER International Conference: Creating Active Futures (pp. 285-299). School of Human Movement Studies, Queensland University of Technology, Brisbane, QLD 4059, Australia..

Carson, W. G. (2004) Wakeboarding injuries

Donnelly, M. (2006). Studying extreme sports: Beyond the core participants. Journal of Sport and Social Issues, 30(2), 219-224.

Jordan, P. W. (2000). Designing pleasurable products: an introduction to the new human factors. London: Taylor & Francis.

Levy, D., Hubbard, M., McNeil, J. A., & Swedberg, A. (2015). A design rationale for safer terrain park jumps that limit equivalent fall height. Sports Engineering, 18(4), 227-239.

Outdoor Foundation (2016) Outdoor participation report.

Perry, B. (1952). The effect of aspect ratio on the lift of flat planing surfaces.

Poodts, E., Panciroli, R., & Minak, G. (2013). Design rules for composite sandwich wakeboards. Composites Part B: Engineering, 44(1), 628-638.

Roozenburg, N. F., & Eekels, J. (1996). Produktontwerpen, structuur en methoden. Utrecht: Lemma.

Slanger, E., & Rudestam, K. E. (1997). Motivation and disinhibition in high risk sports: Sensation seeking and self-efficacy. Journal of research in personality, 31(3), 355-374.

Wakeboarding (2017). Retrieved November 01, 2017, from http://www.wake-parx.com/blog/