Skimming the surface

A design master thesis by Björn Bengtsson

LUNDS UNIVERSITET
Lunds Tekniska Högskola

A design master thesis about lead users and alternative sports

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Abstract

The main reason for this thesis was to broaden my knowledge and learn more about lead users in the context of alternative sports, where an experimental and creative mindset is greatly rewarded. The work is centred around two avid winchboarders with the ambition to improve their activity and broaden the constraint that they are experiencing.

Field research was the main tool for analysing the positive and negative sides of their activity, followed by discussions of how we could make several variables less intrusive and time consuming for them. External factors like increased precipitation, cultural catalysts and the competitive arenas was an important part of the analysis of the future of the sport.

My winch 'Elvira' is designed to broaden the scope of play, whilst simultaneously improve small technical nuisances. The result is an electrical wakeboard winch with an increased mobility by decreased weight and volume, intuitive and simple handling for the operator and improved sensation by solving small issues that affect ride experience, such as uneven velocity and choppy movement in the rope.

Introduction

As I come from an active background, with roots in both alternative sports such as skateboard and snowboard, as well as established ones like sailing, the theme of the thesis was self-evident to me. I wanted to do a sports related project.

The subject however, was not.

Prior to this project I attended a research course intended to prepare us for the master thesis. After formulating a few vague intentions as well as possible approaches and themes of the project, one of the course leaders advised me to take a closer look into the work of Eric Von Hippel and his research on lead users.

After reviewing his work, and drawing parallels to all my prior projects, I realised that he had a very scientific approach to what has always interested me. This was an opportunity for me to learn more about this methodology and work closer with this kind of users.

 Photo: Jonas Wåglund

Aim

The aim of the project was to work closely together with lead users in a conscious manner, rather than just using them as a source of feedback during the later stages, like I have in past projects. It was also an opportunity for me to look closer at the world of alternative sports, its users and how it evolves.

Even though I have a solid background in the alternative sports world, I've never really reflected over why it changes in the manner it does. Finding out why and how it evolves in such a high pace was an interesting and also a motivational reason to choose this field as focus of study.

Motivation was important factor. The intention of combining my interest of sports with my passion for design, was to give me a boost when I was working on this project. This proved to be an important decision during the later stages of the project.

Brief

"Study the genre of alternative sports, with focus on winchboarding. With the help of users selected with a special criteria, find areas of potential which could help the winchboarding phenomenon to evolve."

Definition

The term ‘extreme sports’ which is commonly used, is both problematic and undefined. It has come to label an entire generation of participants as mere adrenalin seekers rather than hard working athletes. During the last decade, the work put in by these alternative athletes gets more and more recognition, as well as the increasing amount of work needed to stay competitive at the top of their sports.

The actual practise of most of the sports that portrayed the image of extreme sports has also changed from being an act of death defiance to a competitive event where casualties is hardly even an issue anymore. As the competitive level has risen, so has safety precautions and professionalism of the organisers and participants.

Still, statistically the sports labelled in this ill defined category aren’t the most dangerous ones in terms of injuries or death. Cross-country horseback equestrian as well as different forms of bicycling have statistically higher rates of injury.

Currently established sports like sailing in the Americas Cup, have evolved to such a state that they are far more extreme than many classic extreme sports. This is a sign that the distinction of the term needs to be re-evaluated.

During this project, I have decided to label the activities as alternative/action sports, with focus on boardsports and winchboarding in particular.

Photo: Vincent Curutchet

The big three

The boardsport culture has been traced in journals all the way back to the 18th century, when explorers passed by Hawaii and observed the natives activities. In the early 19th century, after the United States had taken control over the islands, the newly settled immigrants started participate in the activity. This would be the starting point to a world-wide interest in the sport from paradise.

The surf industry would later bloom in to the stronghold and origin of all boardsports, with a turnover of billions of dollars annually. During the mid 20th century, California based surfers started emulating the activity on the streets when the conditions for real surfing weren't adequate. Using the technology derived from roller-skates, a new activity called street surfing emerged, which later was renamed to skateboarding. After its birth, skateboarding took off with the non-surfing masses and became a large commercial success.

A few years later the hype had cooled down, and the sport was almost forgotten until the late 70's and early 80's when it resurrected globally. The style of riding and obstacles that were used changed drastically, and laid the foundation to the modern form of skateboarding.

That was the point in time where the phenomenon of alternative sports really took off in to multiple directions. Snowboarding was conceived in an attempt to surf on snow, quickly evolving in to another huge success for the boardsport industry. At one point in time, snowboarding almost surpassed skiing in popularity, and was the first of its kind to become accepted in to the Olympic Games, and is still an Olympic discipline.

 Photo: Matthew Williams

WAKE board skate

Wakeboarding stems from both waterskiing and surfing. How it evolved was a quite natural leap from surfing when the waves weren't satisfying enough, riders would get towed behind boats and even trucks on the beach. In the beginning the first wakeboards looked like down sized surfboards, but when a waterskiing manufacturer took interest and modified the design with his experience from their industry, huge progress was made.

Thanks to waterskiing and its long history, wakeboarding could move forward quickly in to a form that was dominant until a few years ago. This form was riding behind a waterski boat which had been redesigned to create a large wave behind it.

Since a decent wakeboard boat costs more than a new car, it wasn't viable for every group of wakeboarders to own their own vessel. More and more people have turned to jet skis and cable-parks. This forced the industry to adjust. This meant that there wasn't any possibility to jump off a wave anymore. Instead people built obstacles very similar to what you can find in a skateboard park.

Around 1997-98, a few wakeboarders experimented with removing the bindings from the board, in an attempt to create something closer to surfing and skateboarding. Today it is called wakeskating, and is basically a wakeboard in wood or foam composite, with grip tape on the top. This means that the riders usually use standard skateboard shoes when riding.

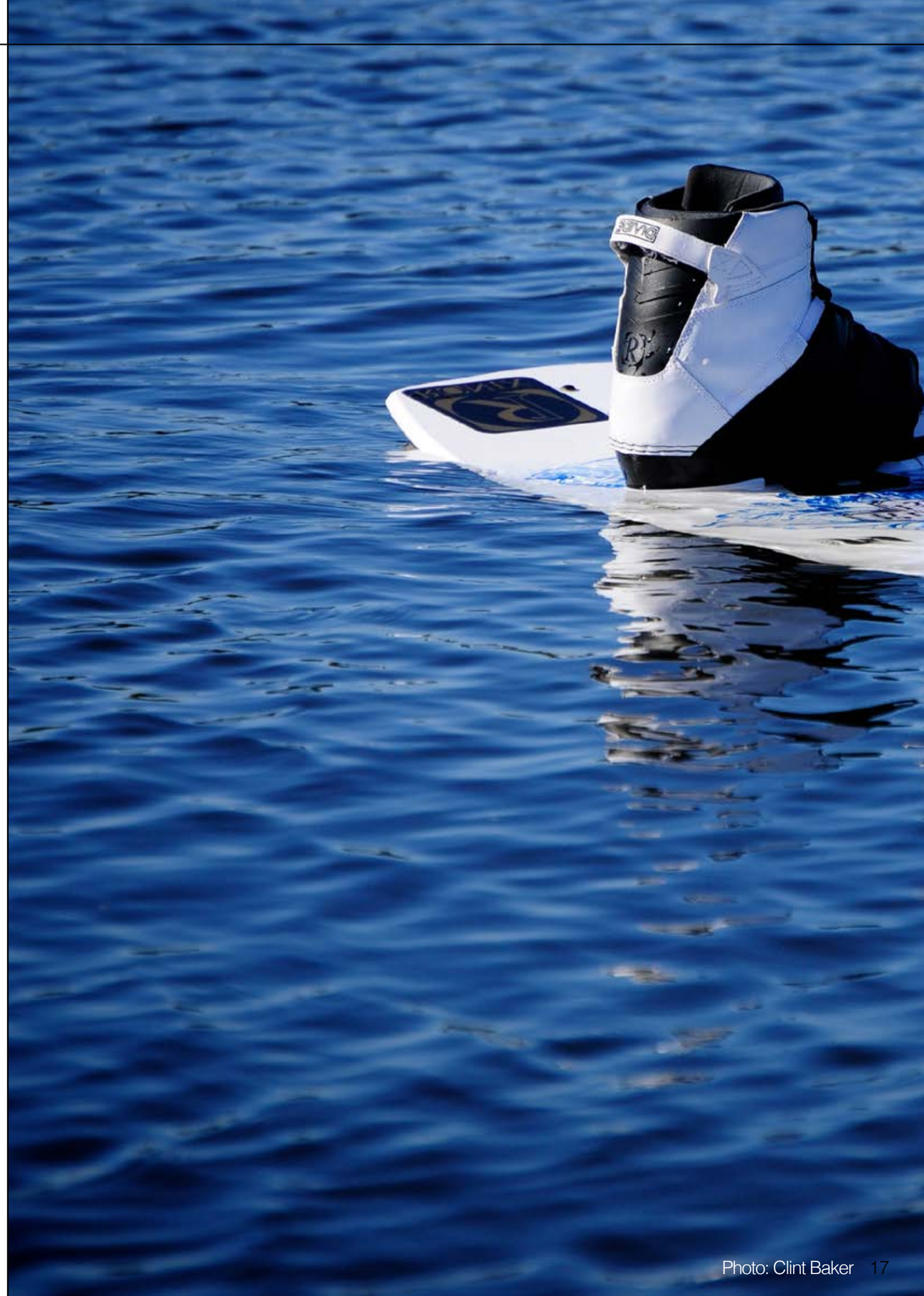


Photo: Clint Baker

Danny Way at the top of his trademarked 'Mega Ramp', which was a reason why a new pair of skateboard shoes had to be developed to cope with the massive forces.

Photo: www.megaramp.com

Lead users

The terms 'user innovation' and 'lead users' were new to me during the initial stages of the project so articles by Eric von Hippel, who is the developer of these terms, was the main source of information.

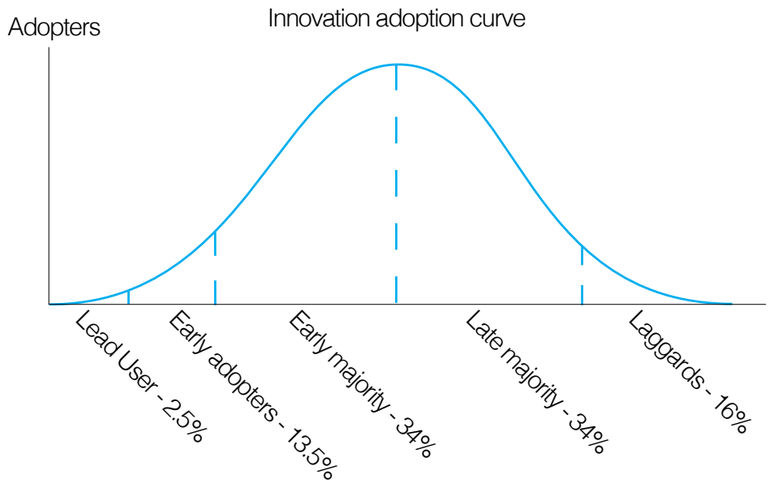
The term 'lead users' was coined in the late 80's by Eric von Hippel. It was a way to denominate a methodology of working closely and learning from users and their feedback. A lot more research on the methodology itself has been made since then. There have been studies that show that lead users also qualify under the early adopters label. Early adopters are users within the 13.5% first to embrace new technology and products available.

I wanted to learn more about the term and methodology, since I have always preferred to work closely with either professional or very qualified users, when the projects have allowed me to do so. It is a very common way to work within the sports industry. Utilising the sponsored athletes in the product development phase, to either spawn new products or refine existing ones. It has also become intertwined with marketing, as a selling point for the products in question.

Indication of lead users (Hippel, 1968):

'Lead users face needs/problems months or even years before the average user encounters them.'

'Lead users expect great benefit by solutions to these needs/problems.'



Evolution and catalysts

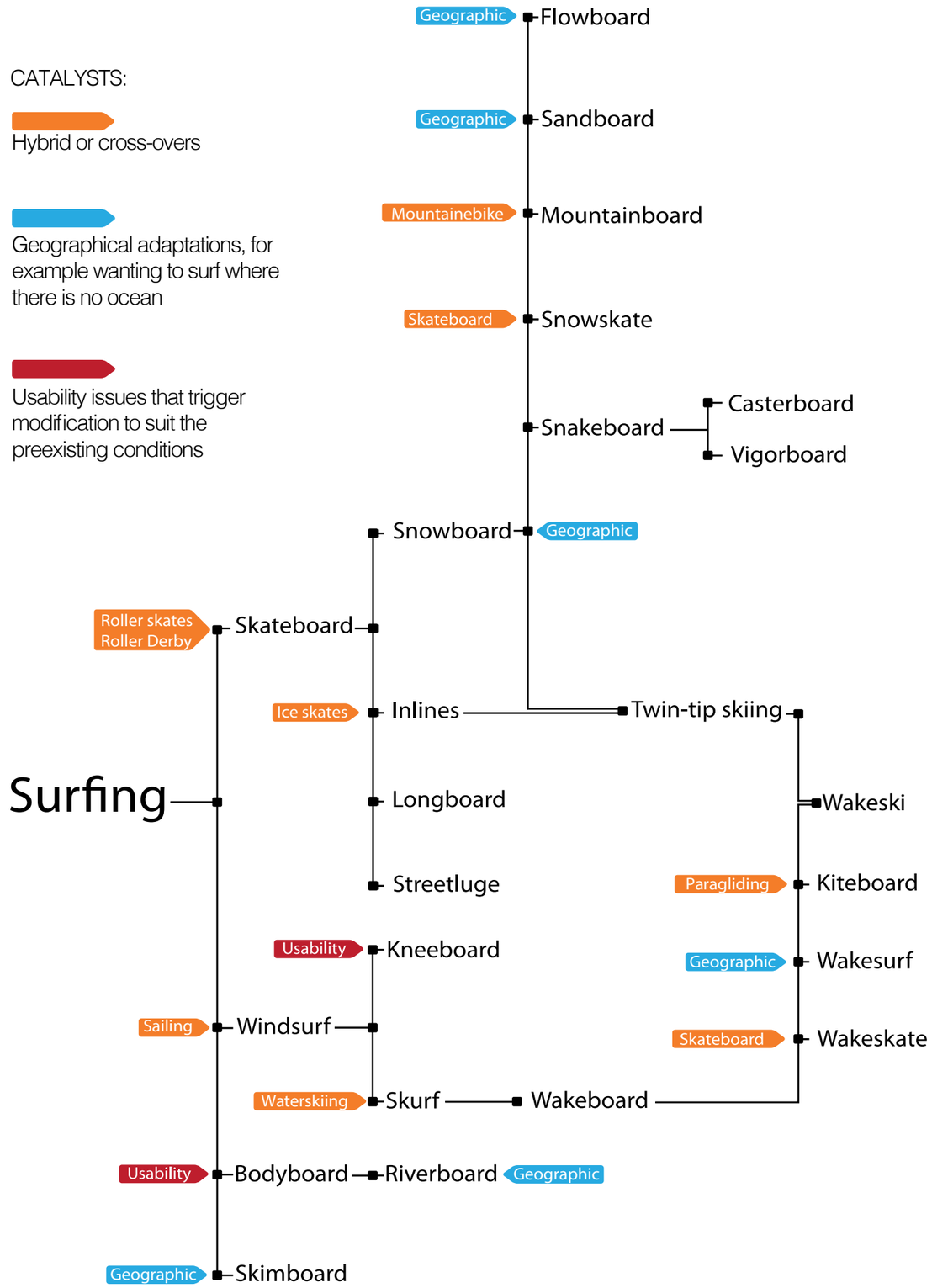
The participants in alternative sports are quick to adapt to the circumstances that they adhere to. Proof of this can be seen in all of the different ways of using a board.

Several of todays actionsports are the results of users tweaking something to suit their certain needs. A lot of times the changes initially were an emulation of another sport. The reason why it keeps happening over and over again, is the unregulated nature of the activities.

Most participants practise their hobby in a manner which isn't focusing on the competitive nature, but rather the individuals personal experience and originality. This results in the federations that try to establish themselves are not able to offer any real value. They tend to cater to a small group of professional individuals and industrial leaders.

When looking deeper in to the paths which the major boardsports have evolved from, with surfing as the starting point, I found a few common catalysts that tend to provoke change.

'Evolution: A gradual process in which something changes into a different and usually more complex or better form.'



Weather fluctuations

There are several sports that rely intensively on weather conditions. For example sports like skiing and snowboarding rely on the temperature and the precipitation, whilst surfing is dependant on wind, tides and the topography of the sea bed.

Due to climate changes, we experience that weather has intensified according to reports from IPCC (Intergovernmental Panel on Climate Change) and SMHI (Swedens Metrological and Hydrological Institute). The effect is heavier precipitation locally during shorter periods of time.

This result is an effect of higher amounts of water in the atmosphere and less in the soil.

When thaw occurs, the soil will also be very saturated, leaving no room for more liquids to pass through. In extension this alone would create new spots for winchboarders to find, but other factors like urban expansion and deforestation are also contributing to this.

Without trees and plants to absorb excess water during growth periods, the saturation of the soil is tremendously increased. Asphalt, concrete and other groundwork that shield the soil will transport the water rather than absorbing it, which is both part of the problem and the solution of the logistics. In the end this means that cities have to create and plan the route of all this excess water.

Skating in empty pools ,Los Angeles during the 70's drought.

The excess water is an issue even without global warming, especially in large metropolises. When all of these factors are summed, we get large amounts of educed water which is a logistic problem for engineers and city planners to solve.

Most cities have storm drains installed, and in the larger urbanised areas we often see concrete canals educe water. These canals are already being utilised for riding.

The weather fluctuations pose an opportunity that is an interesting scenario for mobile wakeboarding. The landscapes will change more frequently. Areas like big lawns, rivers and parking lots could be potential spots for riders to search for. A similar behaviour as skiers waiting for snowfall and then find the perfect off piste, or surfers moving around to different beaches due to the direction of the wind.

A similar scenario as the extremely dry summer during the mid seventies which gave birth to pool skating since no pools were allowed to be filled with water.

Wakeboarder riding behind a car on flooded street.

Milestones

I tried to compare several successful alternative sports to find patterns in their evolution and success. This was a sort of experiment as well as a method to motivate looking further in to the evolution of the sport, gear and contests.

Diagram C shows several sports, from when they were considered to be conceived in to a stable form. The next object was to see how long it took for a mass produced commercial product to hit the market, and then followed by the first large competition.

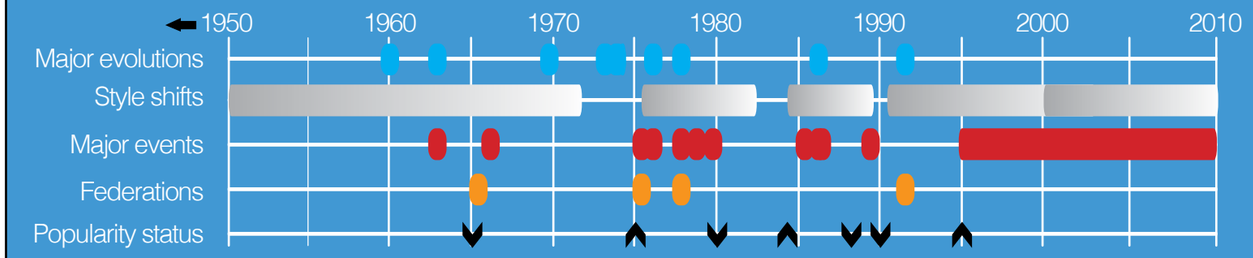
Most sports seemed to have a gap of approximately ten years in between.

The only sport that didn't fit the curve was paintball, where the first product was what actually gave birth to the sport. This was a marking device for lumberjacks, which spawned a game of paintball due to its projectile shooting capabilities.

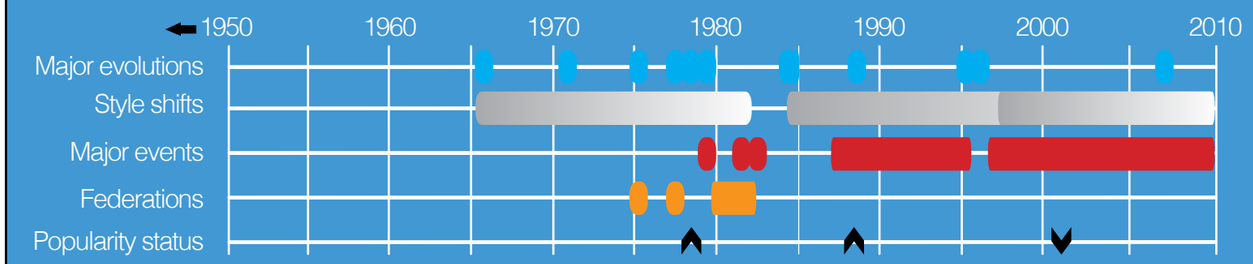
The detailed diagrams A and B, are closer looks in to specific sports, where significant changes in equipment, style of practise, major events, federations and popularity is noted on the time line.

Waterskiing was recorded so long ago that dates and figures were unreliable and inconsistent.

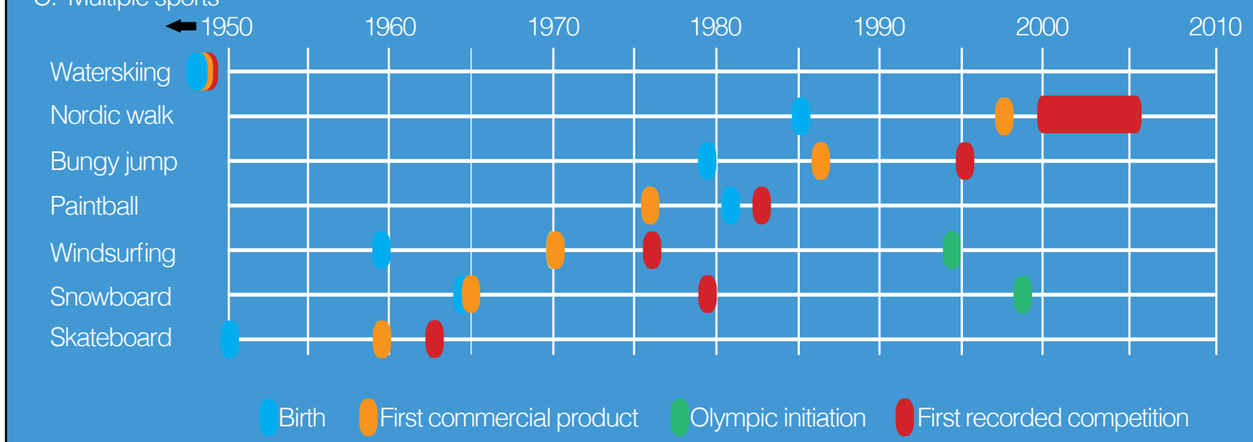
A: Skateboard



B: Snowboard



C: Multiple sports



Towing methods

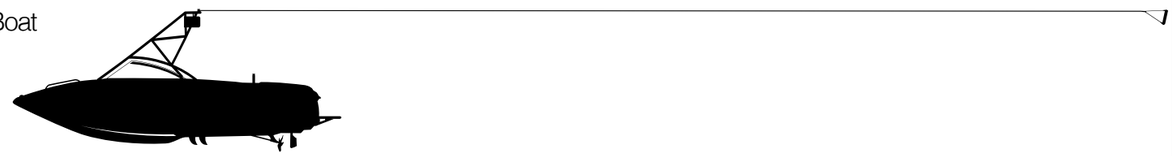
Due to the sheer size of the different tow methods, one can easily see the possibilities of mobility as well as the means needed to either acquire or have access to one. Most of the methods are privately owned, while the cable park more commonly is a business that requires both municipal permits and a large initial investment.

Banshee bungee

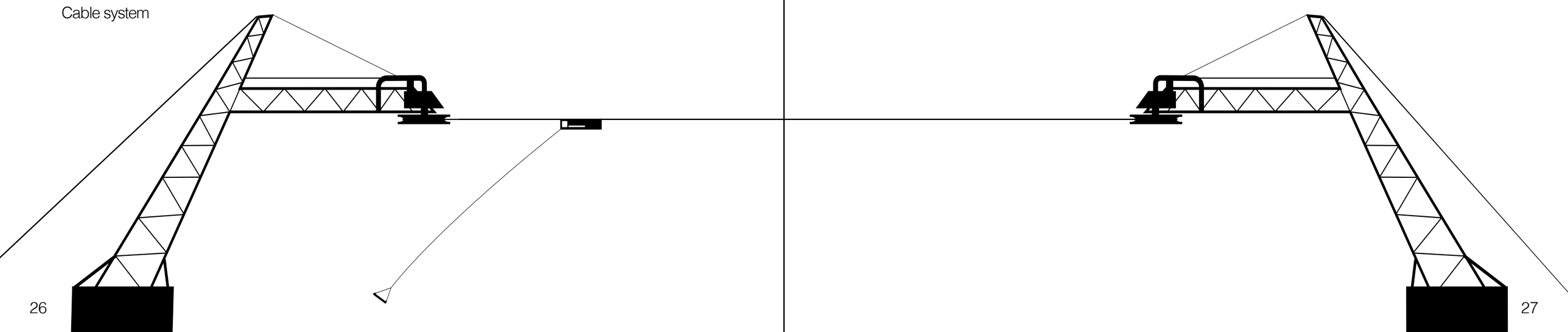
Winch

Jet ski

Boat



Cable system



Cable park

The cable system has been around since the 1940's and hails from Germany, where waterskiing was very popular. The principle of cable parks has not evolved to any great extent. It is basically a large ski-lift placed in a lake, where two large steel cables move around the lake in an infinite loop. It has the capacity to tow several riders simultaneously depending on the size of the system. When wakeboarders started to use the system, they added obstacles around the lake for them to use to perform tricks and manoeuvres because of the lack of wave for launching.

It's a very expensive and space-consuming system with several concrete platforms, but when it's up and operational, it's very beneficial for beginners as well as seasoned veterans.

As far as spectator friendliness goes, it is favourable. Since the use of cables have escalated due to a growing amount of wakeboarders, cheaper more mobile systems have been developed. These are however a compromise of the benefits, and do not accommodate several riders.

Price (approximate):
500.000-1.500.000€ (full system)
20.000-50.000€(Sesitec 2.0)
10-30€ (day pass)

BSR Cable Park in Waco, TX, United States

Wakeboard boat

A boat is the most natural and well known form of towing a wakeboarder. The dedicated wakeboard boat is a modified waterski boat. In contrary to waterskiing where a minimal wave behind the boat is desired, a large and solid wave is preferred for wakeboarding. Companies have tailored their boats to have specific characteristics to enhance the possibilities. The wave can either be very steep which launches the rider upwards, or they can be a bit longer and not as steep to give more travel distance across the waves. They are also often manufactured with water tanks for extra ballast to increase the size of the wakes, but it can be exchanged with a large crowd from 2-10 people in the boat to attain the same effect.

All dedicated wakeboard boats have a tower or a high pylon in the centre of the hull to elevate the ropes fastening point. This is because a low height pulls the rider downwards when in the air, and a high point pulls them forward and less downward. Because of the height of this point, more momentum is created when the rider cuts from side to side making the boat sway. To minimise this issue, several fins are mounted on the keel of the hull.

These kinds of boats usually come with a very powerful internal motor. Usually a V6 or a V8 engine with anywhere from 150-400 horsepower. Most fuel is consumed during the inevitable starting procedure. Speed varies from 16-26 knots depending on boat characteristics and rider preference. The boat performs best when the sea is very calm and flat, which is also the preferred weather of the riders. Small lakes are an ideal venue for this method.

Price (approximate):
20.000-50.000€ (New)
10.000-30.000€ (Used)

Photo: Bryce Dunks

Banshee Bungee

The Banshee Bungee is a fairly new product on the market. It is a braided rubber cord with one main handle and two support handles. It was created for launching riders in to an obstacle or wave.

A group of users stretch the cord to a desired tension, then everyone except the rider let go and letting the rider launch. It needs a steady anchoring-point which could be difficult to find, for example at a beach. It has also been adopted by snowboarders riding in an urban environment without proper slopes to give them speed. It has relatively weak strength, a short effective distance and it is questionable if it could make a rider plane in deep water.

There are also issues with maintenance of the cord. Due to the nature of where it is used, the cords tend to dry out and break. It is however very affordable and mobile.

Price (approximate):
225$ (New)

Photo:Matt Georges

Photo:Matt Georges

Personal watercraft (Jet

A side effect of the rise in jet ski sales was the availability to use them for towing wakeboarders on the lakes. Obviously it can't offer the stability or a similar wave as a real boat, but it consumes a lot less fuel, can access shallow water and is a lot more mobile. They are primarily used when obstacles are involved for the rider, such as rails or boxes. The jet skis have powerful engines, but are also fairly expensive.

Price (approximate):
10.000-15.000€ (New)
2.000-10.000€ (Used)

Kiteboarding

Kiteboarding is a hybrid between paragliding, windsurfing and wakeboarding. It has exploded in popularity the last decade, attracting people from all of the mentioned sports. It is very versatile as far as required conditions are concerned. The rider uses long ropes connected to a kite that varies in surface area. The ropes are connected to a handle, which is hooked on to a harness around the riders waist. It can be dangerous if the rider has not learned properly, both for bystanders as well as the operator. The method of getting airborne is a bit different than the other options. The kite is steered until you get adequate lift and then hover rather than jump.

Price (approximate):
500-2000€ (New)

Photo: Ydwer van der Heide

Photo: Björn Bengtsson

The wakeboard winch

A small group of the wakeskaters started experimenting with building small portable winches, which was both far more economical and mobile than boats. These consisted of a small go-kart sized engine and a spool with about 200 meters of rope. This allowed them to find interesting spots to ride, or places where it was not possible to use neither boat or jet skis, like fountains, small rivers and day drains.

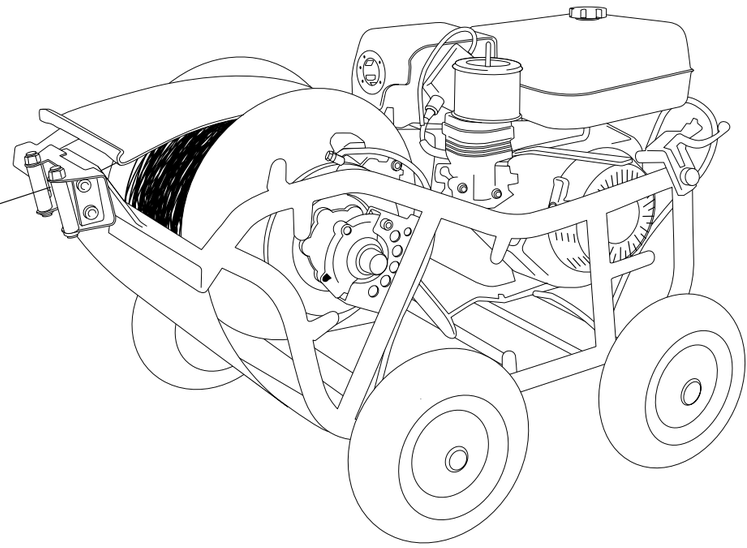
The industry has recognised the change and have adjusted. Now a days, several board manufacturers have decided to stop focusing on riding behind boats, and instead put their efforts in to products made for cable and winches. This means that boards needs to be a lot more durable and robust, as well as possessing different hydrodynamics.

The beauty of the winch is the possibilities to build it yourself. Most winches today are home made, with a few entrepreneurs who continue and try to make a business out of their hobby. At the moment there are two dominating companies on the market.

Most winches built have a combustion engine between 5-13 horse powers. The engine uses a chain drive to connect to a spool with 100-300 meters of extractable rope with a handle on the end of the rope. They usually require some sort of transmission to create enough torque for the starting procedure.

The frame of the winch has grown to carry extra importance to people in the community. It shows both the craftsmanship of the builder, as well as it is a sign of originality and innovation. A well built frame with an original appearance is admired and sought after.

Price (approximate):
3000-4000€ (New commercial model)
100-2000€ (home made)



Market alternatives

It was very interesting to find out that there are almost as many different designs as there are winches across the world. It is also considered the pride and joy of the enthusiasts who are usually very willing to show off their creations.

Commercially available winches

Home made winches

Benchmarking of tow methods

This is a comparison of the traits of the different modes of transportation in a schematic way. The winch and banshee bungee often stand on the opposite side of the spectrum in relation to where the boat and park are situated on the diagram D.

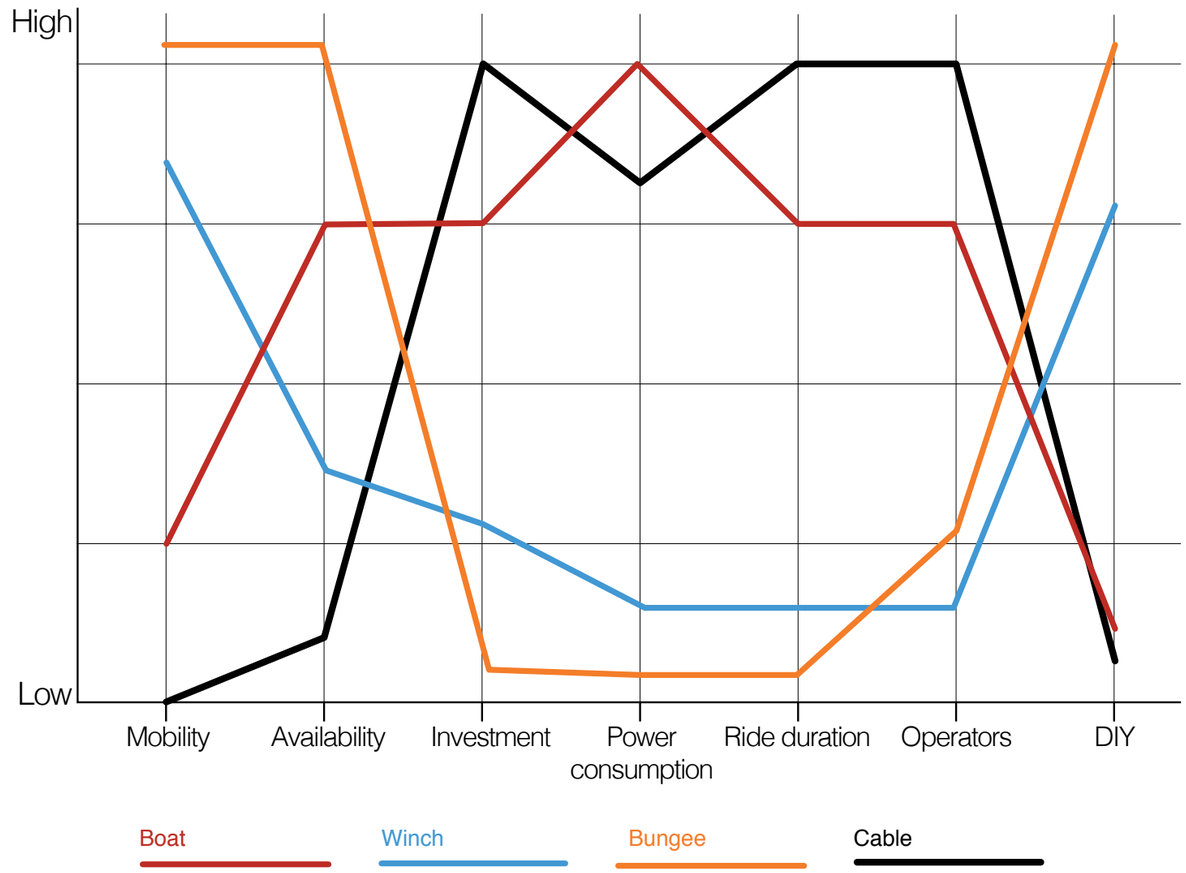


Diagram D.

Photo: Björn Bengtsson

DAV - Dragen Av Vera

Deciding what subjects to study and work with was a fairly easy choice. Two friends of mine, Jonas and Henning, had been posting videos and photos of the hobby online. On their spare time they had built a wakeboard-winch, and used it frequently in a sand quarry near one of their homes. I had been following what they were doing on their blog 'Dragen av vera', as well as on facebook.

They were among the very first in Sweden to build and use a winch, inspired by what American riders were doing. They both also had a genuine actionsports background.

Jonas Ströberg:

Jonas is the manufacturer of the two winches in their possession. Jonas hails from Sala, Sweden. He has been riding behind boats for several years, for a while competitively but mainly recreational. He has always had an interest for motorcycles and engines in general and used to ride both motocross and super motard. Just recently after the project started Jonas became a father which affected the amount of time he had available for both field research and discussions.

Jonas has not been skateboarding or snowboarding more than a few years. He is the one who builds most of the things that are needed, like winches and obstacles.

Henning Åhrberg:

Henning is a product design student living and studying in Malmö. His origin is Sundsvall, Sweden. He has been snowboarding for more than 10 years and is also an avid kiteboarder but is converting more and more towards winch and cable riding.

Henning used to sail dinghies competitively on an international level. He is also the one who cuts and edits the movies that are posted online, as well as most of the other parts of the computer work.

Vera 2.0 (the winch):

Vera was the second winch that Jonas built, and is the one they use the most by far. It was constructed from an old go-kart. The engine is a 9 horsepower Honda clone. The frame of the go-kart was cut in pieces and reconstructed so that it would be able to hold engine, spool and four trolley wheels. Vera weighs approximately 60-70 kilos, carries 300 meters of rope and is capable of a top speed around 40 km/h.

Field research

On several occasions I had the opportunity join Jonas and Henning on their winch sessions. I mainly took a role of observing as well as taking photos and filming, but I did get the opportunity to try the activity out first hand.

12.02.2010 - Soccer field in Oxie

There was approximately 30-50 centimetres of snow on the field. Jonas and Henning were both equipped with full snowboard gear. The first encounter with the winch was after heavy snowfall in a village just east of Malmö. The location was a soccer field surrounded by a grass bank that would be beneficial for the activity. They rode from one side to the other, and jumped on the peak of the bank.

What was immediately obvious was how they communicated with each other when they were on opposite sides of the bank. To signal that the rider was ready, he had to tug the rope two times, and then the operator could start the winch. Even when they were on the same sides of the bank, the high noise from the engine made it hard to communicate orally.

The rope on the spool had a plastic sleeve to protect the fibres. This plastic coating would crack and shatter in the cold weather, which was hazardous to the eyes of the operator.

Even though the winch had wheels, it was hard to move through the thick snow. To make it easier to move through the snow, Jonas had added a piece of sheet metal bent upwards in the front of the winch which acted like a meadow. The thick snow did however have the positive effect of helping the winch to stay put when pulling the rider.

Photo: Björn Bengtsson

Photo: Björn Bengtsson

28.03.2010, 02.04.2010, 04.08.210 - Sandpit, Saxtorp
12.05.2010 - Winch Competition LTH
09.24.2010 - Small river, Helsingborg

A local sandpit close to Saxtorp just south of Landskrona, is the regular location for their activities. The sandpit is being built in to an oasis for people to go swimming in the summer, but at the moment it just looks like a construction site. Occasionally Jonas and Henning bring home-made obstacles to the spot.

Even though there wasn't any thick snow on the ground, the heavy winch was still bothersome to move around due to relatively soft soil and uneven terrain.

During one of these occasions I was given the opportunity to ride as well as operating the winch myself. It was a positive experience, since it did expose a few other aspects that probably wouldn't have been revealed otherwise.

As operator I was instructed to listen to the sound of the machine, since it was the only way to determine the proper speed.

Obviously this takes a bit of training before you tune in to the right frequency. My attempt to drive was way to fast compared to the normal speed. During one occasion at the sandpit, Henning hadn't operated the winch in a while, and had difficulties distinguishing the correct speed. Another aspect of this is that it is hard to communicate the speed, since there isn't really any scale or reference to refer to.

When I got the chance to ride, my first reaction was how much resistance the spool posses when unrolling the rope. It made it hard as well as cumbersome to move to the starting point swiftly. When riding, I distinctively felt how the rope was skipping on the spool. This was because of the high tension was packing the rope tightly, which could make rope skip sideways. It was also noticeable how the speed increased as the diameter of the spool increased.

Field Equipment

The detailed lists of what was brought to the different trips. These were material brought with from the cars to the spot of interest.

During the later sessions, both a water resistant DV camera and a DSLR-camera with video recording was brought along. Both were used simultaneously. There were also occasions when two winches were brought along, mainly when the amount of riders would exceed three.

Snow session:

1 Snowboard per rider
1 Tripod
1 Helmet per rider
2 Snow shovels
1 Can of petrol
1 Winch
1 Pair snowboard boots per rider
1 Cellphone per rider
1 Set of outerwear per rider
1 Pair of gloves per rider
1 Wrench
1 Hammer
1 Screwdriver
Minimum of one DV-camera

Water sessions:

1 Board setup per rider (bindings+board)
1 Life jacket per rider
1 Helmet per rider
1 Pair of shoes per rider
1 Jacket (if the temperature was low)
2 Shovels
1 Different home made obstacle at almost every session
1 Rucksack per person with food and beverage
1 Cellphone per person
1 Can of petrol
Minimum of one DV-camera

Photo: Björn Bengtsson

Upsides of the winch

Low fuel consumption:
A few liters of gasoline will run the machine for several hours.

Low initial cost:
There is no limit of how economical the winch can be built. Anything from wooden frames to lawn mowers can be used as foundation to the winch

Increased mobility:
Compared to riding behind boats, the mobility is tremendously higher considering time to setup and access to water stretches.

Water requirements:
Almost any stretch of water can be used. Anything from water puddles to beaches and rivers.

Versatile application:
It works equally well to use it for snowboard/skiing and skateboard if needed.

Less imposing to surroundings:
The activity is less imposing to surroundings because it requires a lower area of use than boats do.

Spectator-friendly:
It is easier for spectators to gather around and witness everything that's going on.

High fuel efficiency:
The winch only has to transport the rider, and not also the entire weight of the boat.

Technology level:
They are built on a relatively simple technology, with pre existing engines.

Closed system:
Due to the enclosed system of the motor, it makes it relatively resistant towards water and dirt.

Learn how machinery works:
Users claim to get deeper interest and understanding of mechanics and technology.

Temperature resistance:
Combustion engines are very unaffected by temperature fluctuations.

Downsides

Two man operation:
The current state makes it impossible to be less than two people to be able to ride.

Mobility:
Still has issues of mobility due to weight and wheel construction. Car is a necessity.

Weight:
Motor is heavy, as well as amount of rope and frame structure.

Volume:
Spool and motor requires quite a lot of volume, which makes logistics harder.

Sound levels:
Deafening sound level is both dangerous to the operator, as well as a nuisance to bystanders and cripples communication.

Limited distance:
Concept of using rope wound up on spool limits the distance of the rope.

Single direction:
One way ride, limits creativity and effective ride time.

Motor effect:
Most motors need to be equipped with torque-converter because of the starting procedure.

Line tangled:
When the rope tangles on the spool, it is hard to reach and untangle.

Downward pull:
The low center of gravity and placement of fairlead creates a downward pull for the rider.

Combustion engine:
Still an unsustainable fuel source.

Moving parts:
A lot of moving parts that waste energy. It also adds weight because of parts tolerance and requirements.

Water spray:
The rotational movement of the spool sprays water towards the operator.

Stability:
Wheels need to be removed to create a static posture.

Luggage capabilities:
When transporting the winch from the car, often requires assistance from both participants. This limits the amount of accessories they are able to bring along from the car.

Spool diameter effect:
Since the diameter of the spool increases when the rope is wound up, the speed also increases, making it hard to keep an even pace.

Communication:
Oral communication is hard due to distance between rider and operator. This can also be because of visual obstructions or level difference.

Rope skipping:
When tension increases on the rope, the rope tends to skip sideways on the spool. This phenomenon is very noticeable in the end of the rope and handle.

Speed estimation:
Without a speedometer on the winch, speed estimation is done by listening to the sound from the motor. To be able to keep a satisfactory speed, the operator needs practice, and also a lot of upkeep of the skill. It is also missing a scale to be able to reference and adjust speed to suit the rider.

A virtual community

As the Swedish community is very small, with approximately 5-10 active winches across the country, a way to complement my research was to participate in and observe several online message boards dedicated to the topic. This also gave me an opportunity to interact with users from other countries, providing feedback on my project.

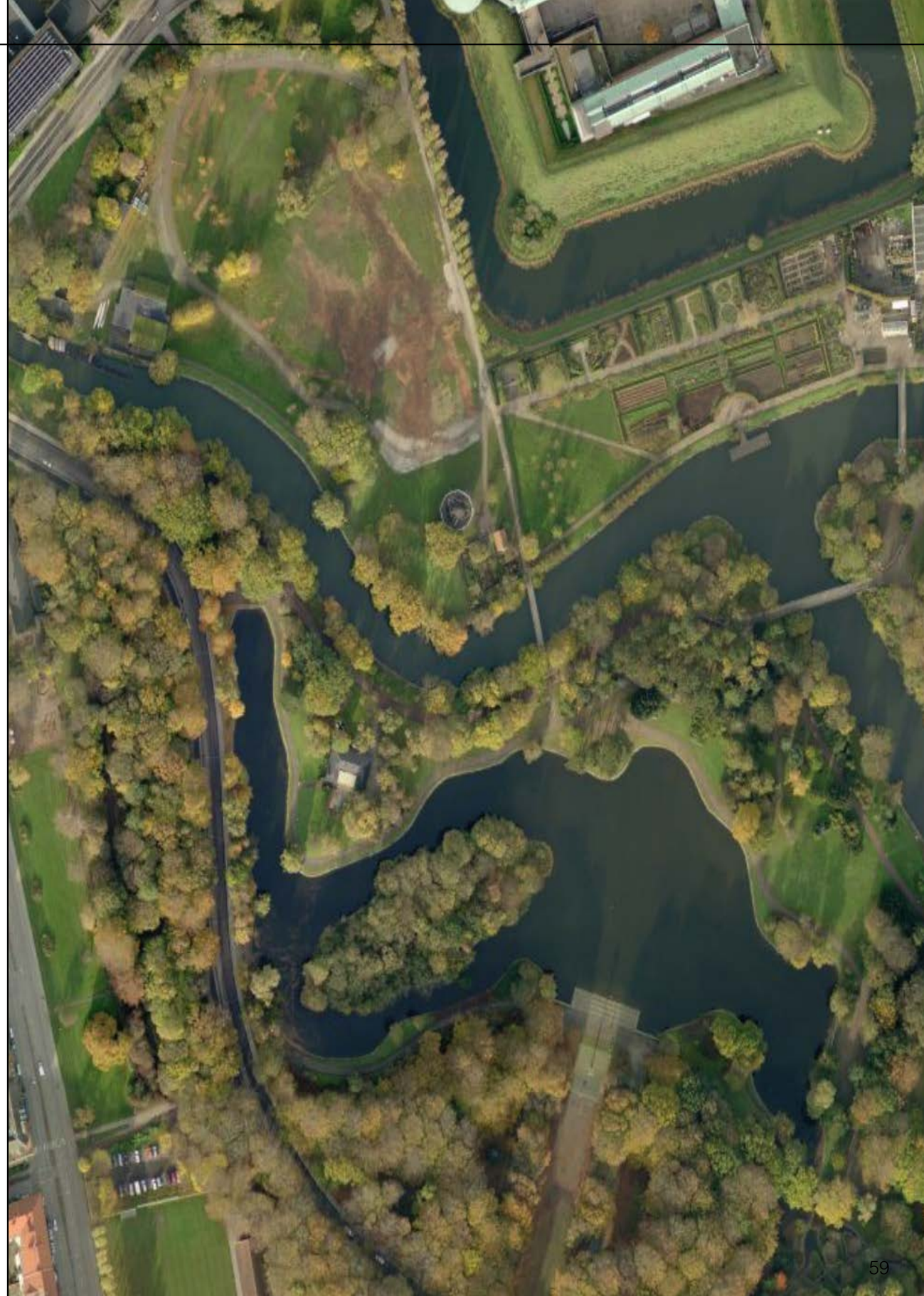
Since the sport has been around for about nine years in Florida, it is starting to become somewhat accepted as a legitimate way of towing riders. There is still some friction between different categories of riders, but this seems to be fading out slowly. There is purist mindset among some people, that a wakeboard is meant to be ridden behind a boat doing aerial manoeuvres. A group of guys who called them selves 'Shred Town', received a lot of publicity and sponsorship after their online movies became noted by the community. Their approach to wakeboarding was very different from the norm. The style was rawer and dirtier, mixed with taking a lot of risks while riding.

Most of the discussions in on the message boards revolve around the construction and methods to build winches. Topics like gear-ratios, diameter of the spool, where and what engines to buy are by far the most common discussions. There is a small group of users who have built several winches which they sell. This lets them start several new winch projects each year where they can change or refine details on the winch.

I started my own topic after a while, to get some feedback from the community and shed some light on what I was doing. The topic started with me presenting myself and the intention as well as asking for some information about habits and backgrounds.

What was pretty evident was how the users who considered themselves to be the ones most active on the forum and experienced with building winches, were the ones who were most conservative with the correct procedure of building a winch when I questioned it.

There were other indications on both the message board and other web resources, that users who came from areas where wakeboard winching was a very rare phenomenon, tended to be far more open to experimenting. Users who did not have the means or funds to follow the more conventional ways of building. These conventions were far more rooted in areas where winching was a lot more common. Obviously the internet does broaden the definition of the community vastly, but as the phenomenon grows locally, the riders tend to move away from the fellowship and community that the internet offers.



The Pendulum effect

As observed in many different forms, phenomenons that turn in to a big trend or grow immensely even outside of its natural target group, have a tendency to create a counter-culture. This happens in both small and large scales in different environments. As small as using a certain lingo or word intensively that later spread, to how things are practised all together.

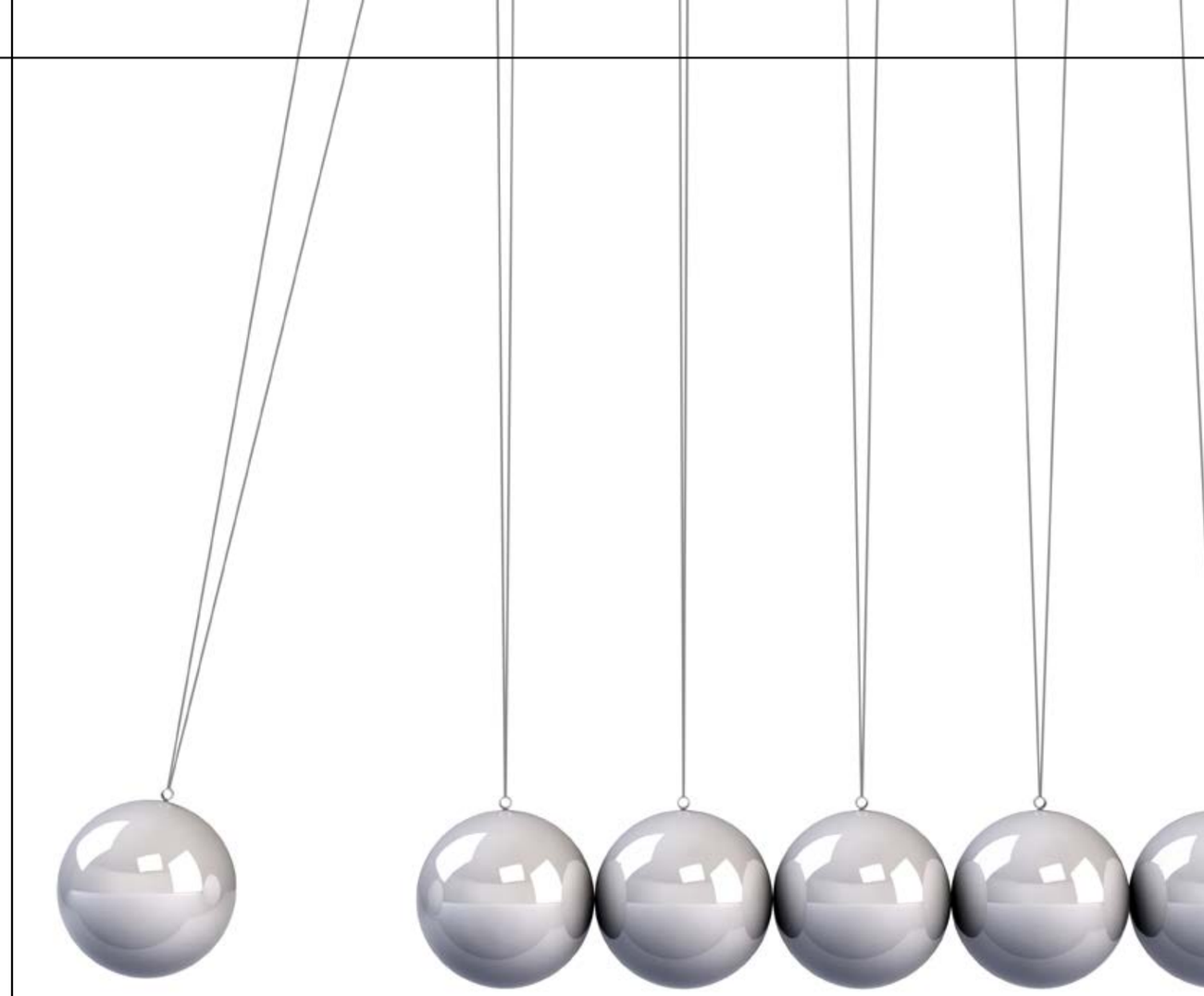
A simple example is how skateboarders wore very baggy jeans during the nineties, inspired by the hip hop culture, which then grew in to a common trend among teens and young adults. Later, during the early parts of the new millennium, rock music became a larger influence and riders adapted over to skin-tight jeans. This also tipped over in to snowboarding, which in extension changed the way boot manufacturers designed their products because of how riders wanted to be able to pull the tight pants over the thick boot collar.

Skateboard shoes changed in a similar fashion, from the very high-tech shoes of the nineties, to minimalistic and retro looking shoes that are worn today. There are some strong indications that the high-tech trend is making a return as we speak. Similarly snowboarding swung from back country riding, to an urban environment.

Within the wakeboarding scene, when the competition grew immensely, a lot of the professionals started emerging from wealthy and privileged backgrounds where they already had access to a boat or lived just next to a lake. Due to the nature of the competitiveness, a very ambitious image of the professionals emerged.

This made me wonder if the entire winch phenomenon could be a counter-culture to this scenario. The poster boys of the community had very crude and revolting personalities. Courage became more celebrated rather then highly technical manoeuvres with perfect execution.

It is a theory that I wanted to use or incorporate to try to figure out the direction of different innovation would have a natural importance.



Trying to visualise this phenomenon turned out to be difficult, which is why I decided to use the more common adoption curve with extension and more detail of the when and where the users head.

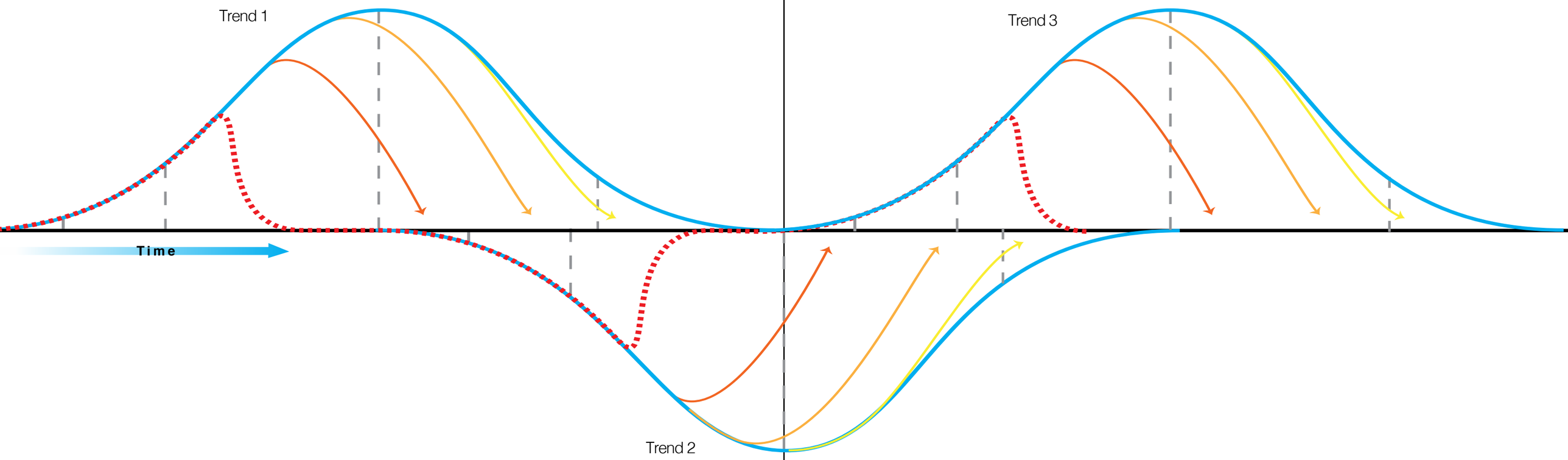
It was difficult theorize about the possibility of users discarding a phenomenon during the adoption cycle, but I think it adds an interesting dimension to the standard diagram. It does need further refinement and simplification. As of now it is completely based on personal experience and observations.

My theory was that the lead users are the first to abandon an activity after or just when it turns in to a stable trend with financial interests. This is the moment when fundamentals start to get rooted, and fewer experimental ventures are taking place. So what I am suggesting is the dismissal of the status quo among these users and portraying an important revolting behaviour.

It is however somewhat of a contradictory statement, as these users are intentionally or unintentionally contributing to the platform which will set the foundation and the rules of the game.

What the diagram is also showing, is how lead users head for the other side of the pendulum, actively participating in the counter-culture.

Of course it is possible that the lead users are the ones who stay with the phenomenon the longest, due to their personal investment in it. Also depending on the commercial success of the activity.



Inspiration

During the first field trip to the gravel pit, I became intrigued by the old industrial machine floating in the water. To me, the scenery represented well what my friends were engaged in.

It was a somewhat secluded place where the only audience were the natural animals and an occasional ornithologist or motocross passing by. Henning and Jonas were allowed to do what they enjoy without any interference.

What made it even better was the water logistics between the two large ditches. The layout can and usually does change from every occasion.

An artificial ever changing landscape.

It was a regular location to visit, with a very dynamic trait.

Urban Exploration

A subculture which has grown after the uprising of the web and digital cameras. Curious people explore abandoned, off-limit or unseen facilities.

Participants frolic on message boards around the web. These forums are usually closed to outsiders, who may get invitations to join after field tests with the person in question. The different cliques have their own favourite and secret spots, which are only revealed to trusted members.

The majority of explorers are young people from urban areas. Their curiosity for what is off-limits or abandoned is what drives them to do it, as well as a the thrills of the dangers involved. There is a high safety awareness among the dedicated ones. Equipment like gas masks with assorted filters, first aid kits, com-radios, climbing gear and different light sources are examples of what they may bring depending on the facilities. Cameras are also a vital part of the equipment.

The codex of the urban explorers is "*Take only photographs, leave only footprints*". It is very important to leave everything intact, the way you found it. They are treating the facilities as historic landmarks, for others to enjoy.

This phenomenon was even more inspirational after getting acquainted with the winchboarding community. There were actually a few discussions where the riders found interesting spots in urban-exploration galleries. Places like abandoned amusement parks and large swimming pools. When these discussions occurred, several other users began to use similar keywords to find resembling places in their local area.

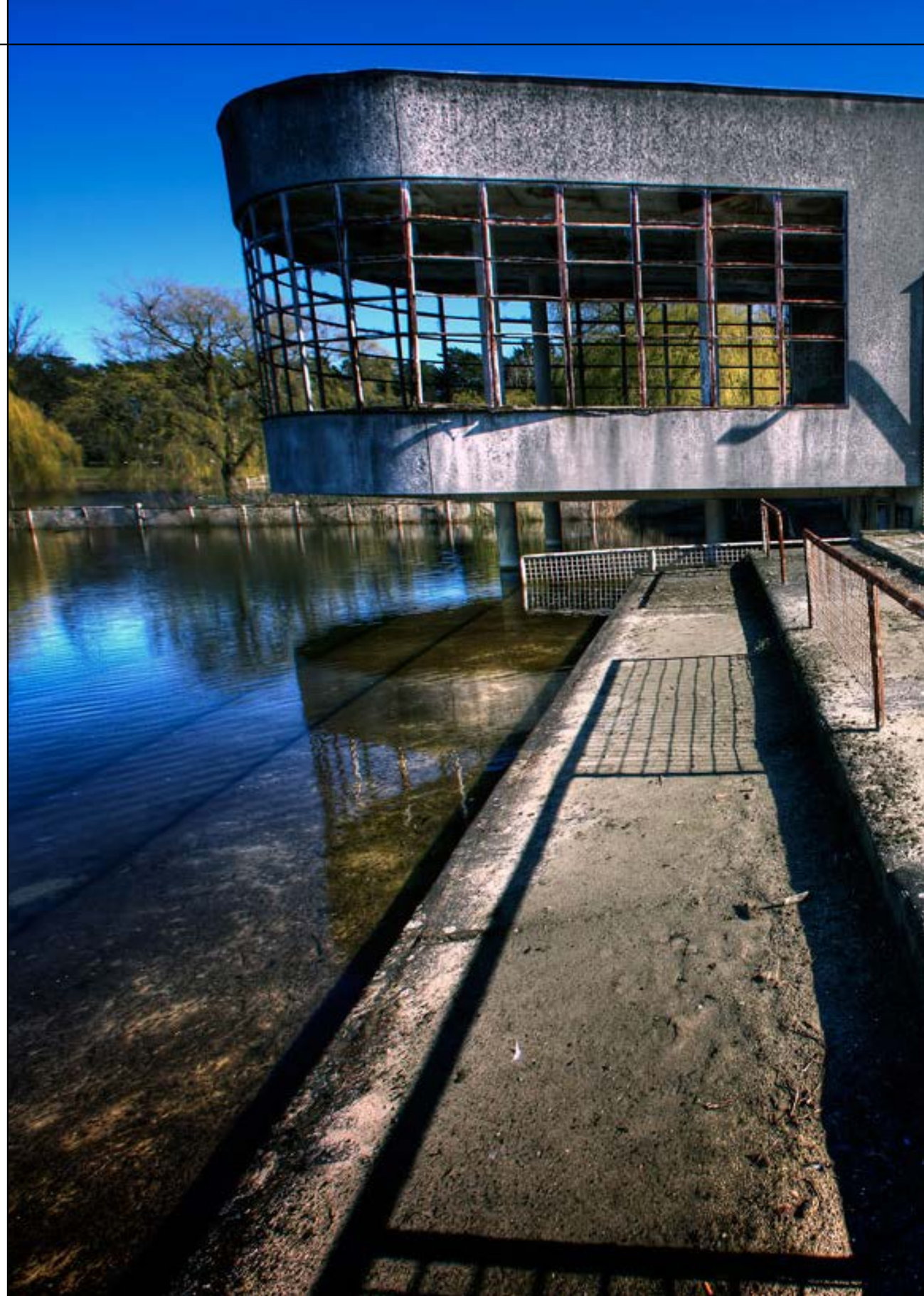
There were also other indications of a similar mentality. Several riders were emphasising the importance of taking care of their spots, to minimise the risk of getting discovered and banned from the premises. Obviously this was for selfish reasons rather than maintaining the spot in its original state.

This is however a common behaviour in many alternative sports. In some there is less concern for the surroundings, and in some there is a lot. It tends to depend on which kind of surrounding it is, and which form of interaction there is.

"You're not going to protect something that you don't appreciate and that you don't care about. So you have to make people care and there is no better way to make somebody care about it than to participate in it, with it. And then they get a feeling - 'Hey, I care about it! What's going on, how can we help it?"(Bartlett, 2008)

A prime example is the large amount of ocean aid organisations that have been started within the surfing community.

This helped me form a clearer image of the potential I saw in the winchboarding community. It also instigated a discussion with my lead users of what they found interesting with their very mobile and explorative lifestyle.



Artificial nature

As the urban exploration discussions went forward, we drifted to how things start up in a natural or already existing environment. Using skateboarding as an example, where the streets were its natural habitat. As the sport has grown, more and more skateparks are being built. These are areas mimicking the original elements, but with a higher efficiency due to the high ratio of obstacles on a small area. These obstacles are usually minimalistic geometric representations of the originals. The layouts tend to be very efficiently designed, but often have a clear path which most riders follow.

The major benefit of these sites, is the possibility to ride all year round regardless of weather. Another strong incentive to why these skateboard parks get built, is to get the riders off the streets, as a lot of people consider the activity a nuisance and even as an act of vandalism.

The majority of all competitions are held at the venues, which is another reason why many riders strive to get them locally. Similar sites has been created for the wakeboarding scene with the help of cable parks. The obstacles in these boardparks are mainly influenced by skateboarding, but also snowboard parks.

During the later part of the decade, these obstacles have been tweaked and tailored to be more specific and suit the needs of the target group. The local boardparks usually function like a training facility, where the dedicated riders know every bump and corner of the obstacles. Later it is possible to apply these skills to other boardparks if or when the opportunity arise.

When riding in uncharted or unfamiliar terrain, the riders tend to have a harder time to master the surrounding. This is usually where you can tell the difference between good and great riders. It also tends to spark more creativity. The riders are challenged to solve how they should tackle the obstacle in a fashion suiting to their capabilities.

The possibility to find totally new types of obstacles for wakeboarding increased quite dramatically when the winch was introduced. There is a fair chance that this will change the way that the obstacles and courses in the boardparks are designed, and this was a strong reason why we wanted to push mobility further.

Photo: Brooke Geery

Photo: Florian Süß / Red Bull

Alternative culture

Other than the environment, I have been inspired by both the mechanical design and the material choices of skateboards. It has an efficient and honest construction, not concealing anything but instead perfecting and adjusting the structural elements of the product. Very simple elements, materials and processes that together form a intuitive and effective product which has seen a massive amount of success.

The aging of the skateboard adds another dimension, as it is possible to figure out a lot about the rider from the scratches and tears. Things like favourite tricks, favourite obstacles or discipline.

This is the opposite side of the spectrum to what a lot of mass produced products look like, where the majority have been applied with protective casings, that hides the structure in its entirety. I made a decision to not conceal my mechanics. This meant that not only would I have to solve problems of constructional nature, these mechanics would also have to have a coherent and considered appearance.

Considering the nature of a winch, it would be hard to achieve a completely casing-free result. My approach to this was to try to design any possible casing so that it would be obvious what's underneath it.

Using the skateboard and its culture as inspiration made it possible to create a cultural bond with a larger mass of alternative athletes to the winch itself.

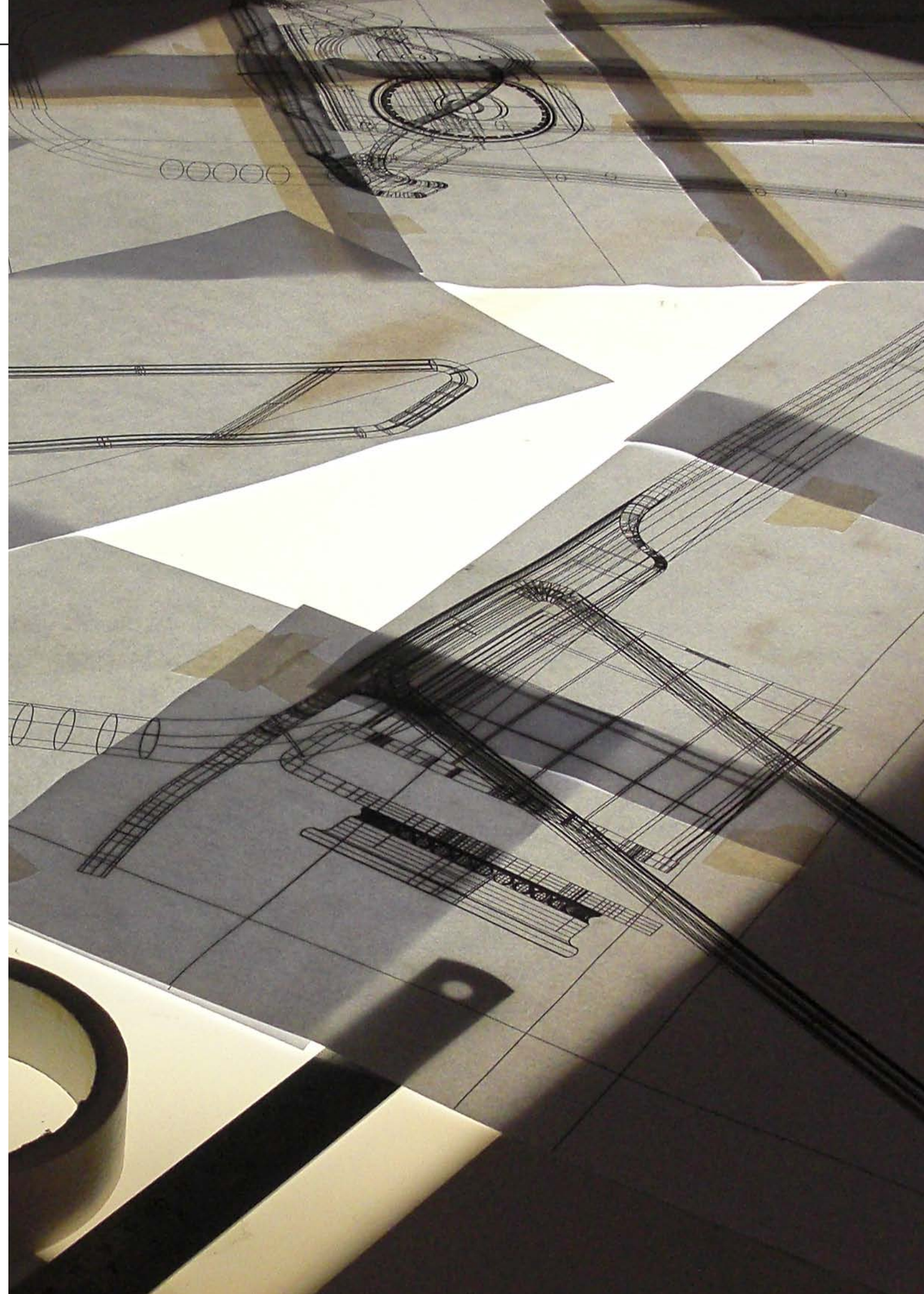
Concept and development

At the beginning of the project I had decided not to address the winch immediately, even though it was very tempting at times. During the field research, a lot of photo documentation was made, and whilst there some times could be a lot of equipment brought along for their sessions it became more and more obvious why I would probably end up designing a new winch. Most of the other equipment held no real interest to change by the users. One of the major concerns were the wear and tear of some boards because of the tough treatment and technique of riding. This is however a problem of constructional and material nature.

Another reason why I ended up choosing the winch, was because of the deep understanding that Jonas possessed in regard to demands, durability and functions.

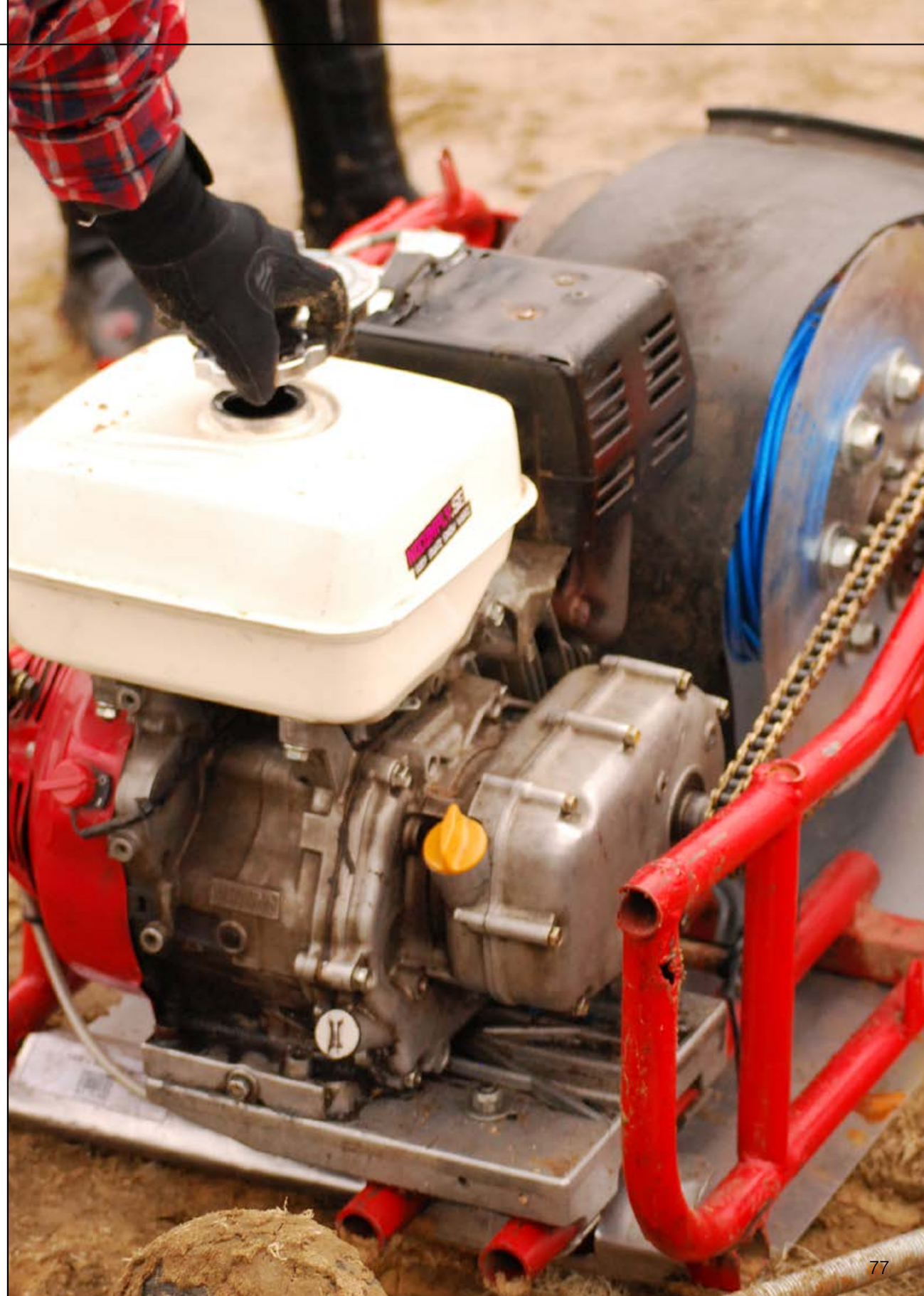
This was important to be able to hold productive dialogues about the product with a lot of his input. Henning had during one of his school projects designed a winch concept of his own. I was allowed to have a look at his ideas and designs. When following them around, it was easy to notice that most spectators and by passers were most intrigued by the winch itself. Even though its sole purpose is to enable riders to do what they love, it is the immediate focal point for almost everyone around.

The only other novel option as I saw it, was to design and create obstacles that would be safer, and with higher mobility than what was being used at the moment. This would however come to be counter-productive to the purpose and direction we had in mind.



Propulsion

An integral part of the entire concept and product was propulsion. It is also a very complicated field of science. We did discuss this a lot, as well as seek advice from several professors and faculty members. It is important to point out that the most power demanding part of a ride is the start, when the rider goes from standing still to water planing. This fact got a lot of priority during this part of the research.



Pneumatic engines

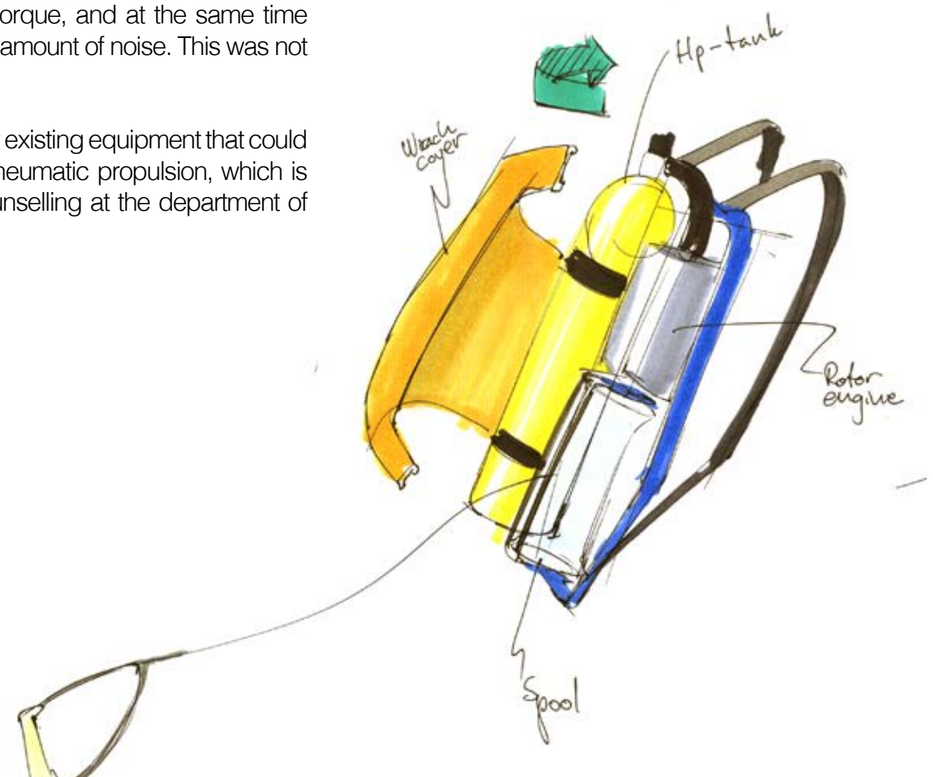
There were two main inspirations for researching further. The first was the large market for scuba diving-gear, where the cylinders are meant to be mobile and the massive amount of energy stored in these. The standard cylinders are made of aluminium and can contain 15-20 litres of air at pressure up to 450 bar. The second reason was because of how air pressure is used within the paintball industry. They use light composite cylinder with 1.1 litres of air at 300 bars of pressure. One single cylinder can send up to 2000 paintball-projectiles at 90m/s, which I thought was reason enough to at least see if there were any possibilities to pursue. There are many examples of compressed air vehicles, but so far none have seen any kind of success on the market. They tamper with similar issues as electric vehicles, where energy per kilogram is far from the rates of combustion engines.

I had high hopes that a pneumatic motor could produce enough torque, and at the same time operate with a low amount of noise. This was not the case.

I looked for already existing equipment that could be utilised for a pneumatic propulsion, which is why I went for counselling at the department of Energy science.

The discussion was about the amounts of energy released, and especially thermal loss, which is one of the major issues with pneumatic propulsion. What I was looking for was a setup that would basically just be a simple connection between the scuba tank and the motor.

What I have found out about the system, was that the pneumatic winch would need several steps of expansion valves to allow the air to expand slowly. This would prevent the large amount of thermal energy loss that would happen otherwise. Without these it would be very unlikely that there would be energy for a single run. The nature of compressed air also require that the components can withstand the forces, which in extension means quite thick material and high tolerances. Aluminium cylinders require hydro testing every ten years. There are risks carrying around that piece of equipment, and with the forces involved, the result of failure can easily be fatal.



Advantages:

- Infinite fuel source, and emission free

- Mobile and modular for transportation

- Sound levels are easier to adjust with construction of the motor and expansion valves

- High water resistance.

- High torque

Disadvantages:

- High loss of energy during compression and de-compression of air

- Requires expensive parts due to high pressure regulations

- To optimize efficiency, the system need to utilize several expansion chambers, which are both heavy and complex

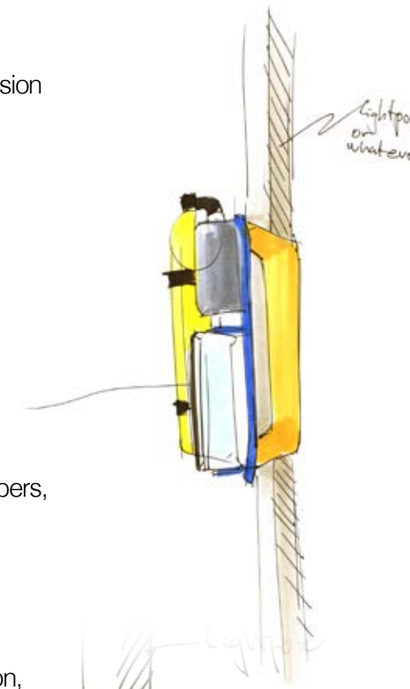
- Pneumatic engines use a lot of moving parts

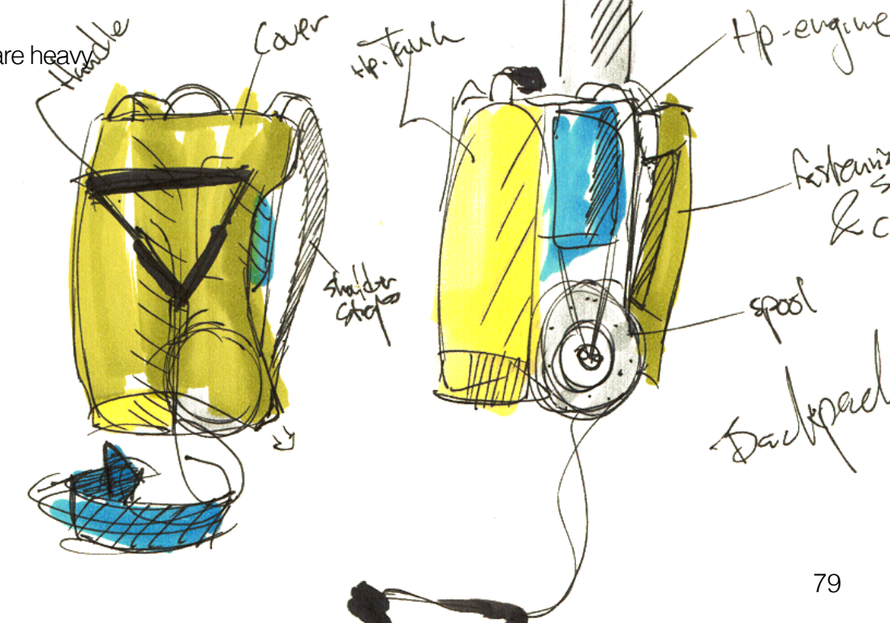
- Compressed air is dangerous if not handled properly

- Compressors that can achieve a pressure of 300 bar, are not very common, and they are expensive

- Regular alloy scuba tanks are heavy

- Low RPM





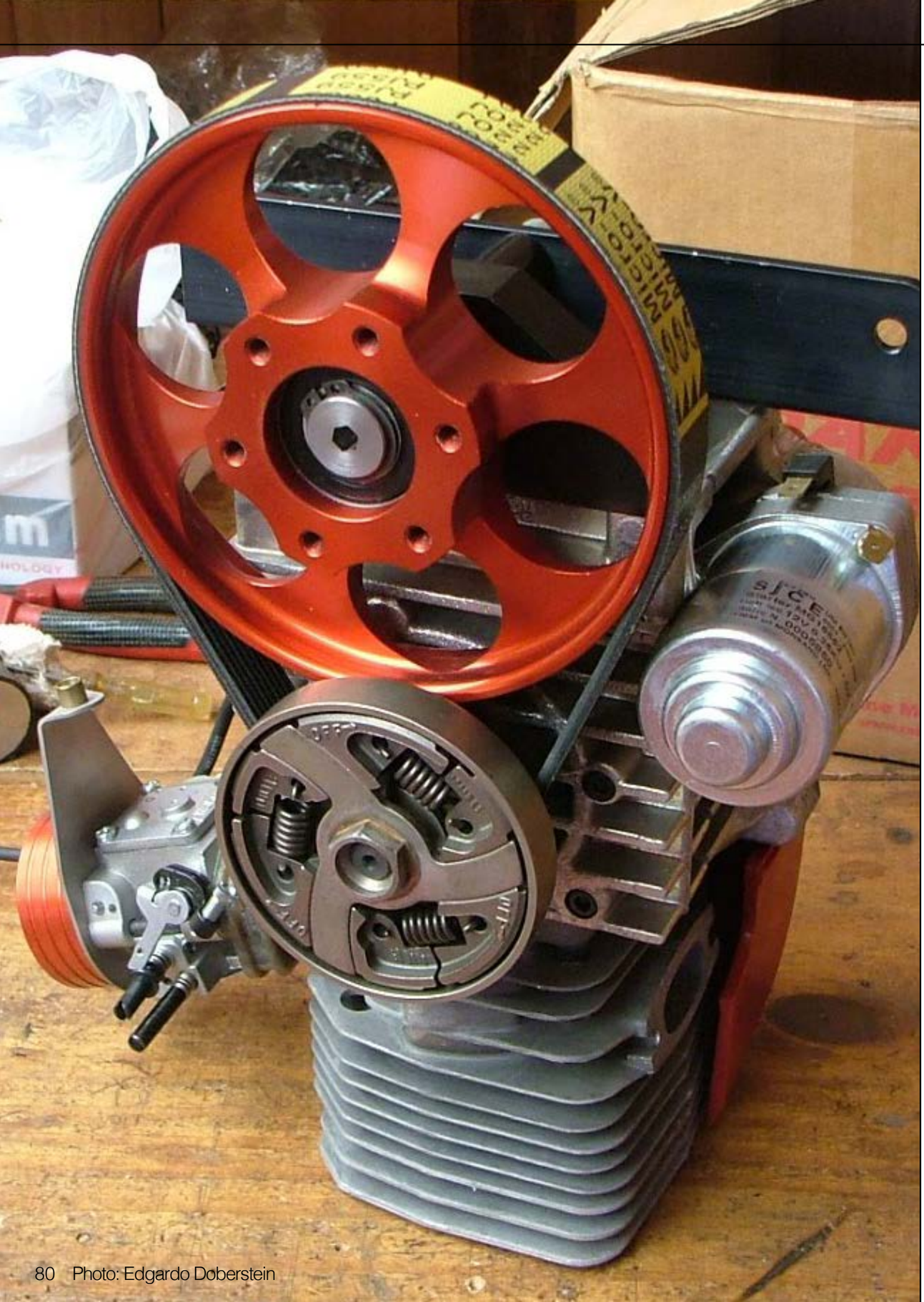


Photo: Edgardo Doberstein

Combustion engine

Interestingly enough, most winches built today use similar motors. They tend to be Chinese clones of Hondas four stroke gx270 motor with 8.5 horse powers. An affordable motor which is not that complicated and well stocked around the globe. This combined with a clutch or torque-converter, is a very sound setup. The engine is however spacious.

I thought another possible approach was to rationalise and find ways to build a winch with the same characteristics as the standard ones, but smaller and combining more parts to make the space consumption more efficient. It was helpful to look at reference products like chain saws, paramotors for paragliders, pocketbikes and go-karts. The three latter categories turned out to use similar parts.

Both powertools and pocketbikes are mass produced, which results in very beneficial prices per unit. Most of them use a 49-90cc two stroke motor. Jonas who had good knowledge about pocketbikes, thought the idea was interesting but that two stroke engines tend to run irregular compared to a four stroke engine. Due to this I researched competition go-karts where performance and continuity is important.

I found a Swedish brand called 'Raket', that manufacture strong yet compact engines from 6-13 hp. This was promising, so I contacted them immediately. The information that I got was that these engines often are used in paramotors due to their low weight and high performance. This engine is quite expensive though, and since it is a performance motor, it requires a lot of maintenance and tuning which is common practice in the go-kart circuit. Another issue with these engines is that the noise they emit is far louder than the standard winch engines. Since the RPM is quite high, it emits an unpleasant high pitch noise.

The exhaust pipe does accumulate a lot of heat and can easily cause serious burns. The Raket engine was a promising alternative for the propulsion during this stage of the ideation process.

Advantages:

- Small but very powerful
- Mass produced, so prices are competitive
- Common technology
- High fuel energy/weight ratio
- Low fuel consumption
- Good water resistance

Disadvantages:

- Sound levels, +100 dB
- Many moving parts
- Vibrations
- Weight
- Emissions
- Size
- Requires maintenance

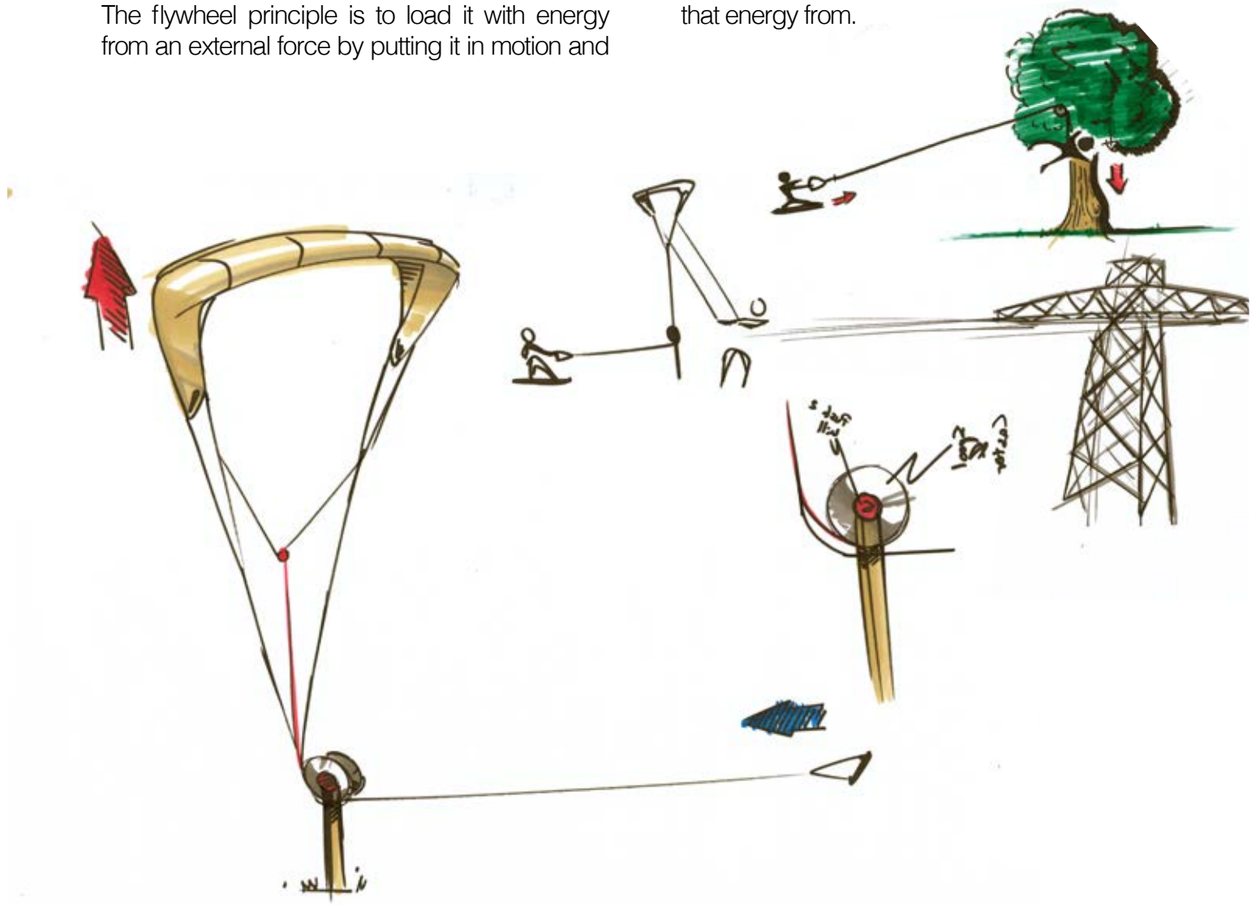
Kinetic and potential energy

An experimental thought, where different forms of kinetic energy produced by either the riders themselves, or naturally occurring in the surrounding would be applied.

Using manpower to wind up a flywheel capable of pulling approximately 80 kilograms for 100-200 meter is no easy task. In comparison, it takes about 4-5 grown men to pull a wakeboarder 40 metres in a reasonably slow pace just above planing. Elite sprinters have been measured to output just above 2000 watts of power at an instantaneous burst, while ordinary people can output between 900-1400 watts in shorter bursts

The flywheel principle is to load it with energy from an external force by putting it in motion and letting it spin freely until the energy is extruded via a similar method like the one that put the wheel in motion at the initial phase. The output can never be greater than the input, meaning that several inputs would be needed to be able to create the amount of energy required for a single run. This would also mean that for the flywheel to be able to store this energy, it would have to weigh quite a lot or spin at very high RPMs.

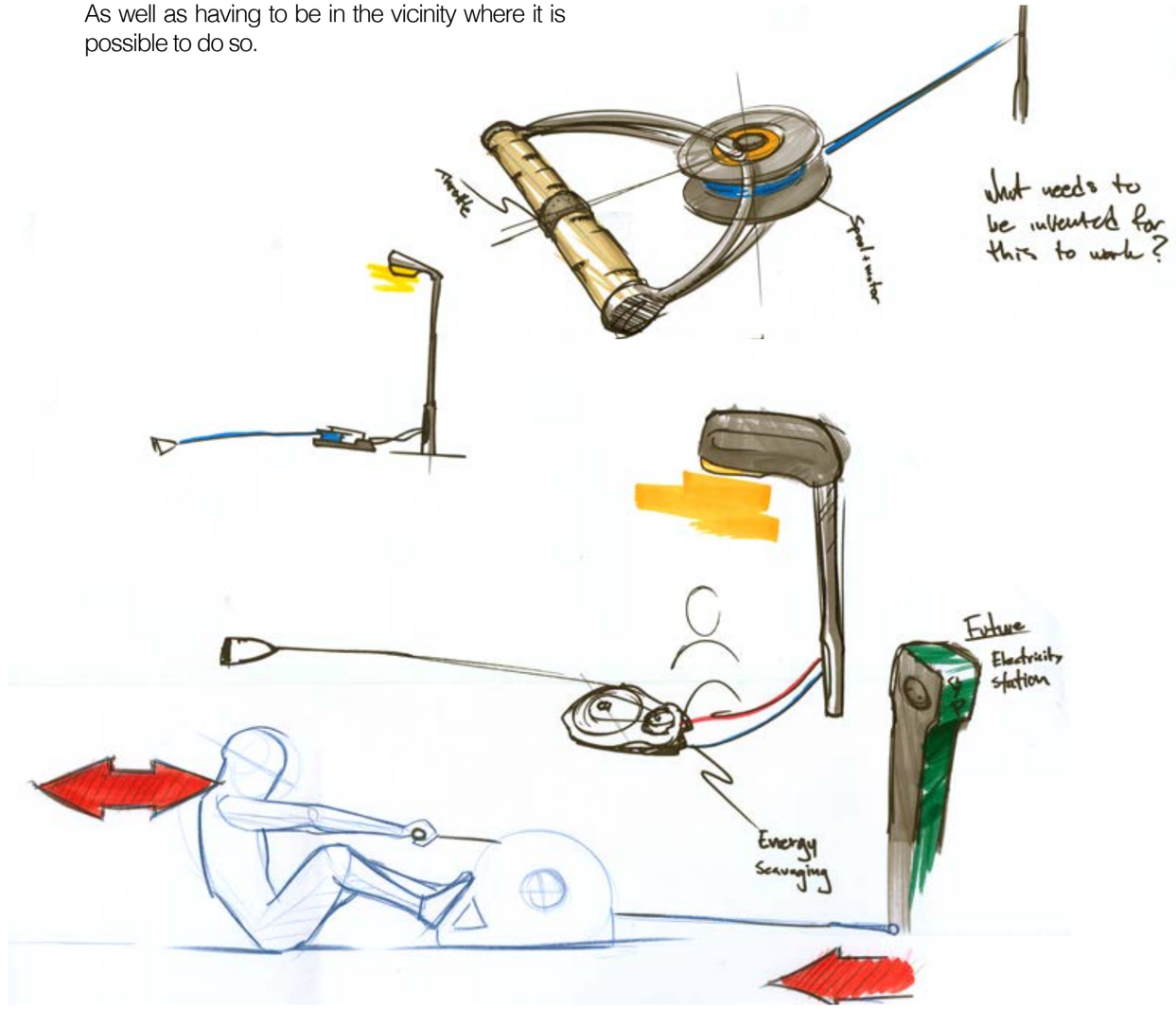
Potential energy was also investigated, with the idea of using the body of the bystanders to create force to pull the rider. This could be done by for example using the gravitational pull. That would however require an elevated platform to receive that energy from.



Energy scavenging

An interesting idea, with focus on stealing energy from sources around the spots where there were possibilities to do to. It could be anything from breaking in to a light pole and hooking up the equipment to its power grid, to attaching rope and pulleys to cars in motion.

These are highly debatable modes of acquiring energy, as well as hazardous in many situations. As well as having to be in the vicinity where it is possible to do so.



Electric motor

Initially there were many factors that responded well with electric propulsion. These motors have an impressive instant torque, which is important in this case. They are also quiet and compact in relation to their power output. During my research, I browsed through a lot of message boards for radio-controlled hobby enthusiasts, but also boards for people who were interested in electric modification of different variants. Many were working on electric bike-conversions which was beneficial to my research.

During this I found a small brushless R/C-motor for helicopters and planes, which had the power of 6500 watts, which can be translated to almost 9 horsepower. Brushless motors are also low maintenance entities with few moving parts. This one had a price tag of just below $100 in hobby stores.

This motor is the choice of many electric bike-modificators Because of this, there were many reference videos of the motor in action, and also threads discussing electronic accessories, problems and all-round knowledge.

I decided that I would use this motor as a starting point of my winch design.

Photo: www.etotheipiplusone.net

Batteries

Since I chose the electric route, this was an important element of the design. Batteries have not changed to any great extent during the last century, and neither have the principles of how the electric motors work.

As the battery market is a jungle of information as well as very complicated, I took a decision to incorporate the same sort of batteries as most of the users with the same motor do. This was LiPo batteries (lithium ion polymer) from the radio control hobby market. They have an energy ratio of 130-200 Wh/Kg, compared to a standard car battery with the ratio of 30-40 Wh/Kg. I was more or less forced to use this battery type to keep the weight of the winch to a minimum.

My alternative plan was to use motorcycle batteries. These however, would not be able to fit in to the system in an efficient manner, with weights toward 6-7 kilograms per unit.
LiPo batteries are growing in application areas and are now standard in Apple laptops. They do however require a specific type of charger to prevent fires or explosions, which is a negative aspect of the technology.

Fuel cells were not considered at all due to their high costs, low availability and performance characteristics.

At a maximum load of 48 volts and 6500 watts, Ohms law (P=U*I) tells us that the current would be 135 Ampere. Since there are no perfect numbers of the amount of power needed to pull a rider, I approximated a run to use 6500 W during the start until planing has been achieved and then far lower consumption to maintain planing. 3000 W was chosen as average. It could however turn out that it would use more or less, which means that the pack should be adjusted accordingly.

After counting the amount of runs during sessions of winching with two winches available, I set the number of desired runs to be 30, ranging from 100-250 metres.

At a speed of 25 Km/h, 6.9 m/s, that would give us a ride duration of 14-36 seconds. I chose an average duration of 25 seconds per run. With some help our basic calculations showed that theoretically we needed 13 Ah to get 30 runs with the winch. There are however other factors regarding batteries and its discharge that could alter the result, but given the complexity of these they were not included.

To get 48 volt and 13 Ah, I would have to parallel connect 3 batteries with 24 volt and 5000 mAh. This would then have to be serial connected with duplication of this setup to achieve 48 volt. The batteries I found were 150x50x50 mm, weighing 800 grams each for a total of 4.8 kilograms. For the batteries not to get fully drained and the cells getting damaged they would need to get shut down before the voltage is too low. This would require a few extra batteries in the battery pack.

Being able to create a mock up of the battery assembly was beneficial to the development of the project.

25 sec x 30 runs = 12.5 minutes.

3000W / 48V = 62.4A

$$X\,Ah = \frac{12.5min \times 62.5Amp}{60\,min/h}$$

X = 13 Ah

Rope management

The major issue I wanted to deal with, was the spool of the current systems. It had a few disadvantages that could be improved. First of all, it is very space consuming and it does weigh quite a bit with all the rope constantly wound up on it. Secondly, as the rope winds up, the diameter increases which in return increases the speed for the rider. It does however have the benefit of being quite easy to manufacture without access to special machines or equipment.

I really wanted to improve this part, and this is where focus was put just before the ideation process.

For reference I used winches from sailboats that employ the capstan equation which has been used for ages in all kinds of industries. The equation states that the force gain grows exponentially from the amount of turns around the winch with a coefficient of friction which is also increasing the result. It does however require that the rope output from the winch is kept with tension, which is called tailing.

Today there are high-speed motorised winches on sailboats with a large sail area. These need to be able to tighten the sails quickly which is very hard with a manual winch. Electric winches are also common as a supplement to lack of crew members.

A big issue with capstan winches are so called “riding turns”, when the incoming rope overlaps itself on the winch, until it finally blocks the outcoming rope. This makes the winch stop feeding altogether until it is untangled.

Winch for sailboats where the jaws grip the rope during heavy loads.

Another inspiration was motorised climbing ascenders. These are electric or combustion powered devices made to pull climbers upwards with the help of climbing ropes. They are commonly used by service personnel that work with high altitude construction, like for example wind farms.

Their RPM is usually very low, which means that they in most cases use a smaller motor with a high RPM that via gear reduction can create a strong but slow pull. This has two reasons, one is that when a winch gets a riding turn, it will come to a instant halt. Levitating in a position above ground, this would be hard to fix, since there is constant force and tension on the rope, making it impossible to untangle.

Due to the relatively low weight and nature of use (1-2 persons), these ascenders seldom need the friction produced by more than one turn around the winch. For chain saws there is an add-on that converts the saw in to a capstan winch. This is used for pulling heavy trees. It has a similar gear reduction to power ascenders, which converts high RPM to increased force.

Since my winch would operate at high-speeds, it would be very hard for the operator to tail the rope by hand to prevent it from slipping. This needed to be automatic, which would turn out to be a difficult task to solve. Several sketch models and possible solutions were created. It was hard to stay away from mechanical solutions that would be complex to build, with low tolerances. It was necessary to keep it simple and reliable.

It is also important that it would be easy to ‘thread’ the system. Complex procedures would probably scare away users or just seem bothersome.

Petrol driven climbing ascender. Single turn around the spool that is equipped with jagged teeth for better grip.

Scenarios

In the concept that was pursued, I had two scenarios in mind. One was winching in an urban environment. The other was winching in the wild. The major difference would be transportation to the selected spot. Both are equally important since one could be considered to be a bit more casual, which would probably be going to a regular spot. I consider the other more exploratory and thorough, which was one of the founding ideas of the entire project.

These are action breakdown charts, where I compared the turn of events of gas and electric propulsion.

Photo: Björn Bengtsson

Electric winch scenario

Inspiration:
- Peers
- Internet (forums, maps, photos)
- Observation
- Word of mouth

Communication (peers):
- Internet (IM, Forums)
- Phone
- Routine (Casual only)

Prepare (home):
- Luggage (board, clothes, winch, camera, obstacles, tools)
- Change of clothes (optional)

Transport (major):
- Car to meeting point
- Mode of transportation
  Foot, Bus, Bike

Explore/inspection:
- Find location (no gear, tools optional)
- Arrange surrounding accordingly
- Evaluate potential
- Safety check

Assembly preparations:
- Change to gear
- Choose gear (board, camera, tools, rope, clothing)
- Distribute luggage (winch, boards, bag, batteries)
- Lock vehicle

Transport (minor):
- Move to spot with gear

Set up:
- Winch
  Unfold front/back legs
  Secure legs
  Attach battery bag
  Connect battery
  Unwind rope

Perform:
- Extract rope to start (rider)
- Attach rope to spool (operator)
- Secure rope (operator)
- Get ready (rider)
  Check rope situation
  Secure binding (if wakeboard)
- Ride/operate
- Unsecure rope (operator)
- Detach from spool (operator)
- Switch duty
(Repeat x times)

Conclude:
- Winch
  Unsecure rope
  Wind up rope
  Disconnect battery
  Detach battery bag
  Unsecure legs
  Fold front/back legs
- Assemble (gear, tools, boards camera)
- Distribute luggage

Transport (minor):
- Return to vehicle

Disassembly:
- Unlock car
- Change clothes
- Load car

Transport (major):
- Return to meeting point
- Mode of transport: Foot, Bus, Bike

Finish up:
- Unload car
- Dry clothes
- Stack away gear (board, winch, camera)
- Charge battery
- Shower

Inspire:
- Upload photos on message boards
- Communicate with peers via internet

Gas winch scenario

Inspiration:
- Peers
- Internet (forums, maps, photos)
- Observation
- Word of mouth

Communication (peers):
- Internet (IM, Forums)
- Phone
- Routine (Casual only)

Transport (major):
- Car to petrol station**
- Car back home

Prepare (home):
- Luggage (board, clothes, camera, obstacles, tools)
- Load winch (min 2 people)
- Change of clothes (optional)

Explore/inspection:
- Find location (no gear, tools optional)
- Arrange surrounding accordingly
- Evaluate potential
- Safety check

Assembly preparations:
- Change to gear
- Choose gear (board, camera, tools, rope, clothing)
- Distribute luggage (winch, boards, bag, batteries)
- Lock vehicle

Transport (minor):
- Move to spot with winch
- Return to car
- Move to spot with gear

Set up:
- Winch
  Pump gas*
  Remove wheels
  Start motor

*Positive difference
**Negative difference

Perform:
- Extract rope to start (rider)
- Get ready (rider)
  Check rope situation
  Secure binding (if wakeboard)
- Ride/operate
- Switch duty
(Repeat x times)

Conclude:
- Winch
  Add wheels
- Assemble (gear, tools, boards camera)
- Distribute luggage

Transport (minor):
- Winch to vehicle
- Return to spot
- Return gear to vehicle

Disassembly:
- Unlock car
- Change clothes
- Load car with winch (min 2 people)
- Load car with gear

Transport (major):
- Return to home
- Mode of transport: Car

Finish up:
- Unload winch (min 2 people)

Transport (major):
- Second party return home

Finish up:
- Unload car
- Dry clothes
- Stack away gear (board, winch, camera)
- Charge battery
- Shower

Inspire:
- Upload photos on message boards
- Communicate with peers via internet

Function analysis & Constraints

I set up some guidelines and constraints for the ideation process. A majority of the constraints were developed during the discussions I had with my lead users, as well as actually operating the machines myself.

There were also individual function analysis for each part of the winch. These will be specified on the specific section of the report belonging to each part.

Mobility

- The system should be able to be transported by a maximum of two persons
- The system should consume a substantially smaller space than standard winches
- The system should weigh substantially less than a standard winch
- The system should ideally weigh less than 20 Kg (Winch+batteries)
- The battery module of the system should use high capacity batteries to keep down weight
- The system should offer a possibility to get electricity from a wall-socket if available

Interaction

- The system should offer a reference of what the current speed is
- The system should effectively eliminate the sensation of the rope skipping (smooth pull)
- The system should not increase speed due to larger spool radius

Noise

- The system should be optimised for minimal noise pollution

Runtime

- The system should offer roughly 30 average rides per charge

Production

- The system should be designed for local production to a major extent
- The system should be designed for production methods that do not require custom tooling
- The production of the systems parts should require a minimum amount CNC-milling
- The system should to a large extent avoid parts made from plastics and polymers
- The system should be adjusted towards a small scale production (500-1000 units)

Safety

- The system should not be able to throw dirt, stone or other particles towards users and operator
- The system should not require the operator to have their hands close to any dangerous or moving parts when they are in motion
- The system shall not require anchoring in the ground to be stable

Price

- The system should be cheaper than standard commercial winches (<4000€)

Ideation

There was some amount of ideation early in the process, when I was discussing different engine ideas and how they could be rationalised. There were some points of this that was brought along for the ideation process when I had more details nailed down.

I was determined to create something that would fit the in to a mobile scenario and because of that I looked at a lot of carrying methods and luggage products.

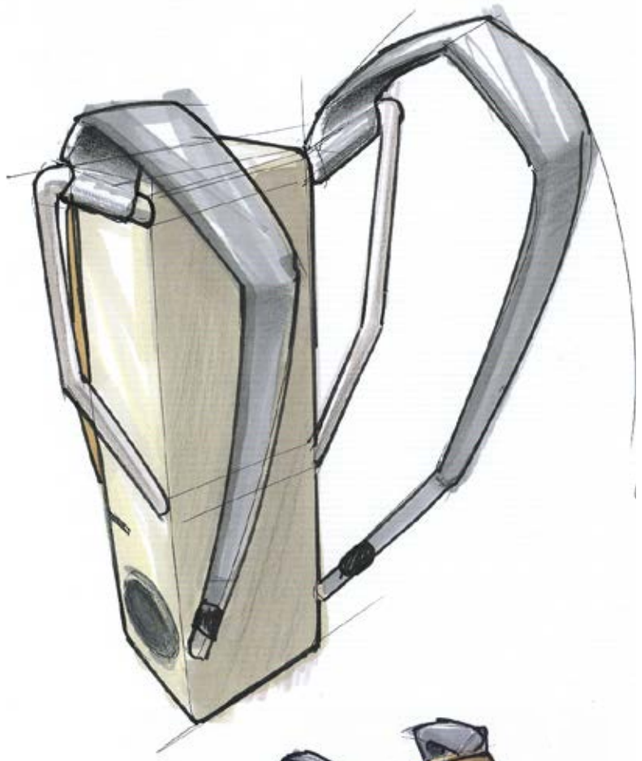
With the research and constraints picked out, three concepts were evolved from both blue sky ideas, and more realistic ones. Several ideas carried through all three concepts and ended up in the final product.

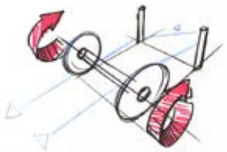
Bag concept

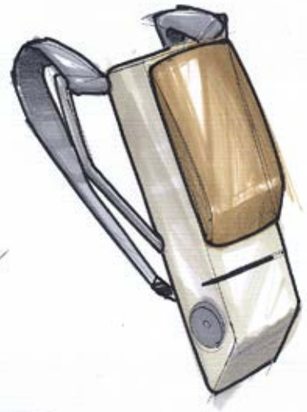
This felt like a natural route to pursue after researching a lot of carrying solutions, especially backpacks and cases. The focus went more in to the mobility of the concept rather than the entire system.

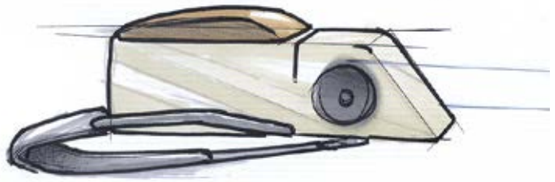
It would consist of a glass fibre body with two compartments. One for electronic components and the other for the battery pack. In action, it would lay on the ground with the operator applying their weight on it for not to move. It would also be possible to tie it to something stable like a tree or a pole.

The spool system would consist of one winch head on both sides of the motor axis. The rope would be pulled in on one side, then turn 180 degrees with the help of two pulleys and pass through the winch head on the other side that would help tail the rope out and release it forward. It would either be carried as a messenger bag or a backpack.





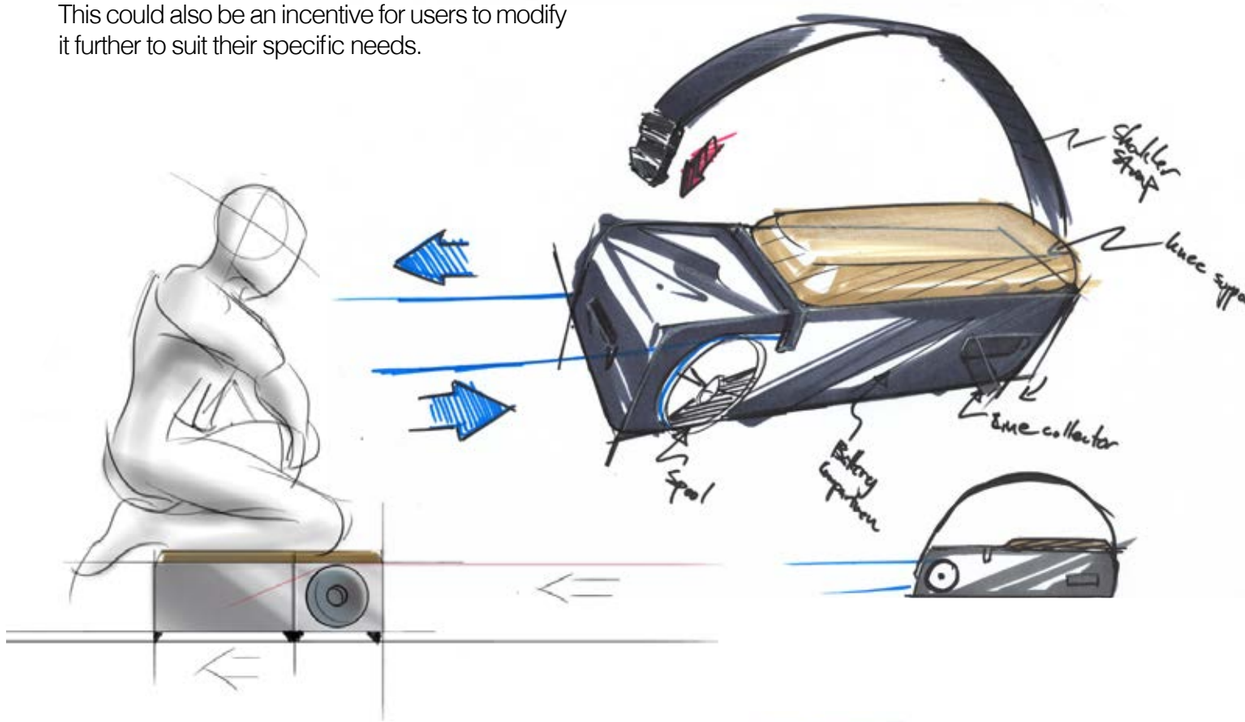


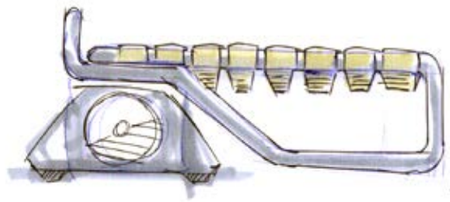


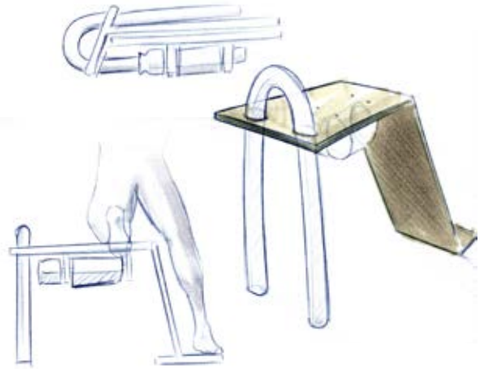
Modular concept

Since it would be a system created for two people, a concept with two modules was explored. A few ideas from the bag concept were incorporated in this one. It would mean that one was containing batteries, whilst the other was motor and electronics. A simple solution would be to use two similar and basic modules containing different components.

This could also be an incentive for users to modify it further to suit their specific needs.





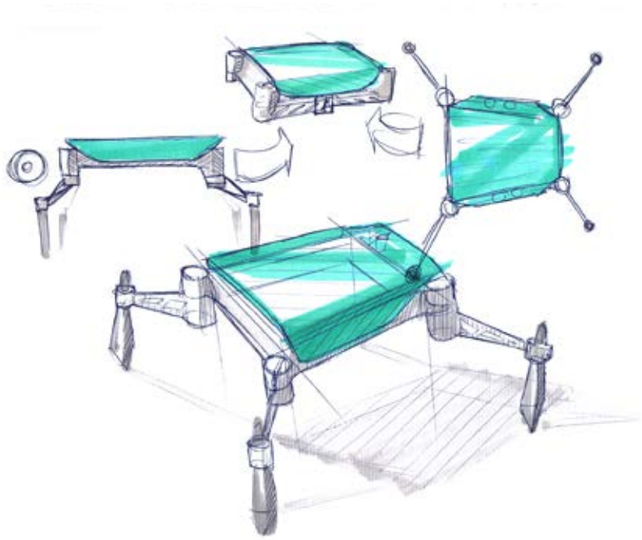


Piggy back concept

A concept conceived after reviewing the photo material from my field research. Trying to utilise the behaviour that already exists to move the rope upwards from the ground as well as applying adequate down force for the winch to stay still.

An elevated spool would be beneficial for the non-captive spool concept as the rope would have more free space to occupy after getting transported through the winch spool.

The piggy back concept was the concept of choice due to its intuitive appearance, keeping true to the original winches, as well as using an established behaviour that wasn't such an obvious solution.



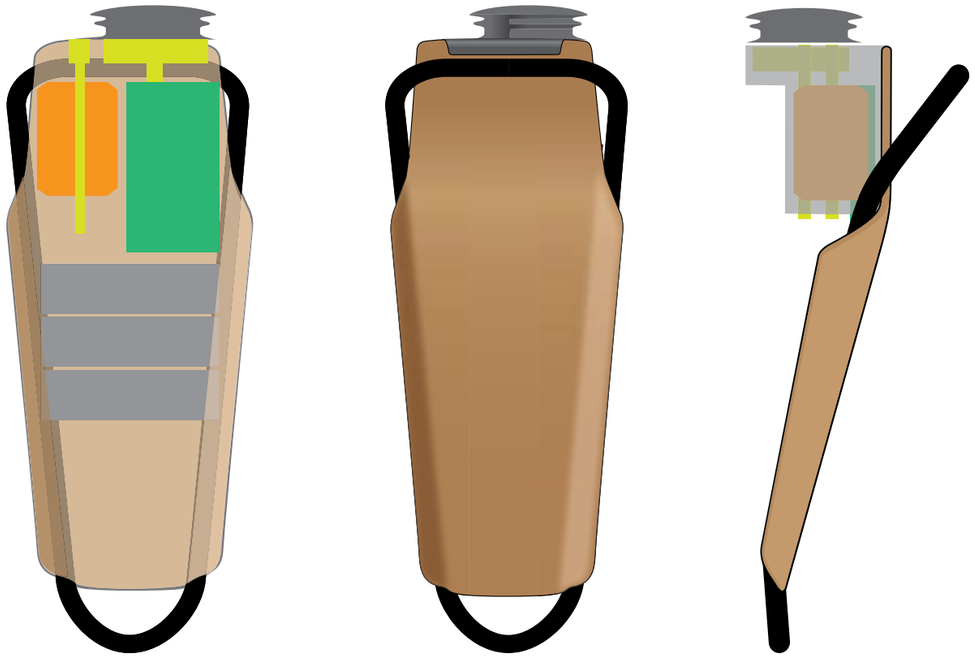
Concept development

The seat would be a fundamental feature of the winch, which is why together with the spool technology, this would take a lot of effort to find a suitable solution.

After assessing the function analysis, production methods, technology and the direction of the concept, I started working with full scale mock ups of the components. Creating different layouts and options how to stack everything in an effective manner.

The layout chosen was the one marked with a green background. The major reason for this was the length, creating a possible leverage situation with the heavier batteries in the back, and the lighter electronic components in the front. The placement of the spool head would also be beneficial for setting this rotating part at the front of the winch where it would be harder to get caught with body parts.

Orthographic layout comparison



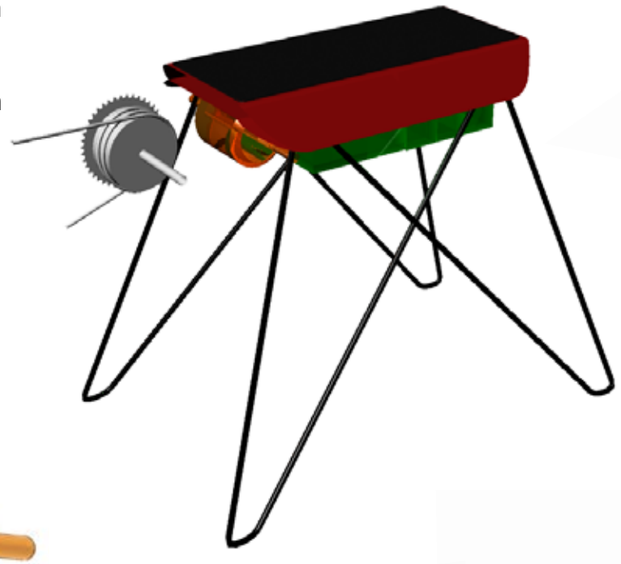
Seating

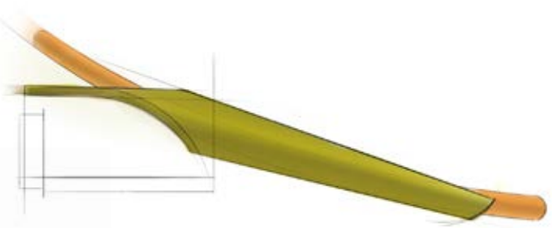
After the layout was more or less settled, the overall concept got a bit more detailed with consideration to earlier decision.

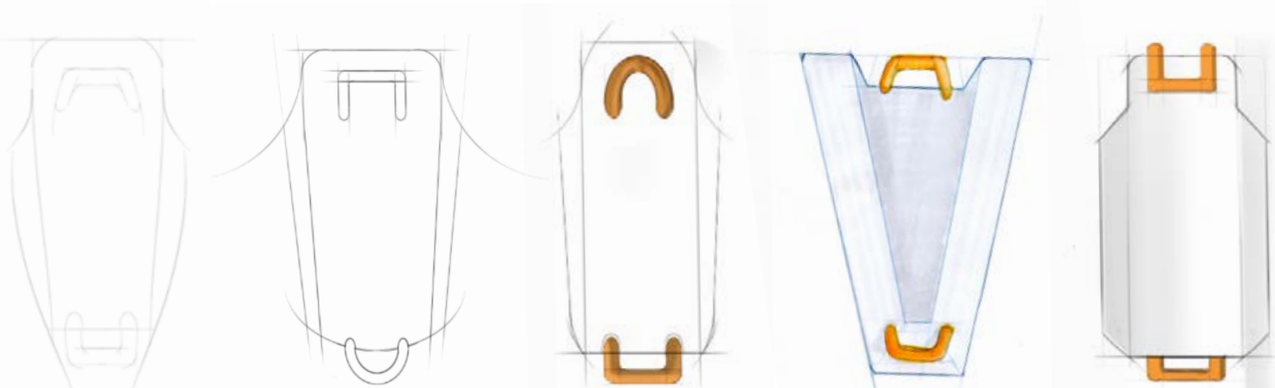
The main idea was to remove the captive spool, and instead use a modified capstan winch. Being able to transport the rope in a less volume consuming manner would simplify transportation as well as prevent other issues from the original model. This is of course a compromise, but both me and my lead users thought it was an interesting idea.

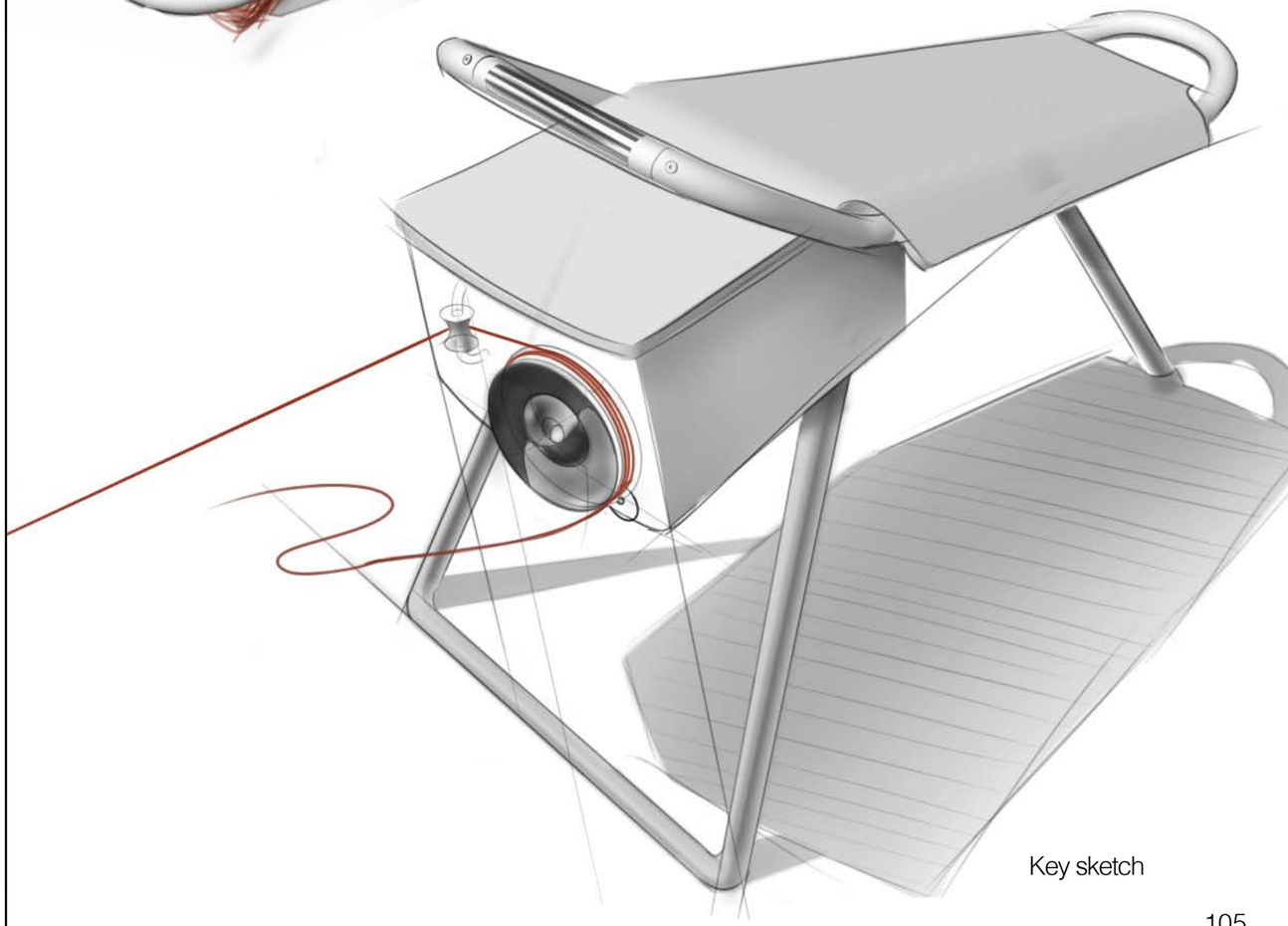
The next problem was to solve how the mechanism of the spool head would work practically.

Design criteria:
- Consume low amount of space
- Stop the rope from skipping
- Few parts
- High friction
- Rope length flexibility









Key sketch

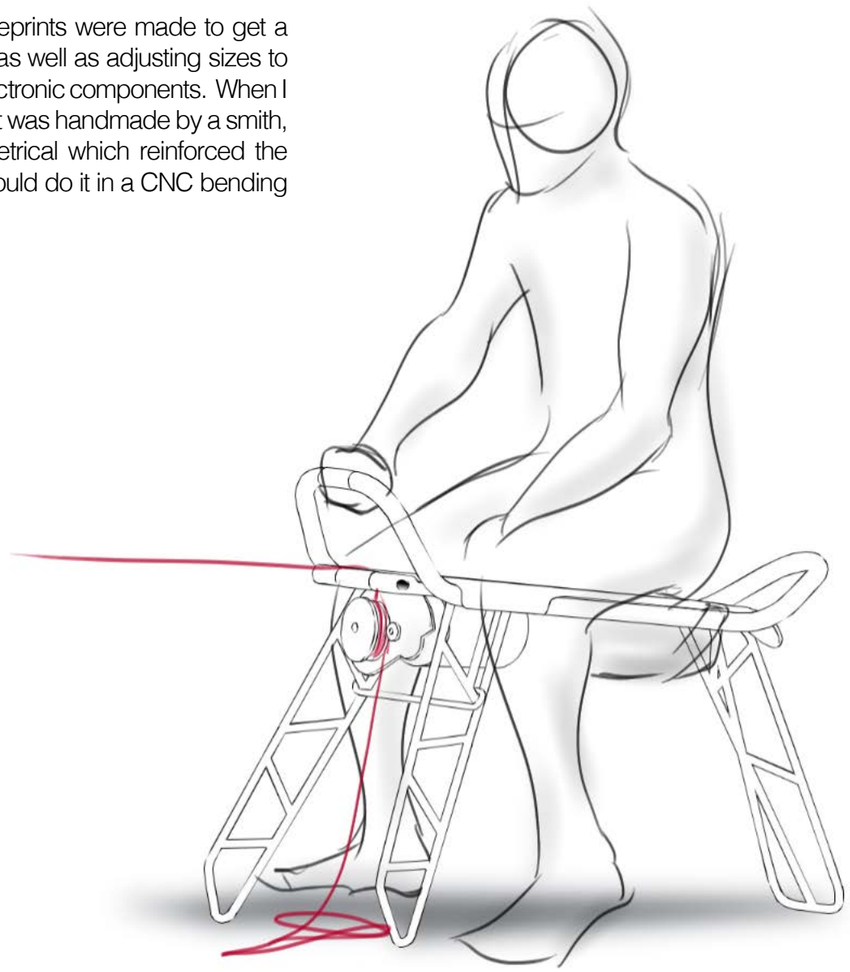
Frame

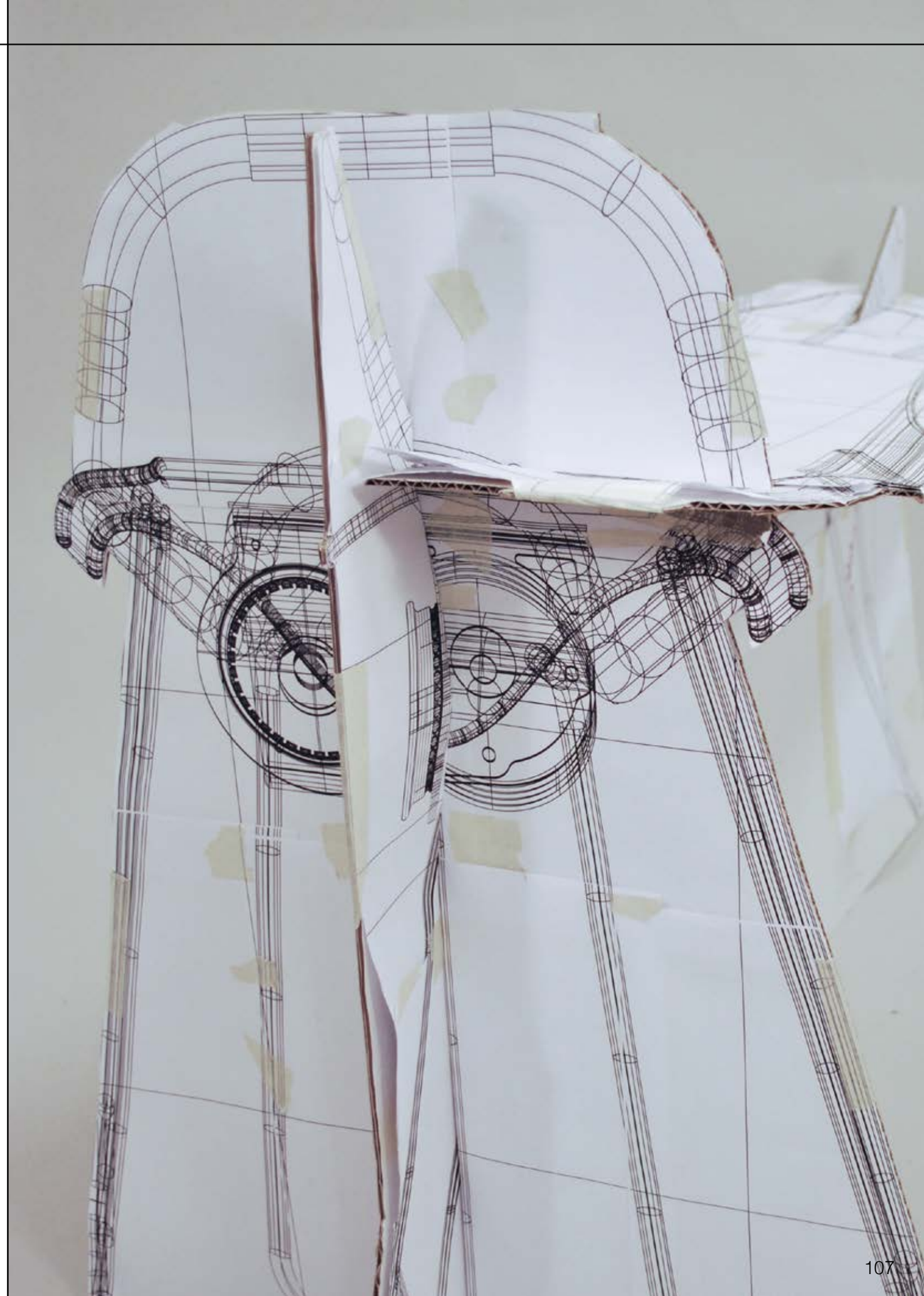
The frame was a pretty straight forward process. I knew I wanted something that looked like a closed loop, with a gas throttle on the front. There were some thoughts of making it end flat in the front with welded corners, but since it would have to be bent in a machine anyway, it did not make any real sense, not practically and not aesthetically.

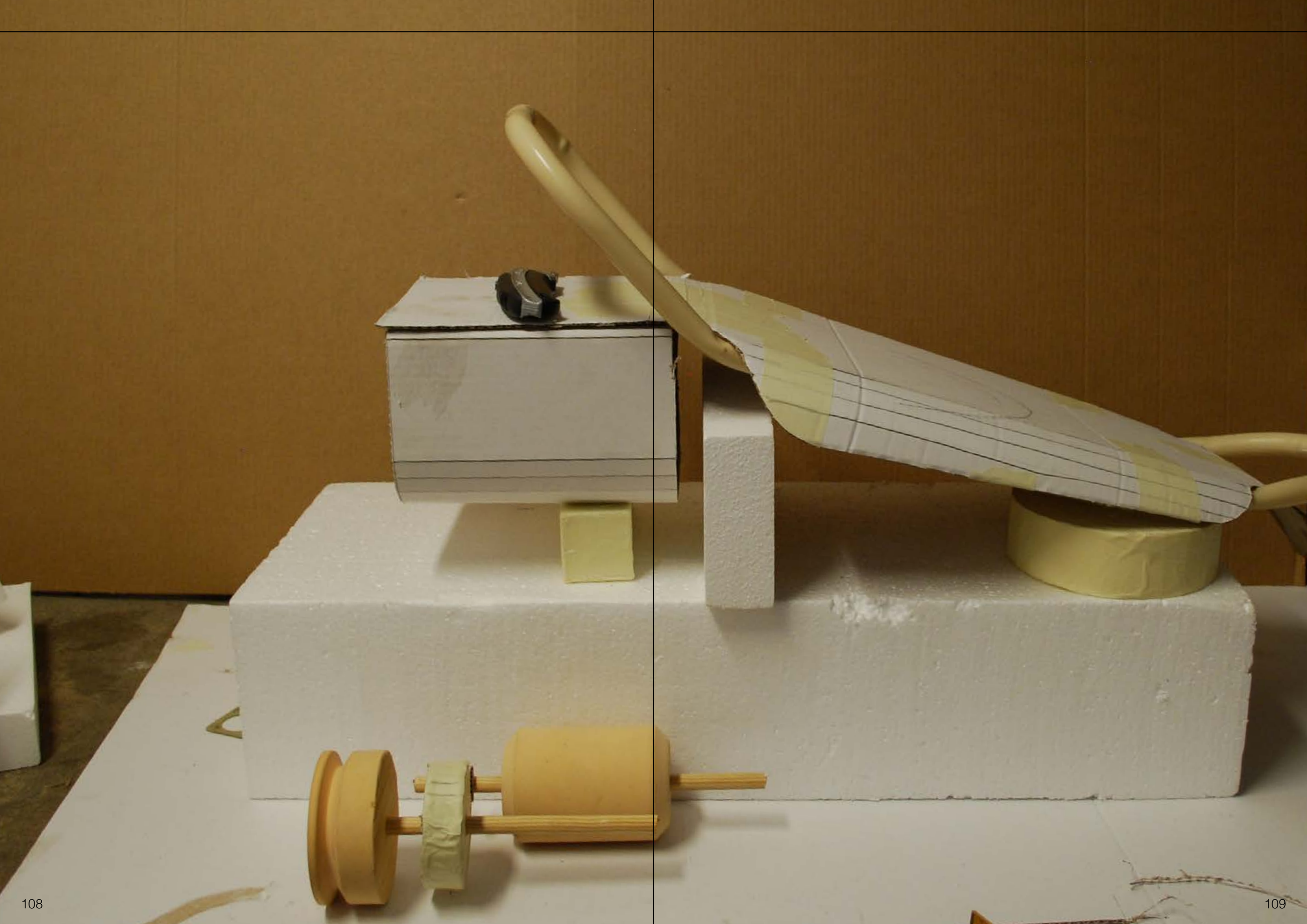
The biggest challenge with this part was to find a company with suitable radii prisms that were willing to do a single run for me.

A lot of full scale blueprints were made to get a sense of proportion, as well as adjusting sizes to match up with the electronic components. When I got the first frame that was handmade by a smith, it was very unsymmetrical which reinforced the notion that I really should do it in a CNC bending machine.

Design criteria:
- Seemingly closed loop
- Relatively thick dimension
- Find suitable angles and radii for CNC production







Spool

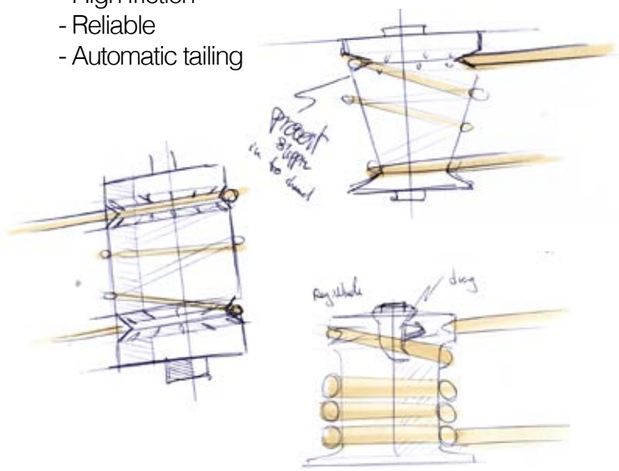
A crucial entity to solve, also a complicated one without the deep theoretical skills that are needed to be able to calculate how it will work. Even then extensive practical tests are needed to see how it would perform under the correct circumstances.

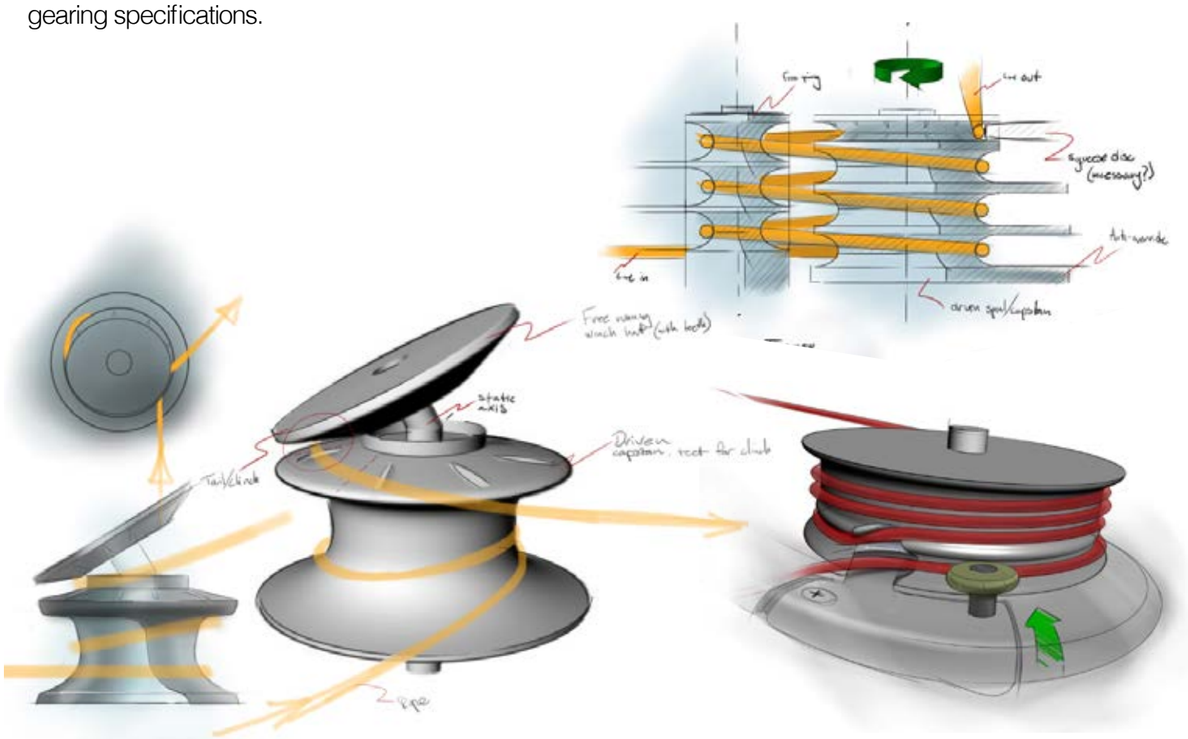
I used a lot of information that I had acquired from the power ascender and sail winches.

The challenge is to get the rope to exit the spool at the correct point, without having the operator pulling it by hand. The crucial point is to keep tension around the roll so that it wont slip backwards. Something needed to grip the rope, without it being an intricate mechanical part.

Since the diameter correlates directly with the speed and needed RPM, I was important to balance this thoroughly with the motor and gearing specifications.

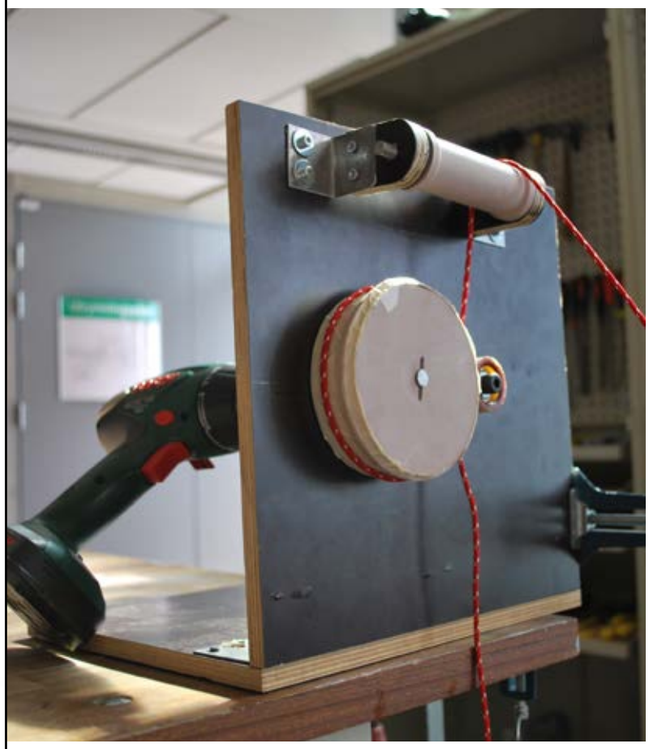
Design criteria:
- Simple to manufacture
- High friction
- Reliable
- Automatic tailing





After a lot of sketching and building small prototypes, I found a way that seemed promising. Applying pressure on the rope with a smaller wheel that only spins in one direction I could prevent the rope from slipping backwards as well as maintain tension in the process. It also help keeping the rope neatly stacked together side by side, not allowing any overrides to occur.

A prototype using a screwdriver as a motor confirmed that there were good possibilities that this would work well.



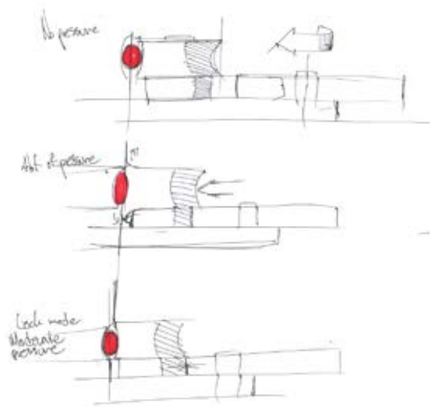
Pressure wheel

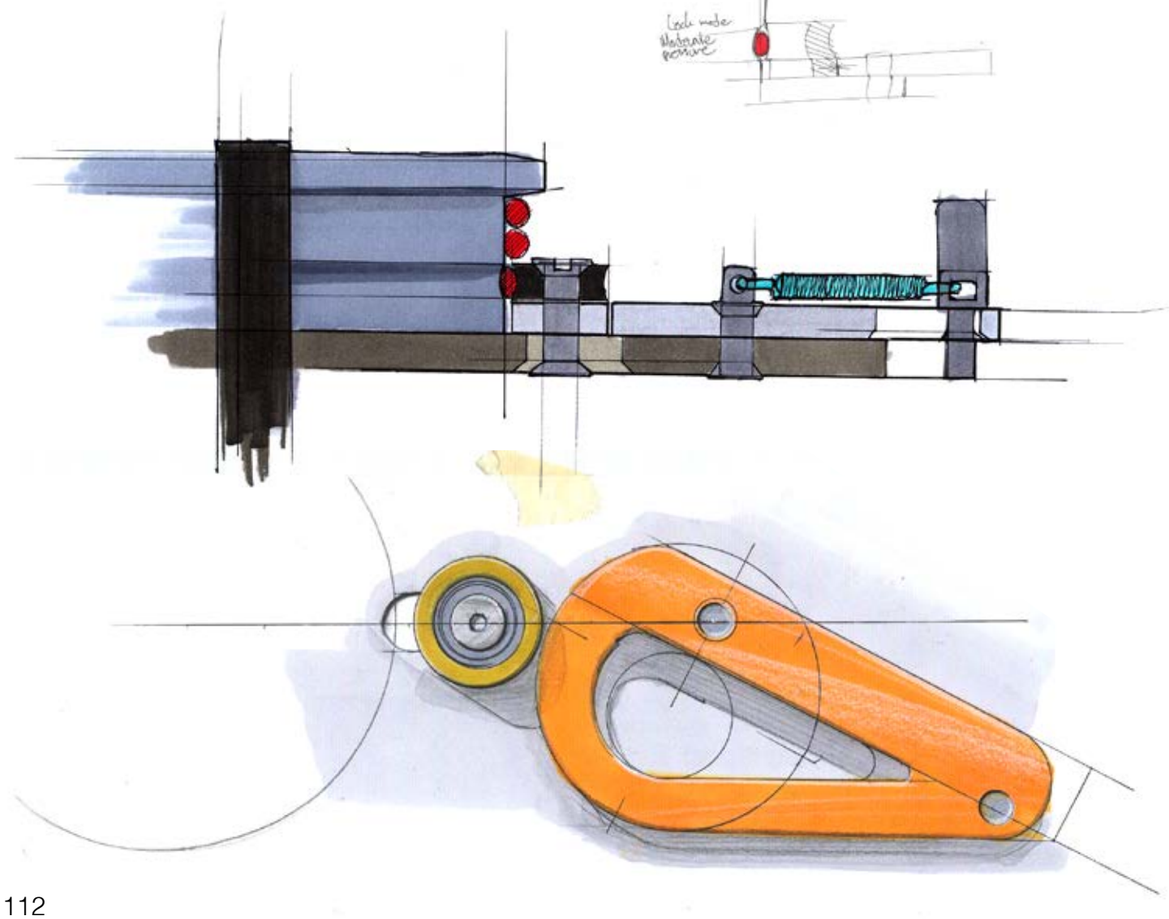
The second part of the spool mechanism. What was important to solve is how the small pressure wheel pushes against the larger spool.

My initial idea was to design a lever that would be tightened prior to every run. My reasoning behind this was that the operator has plenty of time to setup the rope and tighten the lever before the rider is even at the starting point.

After constructing this, I changed my mind and decided to attempt to solve it automatically instead with the help of the belt drive behind the spool.

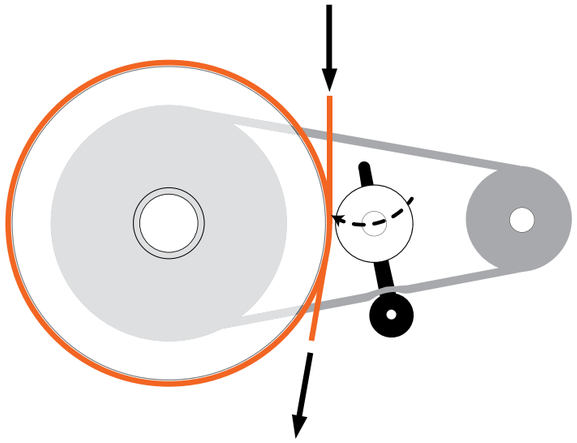
Design criteria:
- Push rope against the spool
- Roll freely around its axis
- In off mode, zero push force
- Mechanics not get in the way of the belt drive





Instead the construction was changed to use a small amount of the belt drive when it was in motion. A small lever with a wheel laying against the belt, will move in the same direction when it starts moving. Since the pressure wheel is fastened on this lever, it will follow in a cut track, applying pressure on the rope. The pressure wheel has a one-way bearing which will prevent the rope from slipping in the wrong direction.

Since the spool doesn't have any clinching jaws and solely relies on surface friction, the rope will eject after spinning its 2-3 rotations around the spool and down to the ground.

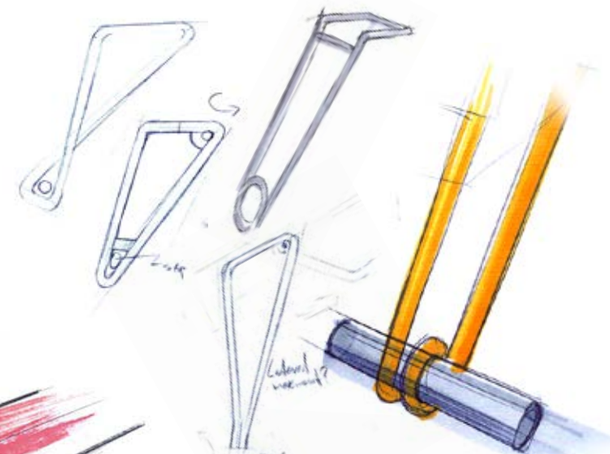


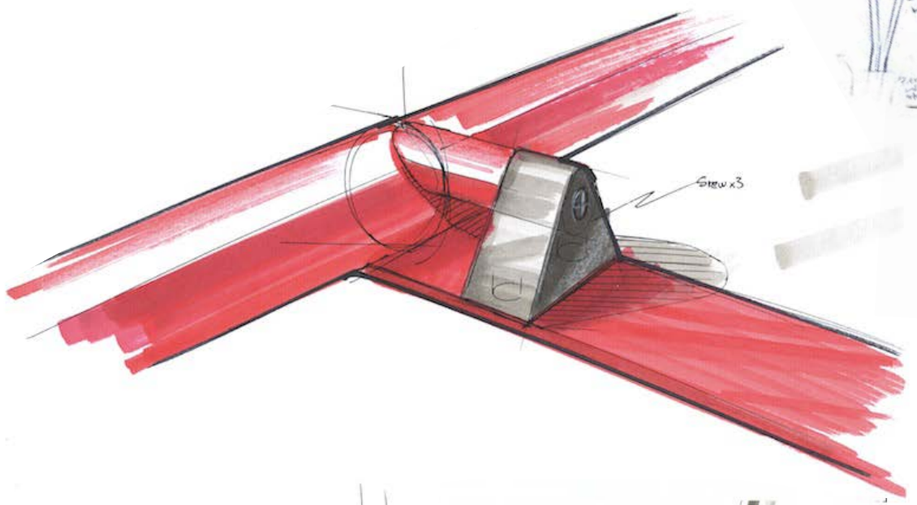
Legs

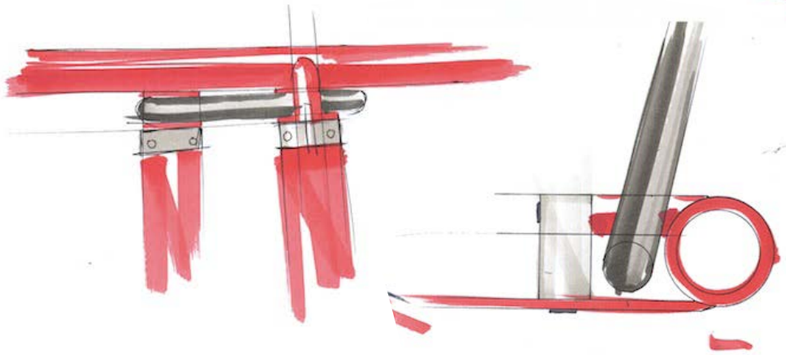
As the winch was supposed to be collapsible, the legs needed to be foldable yet strong. Another aspect was to prevent them from sinking in to soft soil. The contact points needed to be far apart on the ground, to increase stability because of the nature of its task.

A truss structure seemed fit for the task, consisting of bent steel tubes. At the tip of the front leg, I designed a small space where it is possible to insert anything available, like a branch or a shoe, to prevent sinking deep in to the dirt. A simple but strong hinge would lock the legs when folded was also part of the truss design.

Design criteria:
- Stay on top of soil
- High stability
- Foldable





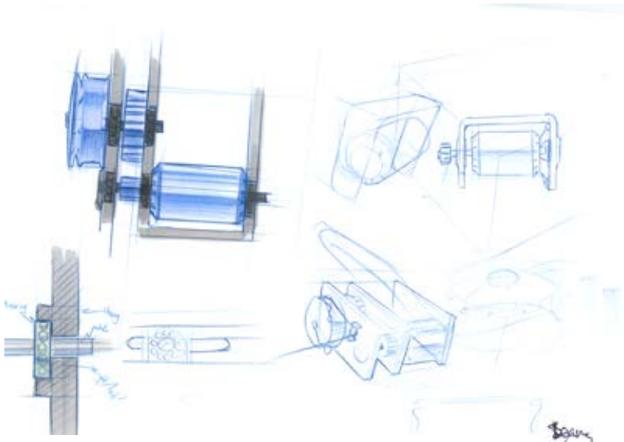


Gearing and belt frame

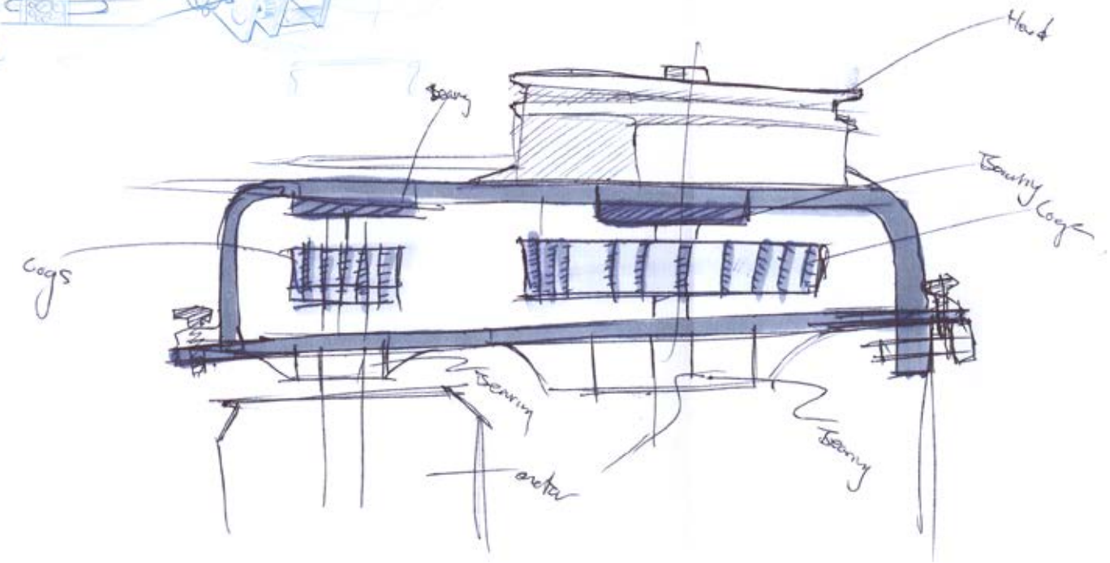
Apart from the spool mechanics, this was the hardest constructional entity to solve. I wanted to reduce the amount of parts to a minimum, which would mean that several of the parts would have cooperative traits. My initial thought was to simply bend a thick sheet of metal to hold the belt drive, axis and the motor housing. It would function like the heart of the motor construction. That would make it easy to water cut the pattern and then send to the workshop.

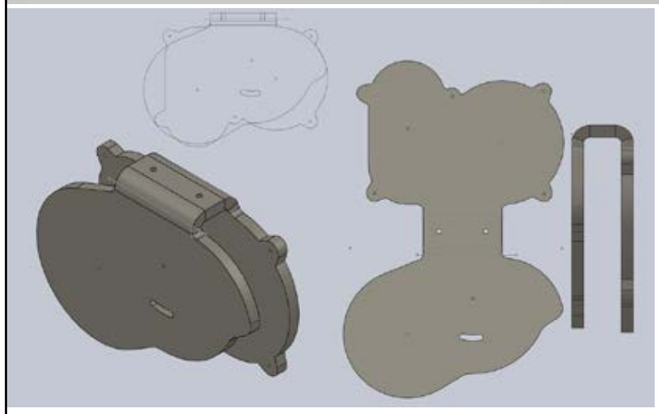
It turned out to be almost impossible to find someone to bend and shape a sheet with the dimensions that were necessary. The original gearing layout also had two long axis, going through the entire motor housing. One for the motor, and one which the spool that needed to be long for stability and load resistance.

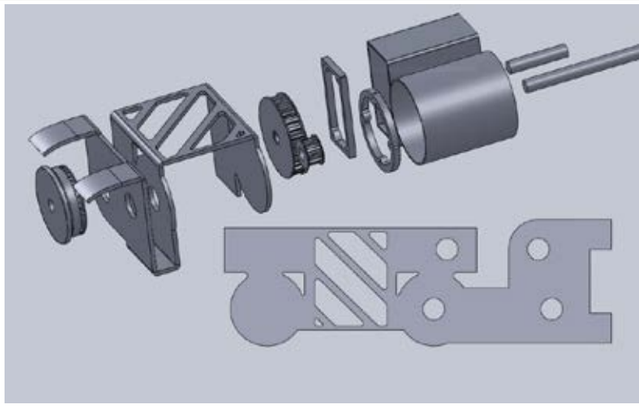
The gearing was designed with belt drives in mind to keep down unnecessary noise. Belt drives have other beneficial traits like zero maintenance and high efficiency that made it beneficial.



Design criteria:
- High stability
- Simple to manufacture
- Connect to several elements
- Low volume
- Low maintenance







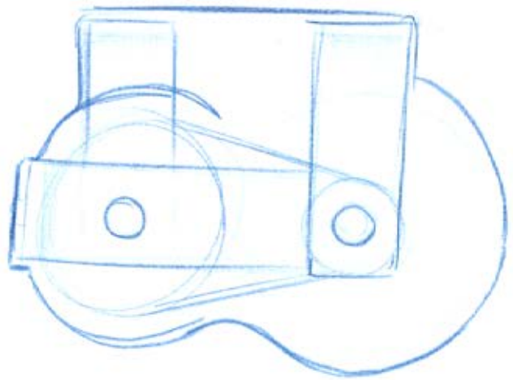
Motor housing

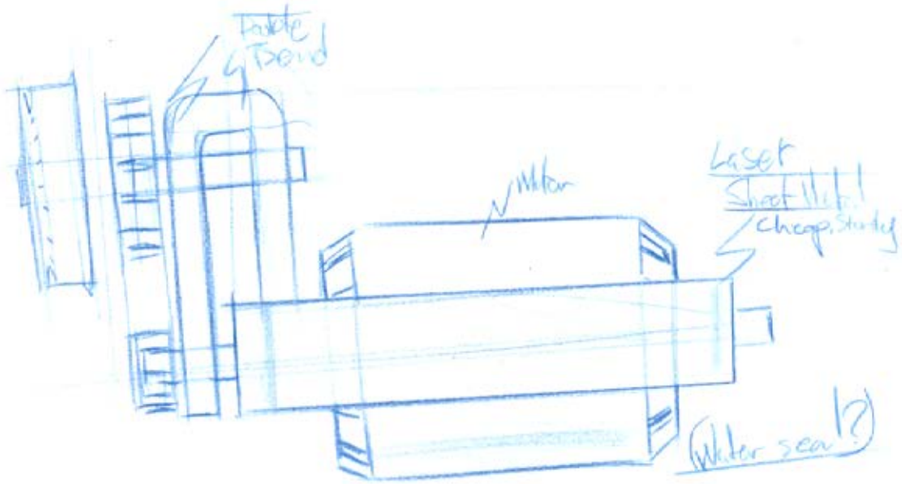
An important part of solving the puzzle that also needed to fit aesthetically. I really wanted to use a gear reduction, consisting of a belt drive. This was because of the high RPM that the motor was capable of, which could then be transformed in to more torque.

Since there are electronics involved, water resistance was important. Ideally the motor and electronics would be in each of their own compartment. This would however make the housing more complex. Instead, my solution was to put them in the same compartment, and then shield wires and electronics with the sled for the circuit board.

The sled would then sit tightly next to the motor and shield the delicate electric components.

Design criteria:
- Contain motor and electronics
- Simple to manufacture
- Water resistant
- Space saving

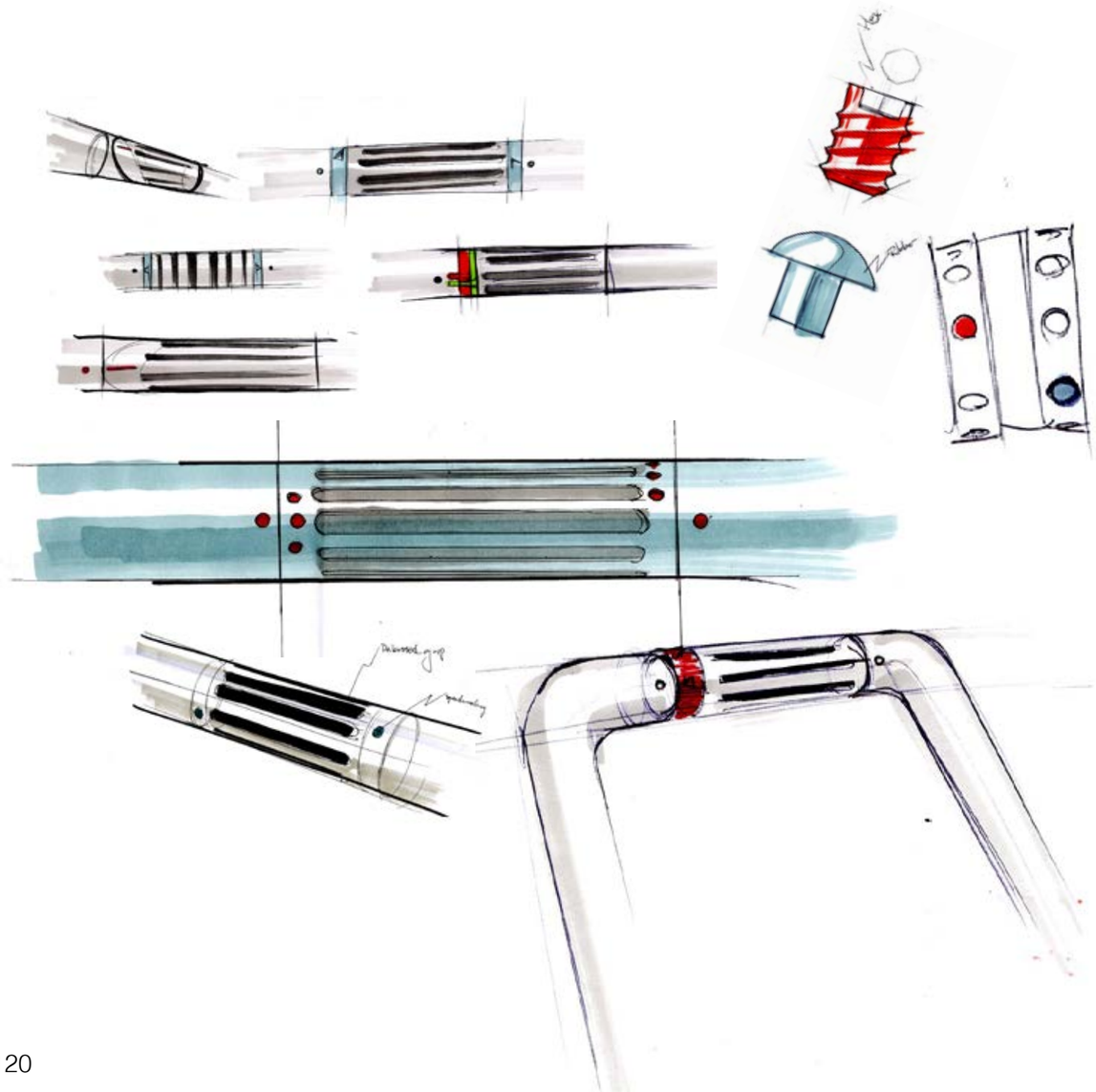




Speed throttle

The need for reference, a comfortable and convenient method of regulating speed was the goal. A simple and intuitive reference in the form of colored inserts that could be moved in the handle. The speed markings are easily removed by pushing them out of the hole, since they are not threaded. The red hex screw indicates when the motor is in idle mode.

Design criteria:
- Intuitive
- Comfortable
- Speed indication
- Discrete

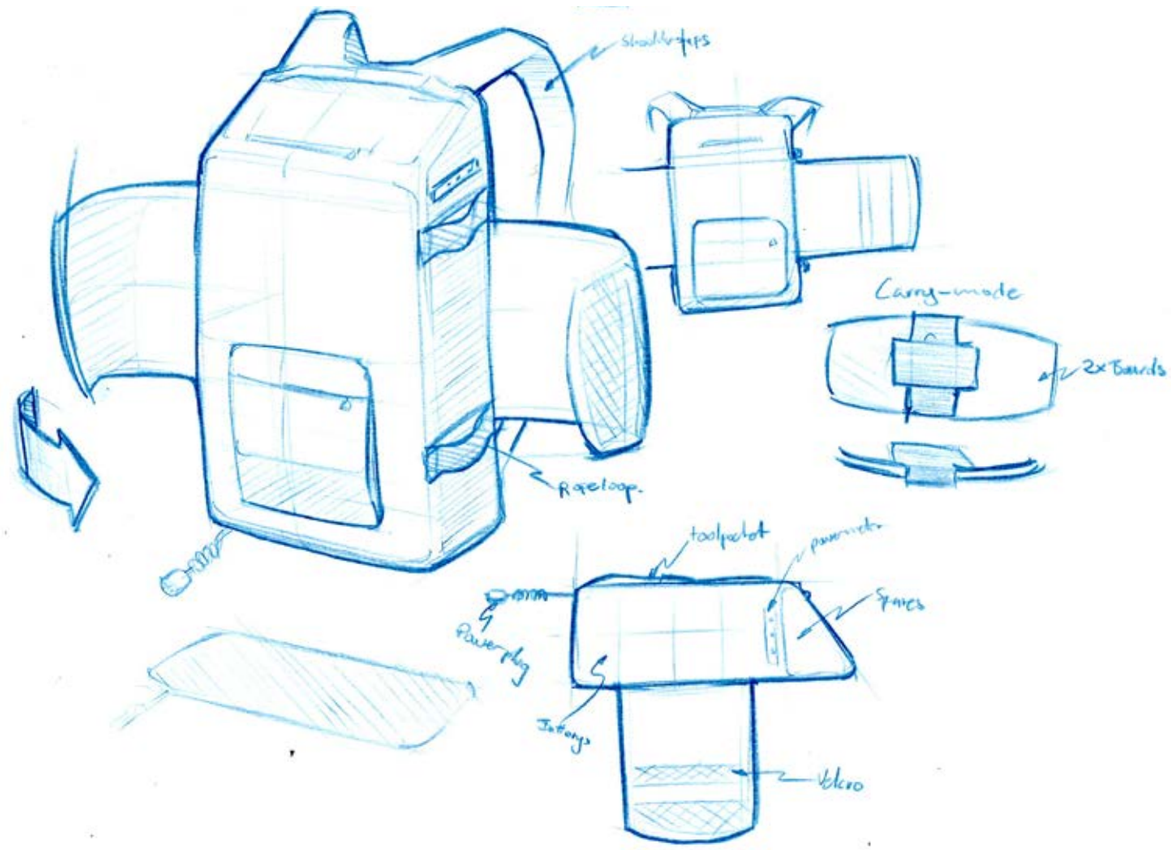


Battery transportation

As the batteries would weigh under eight kilograms under optimal circumstances, it would be fairly simple for one of the riders to carry it whilst the other carry the winch.

The bag needs to be protected from water and shocks that could damage the battery cells. It would also be optimal to have a compartment for hex keys that are the only tools needed to disassemble the winch.

Design criteria:
- Waterproof
- Fasten under winch
- Durable textile material
- Carry >6 LiPo 5000mAh batteries
- Carry hex keys
- Rope fastener
- Extra belts
- Pocket for pulley
- Protect batteries
- Strap/s for carrying



Manufacturing

I have during the years at LTH become more and more interested in production methods, which made it natural to explore the possibilities of these during the master thesis.

From the very start of the project it was clear that the market for this kind of product is, in its current state, limited at best. Several of the current manufacturers struggle to keep afloat, with both boats and cable systems as competitors. This is a market where the majority of consumers build their own systems, with it being fairly simple to do so.

My vision of the project was to end up with a product that had been focused to be produce on a local scale, eliminating a majority of the parts that would need to be imported from across the world. To do this in an effective manner, it was important to work with methods that had a low setup cost even in low volumes of production. I did not want to use any custom tooling in processes like injection moulding or die-casting. It was not impossible that similar methods could be utilised in a future version. This is what could be good to keep in mind for future transition to larger scale production.

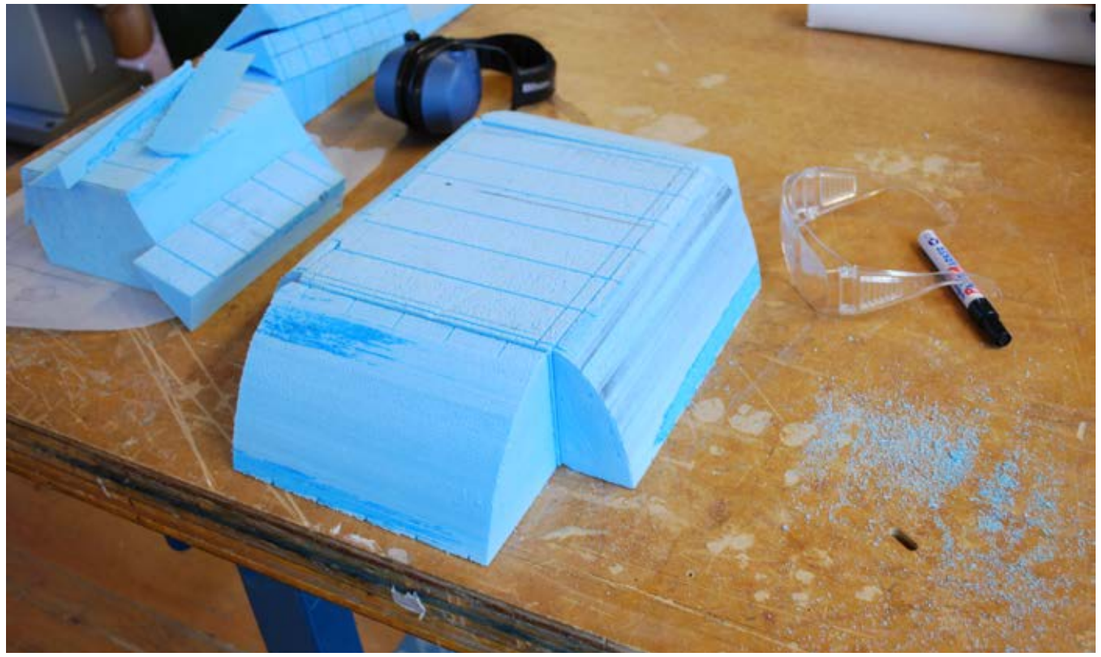
Milling
There are also a few methods of production that are completely free of tooling, like CNC-milling, which can be very expensive due to setup fees and machine time. I decided to stay away from 3D milling because of this. I did allow myself to create parts that could require milling in straight lines, the kind that is done manually in old fashion mills that are not controlled by computers. This is also time consuming, but easier to find workshops with the needed capabilities.

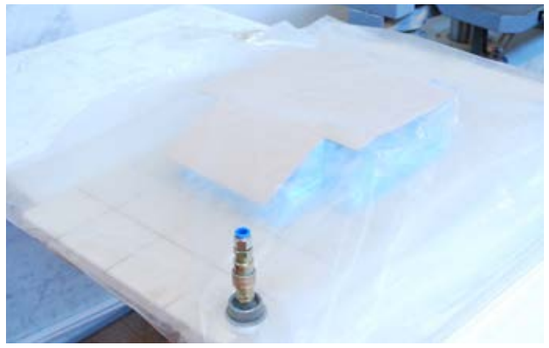
Manual welding
It is a very common and inexpensive method to join two parts of metal. It is possible to learn and perform in almost any setting. Aluminium is a bit trickier and would require a bit more training, but still feasible. Robot or CNC-welding was not an option.

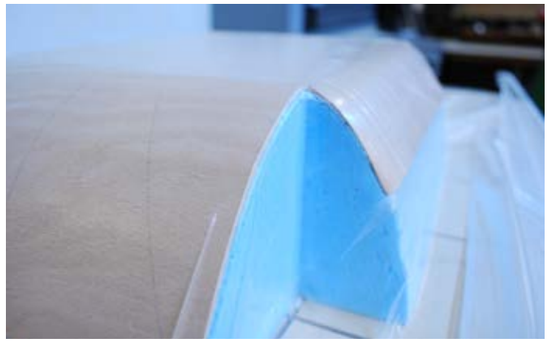
Lathe/Turning
A process available in mechanical workshop almost anywhere. Both CNC-version and manual versions exist. I wanted to stick to manual, since the process is so straightforward that computer assistance shouldn't be necessary.

Bending and rolling sheet metal
Both are perfectly fine to work with in a manual mode, and also a method that the majority of workshops have available. Bending thicker metals than 3-4 millimetres can however be a challenge to find companies who are willing to do.

Most kind of woodwork is possible to do at home, which is why I thought that veneering and similar manipulations of the material would be fun to work with. My initial thought was to use vacuum forming, since the negative shape can be manufactured inexpensively in Styrofoam or other low density and cheap materials.



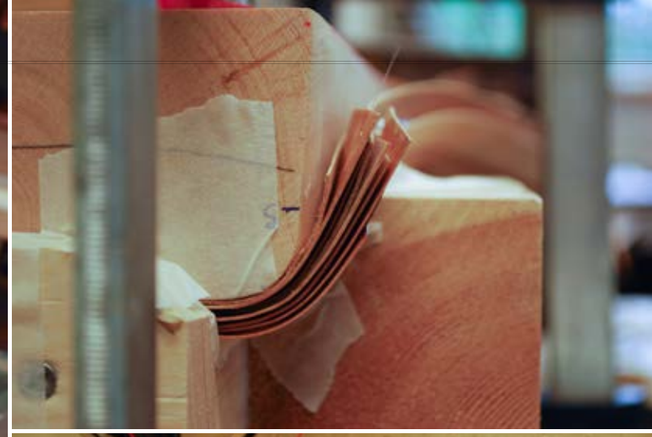


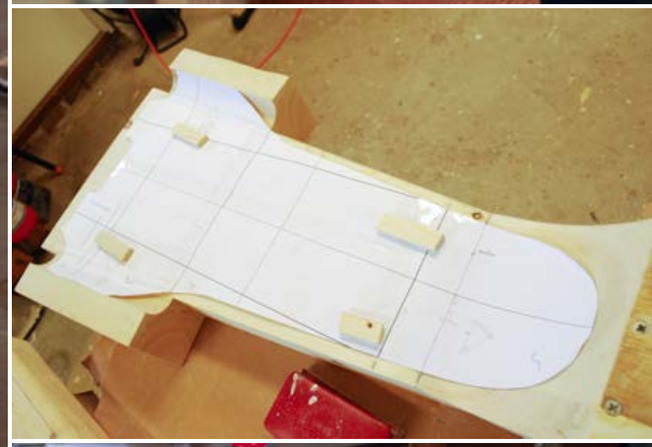


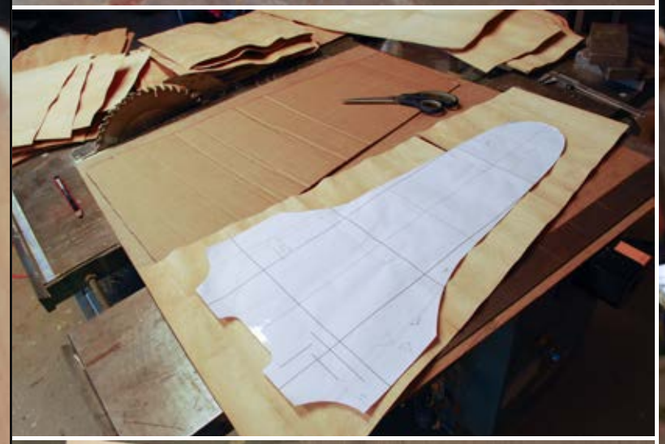
My first experiments with vacuum forming was not successful, mainly due to technical failure of the compressor which overheated after a short period of time. There were however many lessons to be learned like what sort of glue was appropriate, and how you should prepare the veneer before putting it together.

Seat construction

After the failure of using vacuum forming to create the desired shape and bends of the wooden seat, I was advised to use the traditional method of shaping veneer. After building a mold with both the negative and positive shape made out of wood, it was sufficient to use standard clamps to achieve enough pressure. Instead of common wood glue, a two-component adhesive used in the boat building industry was applied with great results.







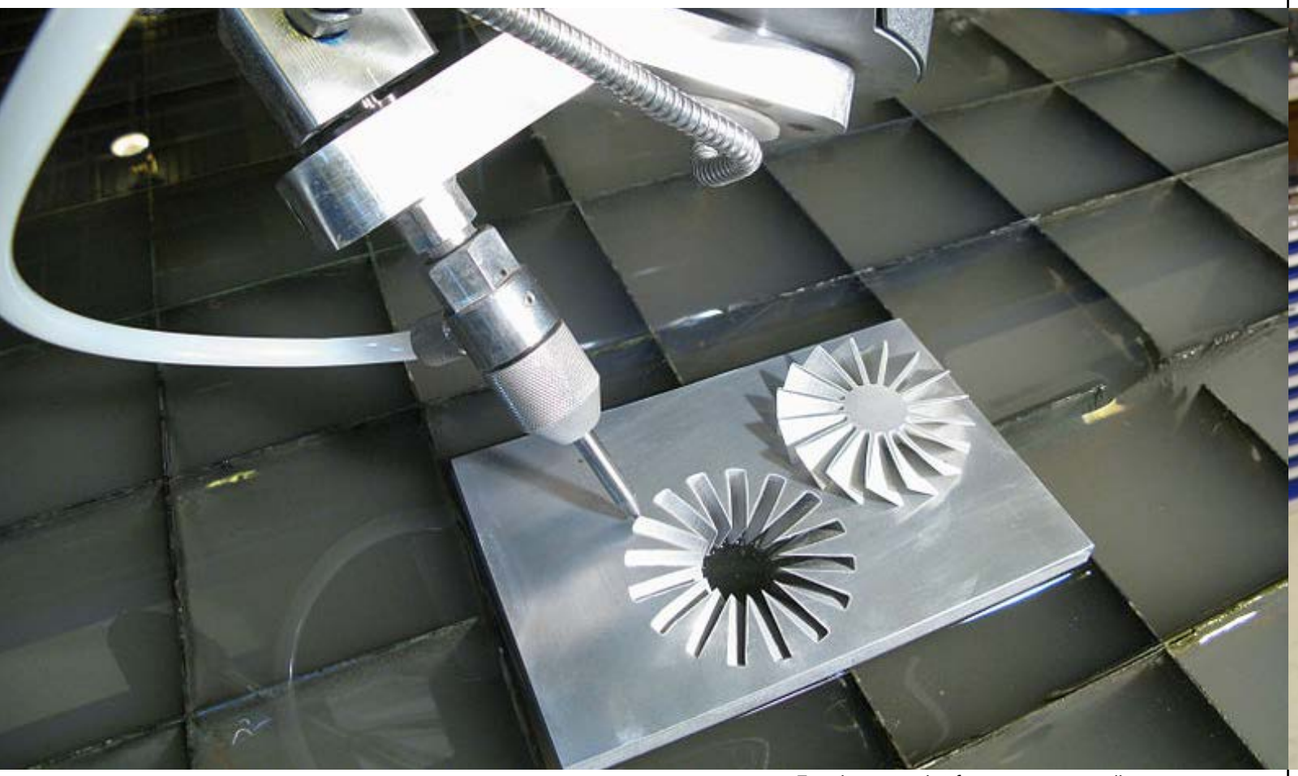
CAD possibilities

Two methods of cutting metal and other materials, completely free of any kind of tooling. All that is needed is a digital file from CAD-software, with the contour of the part in question. Water-jet has the ability to cut a lot thicker metals than laser, and does so without hardening the cut edge like a laser does.

A problem with water-jet is that the cutting stream can deform so that edges are far from perpendicular to each other. This was something that I was prepared for and tried to adjust to accordingly by not cutting important parts with it.

Since the mechanical properties of pipes are very beneficial in construction of different objects, as well as the process of CNC-bending tubes is very swift, made me decide to learn more about it and preferably incorporate it in the project.

The major issue with this method is to find a company that has a large variety or just the right prisms, a sort of radius tooling, for their machine. The important aspects is the diameter of the pipe as well has the radius of the bend prism. Many companies display their range of prisms on their web pages for the customers to see.



5-axis water jet from www.wardjet.com

Photo: Björn Bengtsson

Materials

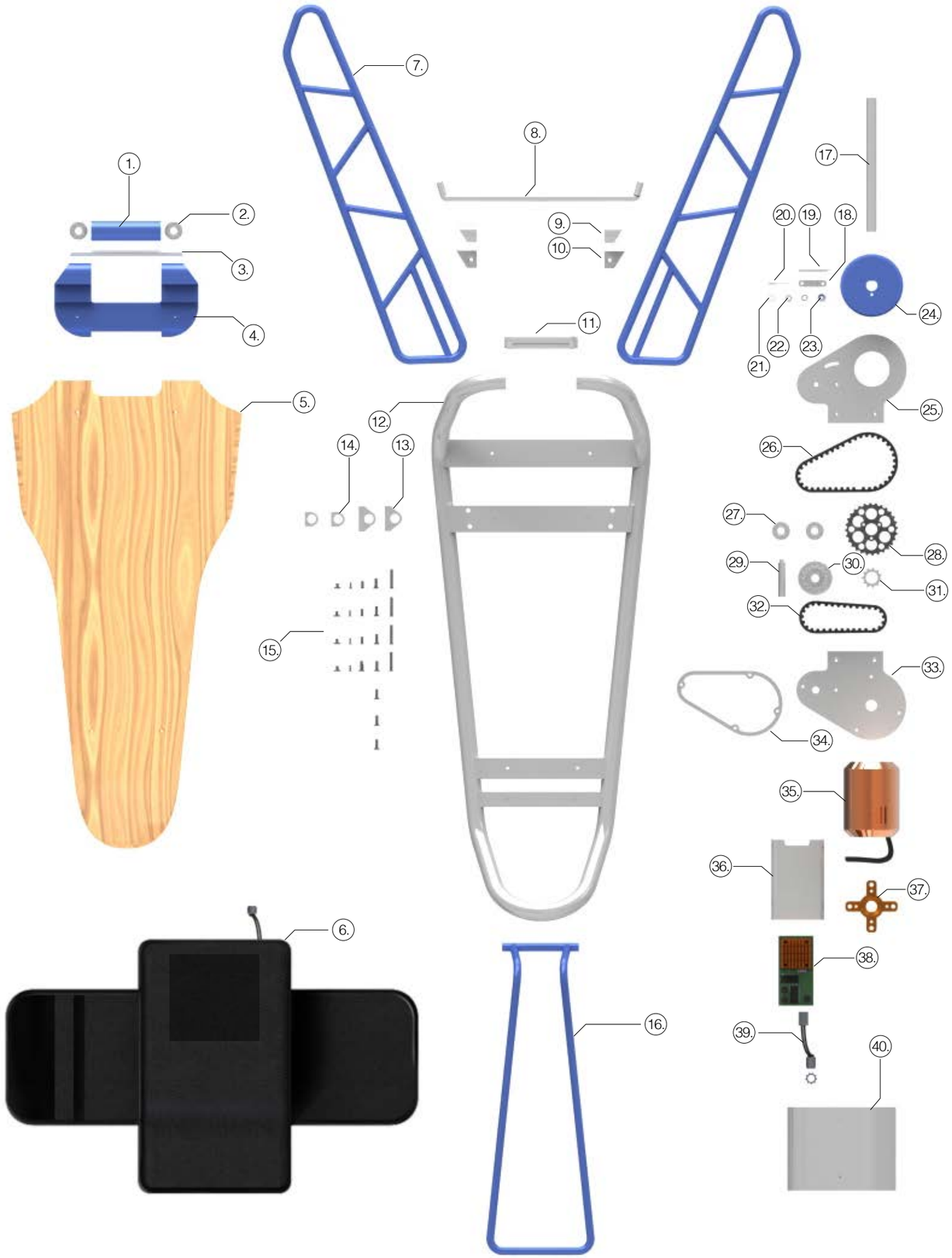
My inspiration and the impression of the sport that I had picked up from watching, talking and trying it out, made the choice quite obvious. The production methods and demand of durability made it easy to pick what kinds of materials that should be included.

Most of the manufacturing is adjusted for metals, where I wanted to use as much aluminium as possible to keep weight and corrosion to a minimum. For the scale model this would however prove to be difficult.

Most of the workshops working with aluminium tended to have too much to work on already, or did not have the tools that I was looking for.

This meant that I would have to build the model in ordinary steel, which would obviously be reflected in the weight of it. The positive side of this was that I was able to work on some things more on my own, rather than relying on others to do it for me.

I thought it was logical to avoid polymers in as big extent as possible. Mainly because these processes often require investment in form of tooling, but also because of their quality and resistance to weather fluctuations. My philosophy was pretty simple. Plastics crack and break, metals bend or dent. Obviously this is a truth with modification, it did however make it simpler for me when planning and design parts as well as researching manufacturing processes to utilise.

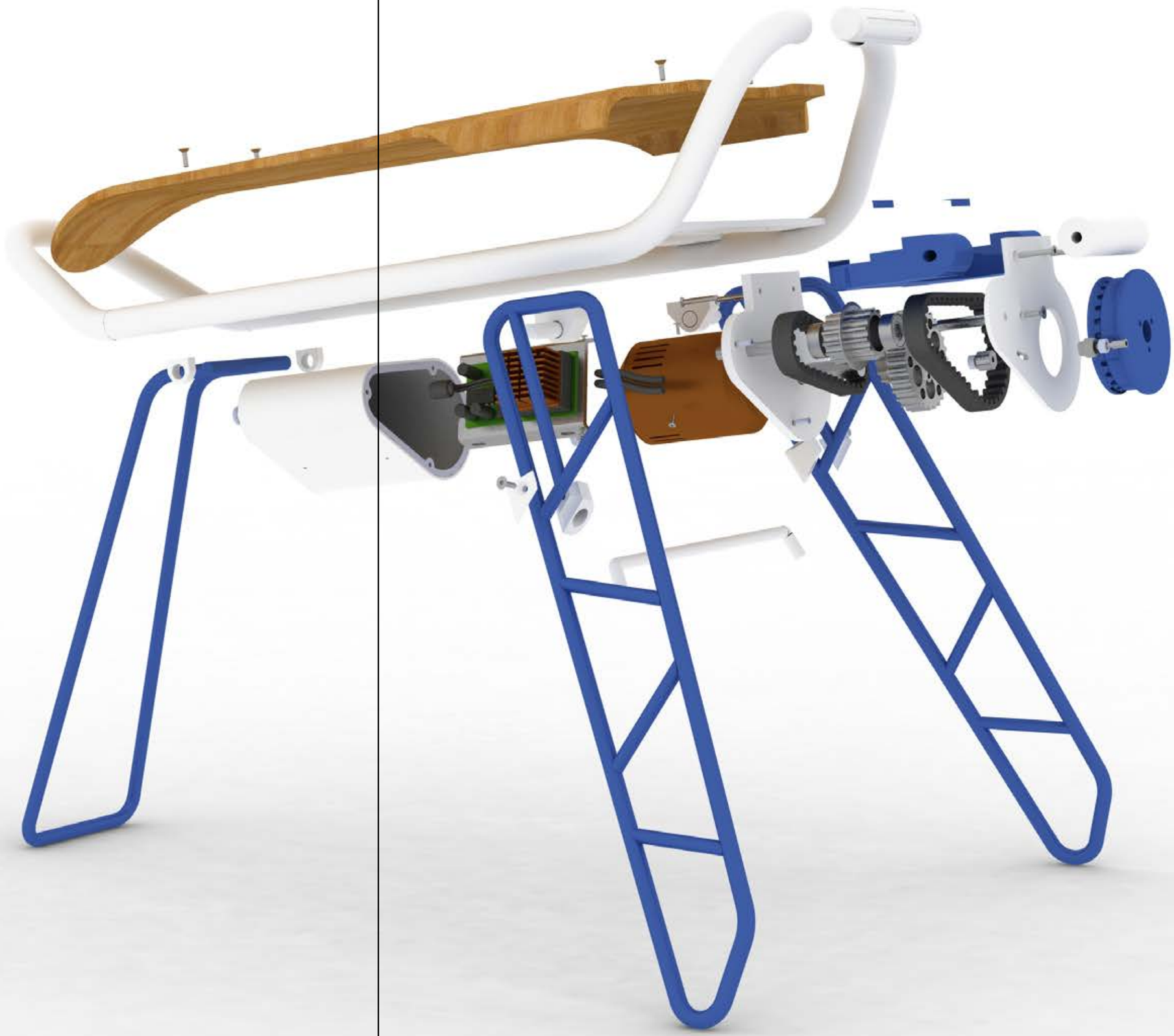


Winch components

1. Rope fairlead
2. Fairlead bearings
3. Fairlead axis
4. Fairlead mounting
5. Veneer seat
6. Battery container
7. Front legs
8. Leg stabilizer bar
9. Stabilizer mounting shim
10. Stabilizer mounting lock
11. Speed throttle
12. Main frame
13. Front leg joint
14. Back leg joint
15. Complete set of countersunk bolts
16. Back leg
17. Main drivetrain axis
18. Roll arm lever
19. Pressure roll swing joint
20. Pressure roll axis
21. Pressure roll
22. Single direction bearing
23. Pressure roll tension wheel
24. Winch spool head
25. Front protector plate
26. Gear belt
27. Main axis bearing
28. Drivetrain cog
29. Drivetrain secondary axis
30. Dual belt drive cog
31. Main drivetrain cog
32. Gear belt
33. Back protector plate
34. Protective casing collar
35. Brushless 6500w motor
36. Mounting sled
37. Motor mounting plate
38. Circuit board with heatsink
39. Internal battery connector
40. Protective casing

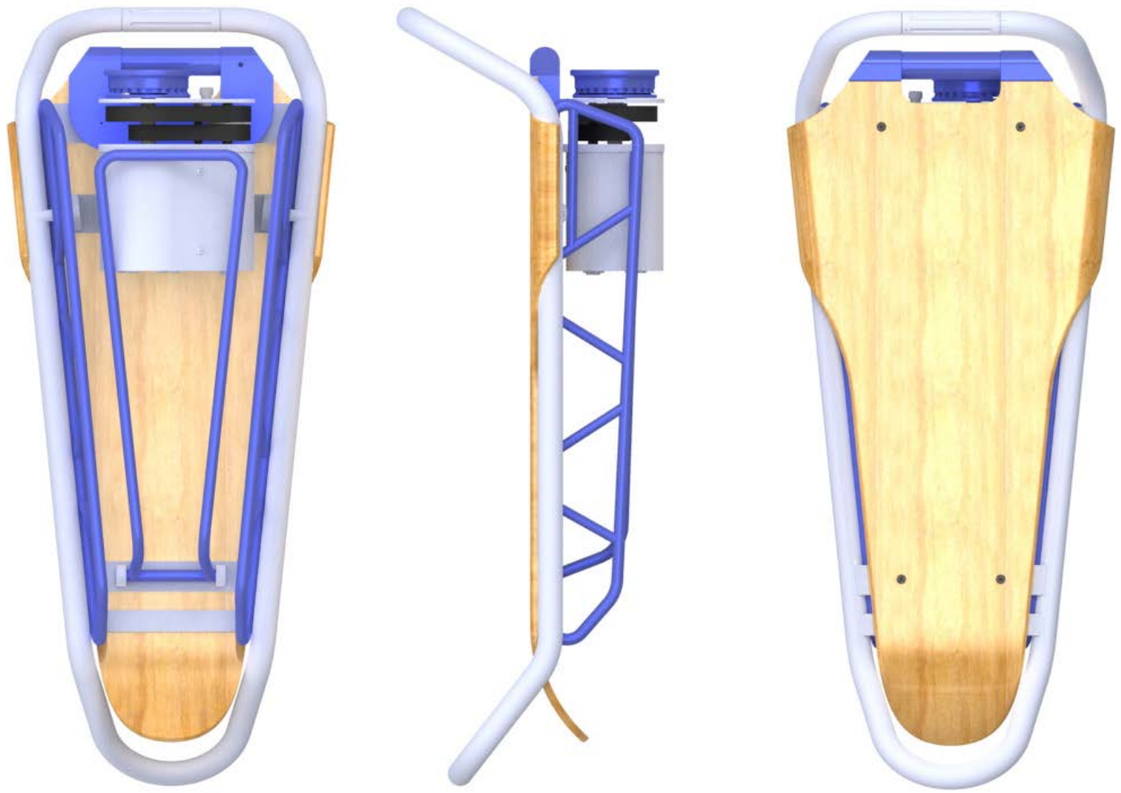
Exploded view

It is possible to disassemble the entire winch with a two sizes of hex-key as a majority of the bolts share the a common dimension. The exceptions are the embedded lock screws for the cogs, spool head and fairlead.



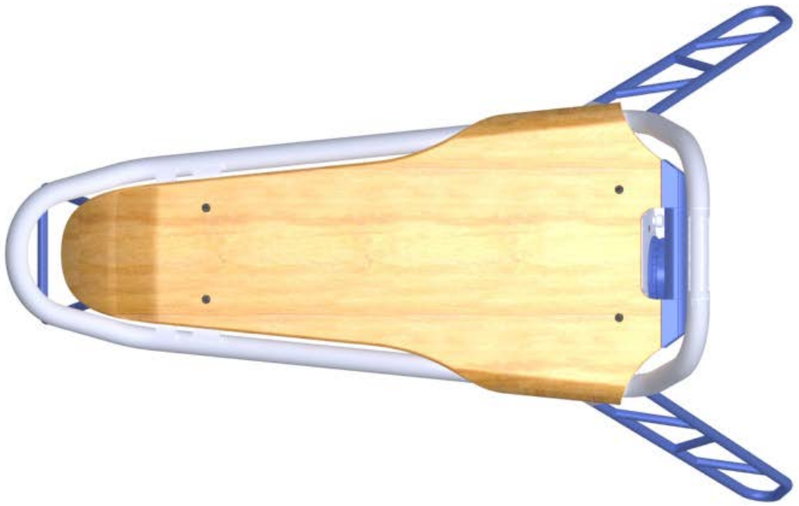
Transport mode

Since mobility is key to the activity, portability of the winch when in transportation mode is designed to have an effective size and volume as possible, combined with weight saving construction. The prototype was produced in common steel since the possibilities for aluminium manufacturing were limited at best. Yet the total weight, excluding battery case, was well under twenty kilograms. This show that it would be fully possible to reduce weights further, with the disadvantage of increased production costs.



Operation mode

The posture and driver position of the operator spawned from of the key insight to they used the current winches. Using this as an advantage to being able to solve several of the other requirements like mobility and constructional nature did end up in favor of the design.



Peripheral improvements

There were several improvements to the system that fell outside of the physical design of the winch. Communication between participants, Intuitive user-experience, reduced set-up times which includes the time spent transporting equipment.

Several small details to make life easier and letting the participants focus on what was important was all taken in to account. There were several angles where all the problems and solutions had to be addressed from. Production methods, cost efficiency, ride experience, operating usability, the surrounding environment. This makes it hard to describe every design consideration and solution, even though they all have a significant importance in the final result.

My vision was always to see this as a form of starting point for a small scale manufacturing for a company with passion and interest but limited resources.

Mobility
- The system should be able to be transported by a maximum of two persons
- The system should consume a substantially smaller space than standard winches
- The system should weigh substantially less than a standard winch
- The system should ideally weigh less than 20 kg (winch+batteries)
- The battery module of the system should use high capacity batteries to keep down weight
- The system should offer a possibility to get electricity from a wall-socket if available

Interaction
- The system should offer a reference of what the current speed is
- The system should effectively eliminate the sensation of the rope skipping (smooth pull)
- The system should not increase speed due to larger spool radius

Noise
- The system should be optimised for minimal noise pollution

Runtime
- The system should offer roughly 30 average rides per charge

Production
- The system should be designed for local production to a major extent
- The system should be designed for production methods that do not require custom tooling
- The production of the systems parts should require a minimum amount CNC-milling
- The system should to a large extent avoid parts made from plastics and polymers
- The system should be adjusted towards a small scale production (500-1000 units)

Safety
- The system should not be able to throw dirt, stone or other particles towards users and operator
- The system should not require the operator to have their hands close to any dangerous or moving parts when they are in motion
- The system should not require anchoring in the ground to be stable

Price
- The system should be cheaper than standard commercial winches (<4000€)

Project hindsight

Just like all projects, there are shortcomings that get solved post-presentation, and this is not different. When is was planning the project during its initial phase, I was thinking about building something that would actually be operated, and then to work with my lead-users in an even closer fashion in an iterative process.

There are many details that I am still not fully satisfied with, but as an overall concept I think that it is an interesting approach to what is currently available. There are a few enthusiasts who are experimenting with winches that can be used and operated by a single person riding alone. To me, this was never relevant or interesting because I think that if the phenomenon had been conceived as an activity for just a single person, it would never have gotten as far as it is today. The mutual experience is half of the pleasure. You could almost say that it is the closest thing we have to an alternative team sport.

Since it was such a construction-heavy project, it is hard to say exactly which parts that will fail or not fail. My biggest concern is the spool system combined with how the rope will stack up on the ground. Will it have enough pull and how much will the rope tangle when on the ground?

Other details like material thickness and how they will perform under the load of a rider is of course something that is uncertain. I'm sure there are some parts that are grossly over dimensioned, as well as some parts will be in an opposed situation.

In retrospect, an alternative would be a collaborative project with a with students from other faculties. There were many times during the research when I was completely lost in these technical fields.

My process

From day one, I really wanted to build a model that was full scale and true to its materials. To me, foam models are less exciting, since their touch and feel seldom lives up to the tactile experience that I find important.

It was also an incentive to get the majority of parts produced in the method that they were intended. This gave me a great opportunity to learn a lot from the commercial world, which was probably the most important lesson during the entire project.

There were many tough, but important, lessons working with real manufacturers. It is safe to say that most parts would have taken fraction of the time to produce entirely on my own in the workshop. This was a revelation that would reoccur several times through the process.

An upside to all this was how it gave me a chance to test my eye for work quality. It was quite obvious that most of the parts that I ordered were done in haste, which was clearly shown in both tolerances, finishes and miscellaneous details.

User interaction and experience

Working with Jonas and Henning was never a problem. Jonas who became a father during spring did get a bit less time to talk and ride, but it was never a problem to give him a call and ask about opinions and thoughts on certain topics. When the real model was taking form, I got a lot of encouragement from both as they saw the progress and thought taking form.

I think that I was absorbed in to the group of people quite instantaneously, mostly managing cameras and observing their activities. I was encouraged to ride a lot by both, but really wanted to stay observing to not get too comfortable with the methods and try to stay objective.

The online community was slightly harder to get involved with. It was hard to get taken seriously at first, since my initial post was just stating my business and asking about their habits.

It was important to show some early dedication, which was one of the reasons why I started conceptualizing and asking for feedback early.

I am not a big fan of this kind of information sourcing because the discussions and arguments are never similar to holding a conversation face to face. You have to address real enthusiasts to get constructive criticism instead of just blurted out statements of what they see.

This is obviously a big problem all over internet.

Futurepossibilities

What is the future of winchboarding? I am hopeful that it isn't a fad that will fade away any time soon. It has many of the ingredients of what makes an alternative sport successful. It is relatively easy to setup, modify and acquire. Spectators do not need to do any real effort to see it, and organizers can keep the venue small compared to the other wakeboard alternatives. The most important aspect is the possibility to improvise in any occasion, while riding, finding spots or fine tuning equipment.

If it would transform in to a sport or stay as somewhat of a novelty act is hard to predict. Mobile cable systems are still preferred by many riders, and will continue to evolve because of the small investment in comparison to a permanent park.

My hopes are that riders will continue to explore their surroundings with these, and not fall in to the normal pattern of becoming dependant on municipal parks with their static and minimalistic designs.

Conclusion

In the end, there were many lessons learned during the project. Not only about lead users and alternative sports. I learned a lot about my own process, where I excel and what kind of scenarios that I find particularly challenging. There were moments of realization of how I want to steer my future professional career. In what situations my creativity is flowing in an effective manner, and when it doesn't.

As my project went overdue, I had plenty of secluded nights in my temporary workspace where I had to keep pushing to solve the issues ahead. It was sometimes very hard to both focus and motivate myself to push on forward. It was straining mentally and my confidence took quite a beating during this period of time. The most important insight for me was how much more fulfilling I find it to work within a team rather than as a solitary designer.

The end result was quite hard for people without the needed insight or interest to appreciate, being the niche sport that it is. However, I am quite used to this response. It has always been lot more rewarding to get the feedback, reactions and discussions from people who can see the value of my ideas, which has been a recurring theme through my education. This is especially true when involving people who always strive for improvement and aren't afraid to test boundaries and experiment their way forward.

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I have also acquired friends and future colleagues that have been invaluable to me during all different situations through the last couple of years, and continue to be to this day.

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I would like to thank my examiner for always challenging me to the full extent and beyond of my abilities. It has been challenging but always worthwhile.

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