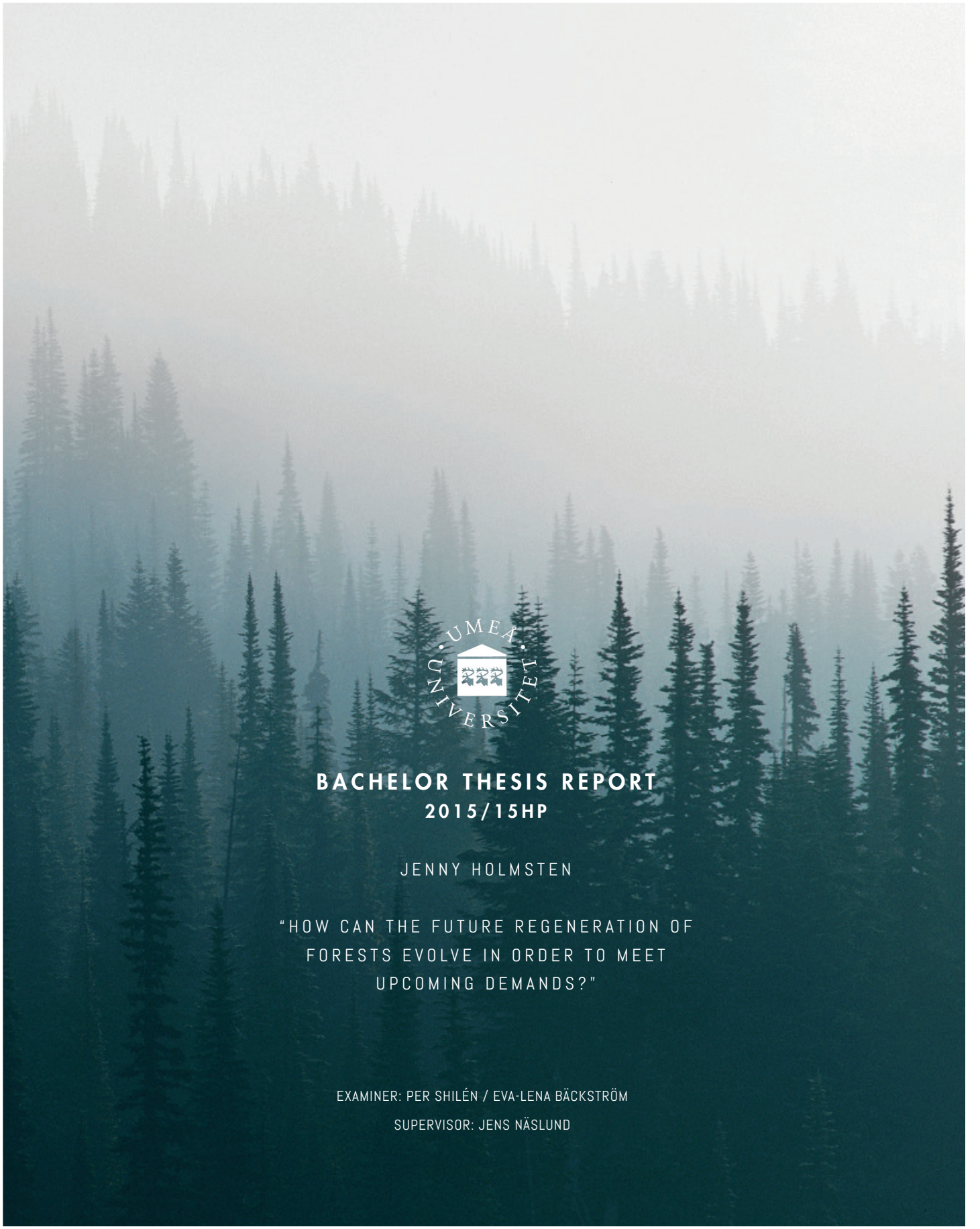

BACHELOR THESIS REPORT
2015/15HP

JENNY HOLMSTEN

"HOW CAN THE FUTURE REGENERATION OF FORESTS EVOLVE IN ORDER TO MEET UPCOMING DEMANDS?"

EXAMINER: PER SHILÉN / EVA-LENA BÄCKSTRÖM

SUPERVISOR: JENS NÄSLUND


"ITS MUCH EASIER TO CREATE A DESERT THAN A FOREST"
- James Lovelock

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BACHELOR THESIS

HOW CAN THE FUTURE REGENERATION OF FORESTS EVOLVE IN ORDER TO MEET UPCOMING DEMANDS?

ABSTRACT

Forests cover about 30% of the earths surface and is a vital resource as a habitat for plants, animals and humans. Today climate change and global warming is a fact and something must be done. We burn massive amounts of fossil fuels and during this combustion carbon dioxide is created. To help eliminate this global change we need to start caring about the forests. The forests have a major role in climate change and global warming. It currently contributes to about one-sixth of the global carbon emissions.

But today deforestation is a real environmental threat. The world trees are being cut down too quickly for the earth to regenerate new forests. And while the society is moving into a more biobased economy the preassure of a efficient forest industry and forest regrowth is increasing drasticly.

A new way of reforestation must happen, a sustainable and natural method must be implemented.
In Sweden and the scandinavian area the method has had a stagnant development. Is done manually with a standardized procedure not taking natural properties into account. Money often goes over quality.

My project will focus on developing a concept that can live up to the upcoming future demands and the environmetal aspects that needs to be taken in account to ensure a healthy and sutainable forest.

The final result performes an efficent and precise reforestation and enables for a detailed planning and analysis of the area in advanced.

COLLABORATION

The project was conducted in collaboration with the Forest Technology Cluster (Skogstekniska klustret), SLU and the Swedish Forest Agency (Skogsstyrelsen). The cooperation with the various parties has meant that they acted as a source of information and a source for evaluation during the ideation phase. The Forest Technology Cluster has sponsored this project.

The project has been supervised by Jens Naslund from Husqvarna Group.

Contacts during the project:

Urban Bergsten, SLU
Profesor in Forest biomaterial and Technology

Claes Fries, Skogsstyrelsen
Silviculture specialist

Jens Näslund, Husqvarna
Projekthandledare

DELIMITATIONS

I define myself to look at Scandinavian forests and methods used for reforestation. This gives me the opportunity to perform more detailed observations and research.

TARGET GROUP

The project have one main target group, the forest industry. The forestry industry, meaning the companies or government entities that own forest in Sweden or sell services such as reforestation.

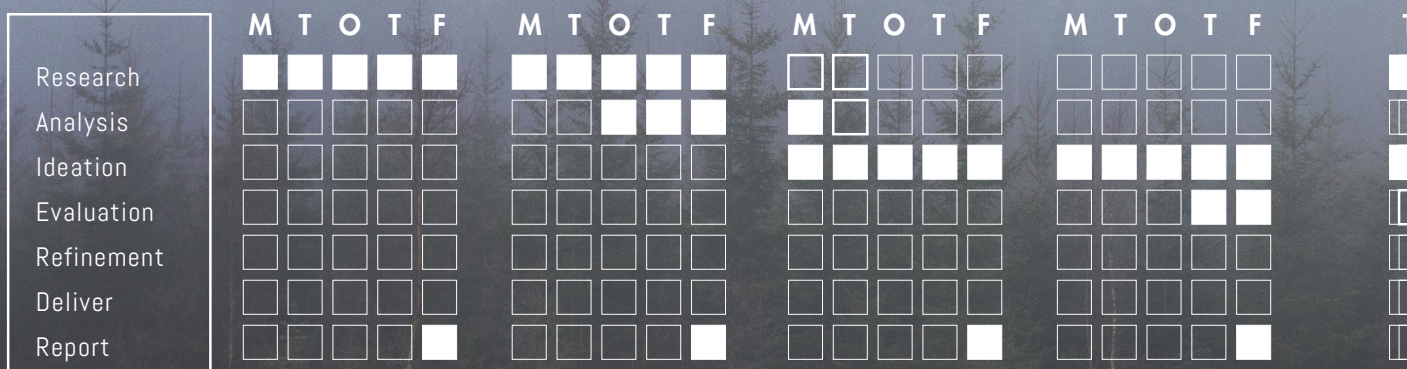
However, I would like to explore the possibility of offering a service that allows the individual landowner to get closer to the planning of their own forests.

WHY FUTURE FOREST?

I have no background in the forest industry but after being made aware of how deforestation becomes a bigger and bigger threat to the environment, I felt that this was something that I could dive deeper into. I was born on the country side and have always spent much time in the woods and nature. It is very dear to my heart. I felt that this interest would take a big part in a project like this. I have chosen to look towards the demands that will be put on the industry and the environmental questions for the future.

The project has challenged me on several different levels in terms of both research within a completely foreign area to the design of a complete system consisting of several parts.
The end result reflects my interpretation and my vision of the future forestry with an innovative height and a vision for 2030.

TIMEPLAN



- Research
- Analysis
- Ideation
- Evaluation
- Refinement
- Deliver
- Report

V 9 - V 17
Spring term 2015

Each column represents one week of the project.This timeplan is designed to facilitate an overall planning of the work to be performed but also to quickly show how I have planned to do the work and what steps I will go through. The schedule will change during the project.


M F M T O T F M T O T F M T O T F M T O T F M T O

RESEARCH // ANALYSIS

During the research phase, I have conducted interviews with knowledgeable individuals in the industry. These individuals all have different areas of experties and backgrounds. I have also read articles, scientific reports on the topic and used the internet as a source for raw information. Citations is to bee seen in the end of this report.

The research ends with a analyze phase where I define the problem areas and how I will continue against these challenges.

FORESTS AND CLIMATE CHANGE

Forests cover about 30% of the earths surface and is a vital resource as a habitat for plants, animals and humans.
The forest provides us with its own ecosystem that gives us both climate control, pollinating insects, water purification, natural pest control and the formation of fertile land for food production. This is a scientific fact.
Today the world is getting warmer and warmer, mainly because we burn massive amounts of fossil fuels such as oil and coal. During this combustion carbon dioxide is created, wich is one of the greenhouse gases that contribute to global warming.
Due to the climate change storms and forest fires is also getting more and common and we loose hughe amounts of forest every year.

The forests have a major role in climate change and global warming, it currently contribute to about one-sixth of the global carbon emissions.
Planting a tree is one of the most effective methods available for carbon emission. When a tree is planted, it leads to reducing emissions when the tree absorbs carbon dioxide from the atmosphere and bind it through photosynthesis. The tree also improves the surrounding soil by increasing the availability of water, which contributes to increased biodiversity. When managed sustainably, they produce woodfuels as a alternative to fossil fuels.

But today deforestation is a real environmental threat. The world trees are being cut down too quickly for the earth to regenerate new forests. 12-15 million hectares of forest are lost each year, the equivalent of 36 football fields per minute. Forests are cleared for a number of reasons. Such as harvesting timber to produce wood and paper products, clearing land for farms, plantations, cattle ranching or clearing land for urban development.

INCREASING DEMANDS

Wood fuel has been used as an energy source ever since humans learned to use fire. Today, the interest in biofuel is greater than ever.
We are moving into a biobased ecomony[1] and increasing the extraction of forest fuels means an intensification of the logging industry wich leads to implications for forest ecosystems in both short and long term.

With increased pressure on the production of biofuel there is reason to renew the existing system, technology and logistics in order to increase the amount of biomass that is expected in the upcoming market.

And in order to increase this production we must ensure a good regrowth of the forest.

[1] Biobased economy - a comprehensive approach to address several of the major societal challenges, food supply for a growing global population, long-term productivity in agriculture, forestry and greenhouse gas emissions.

WHAT IS REFORESTATION?

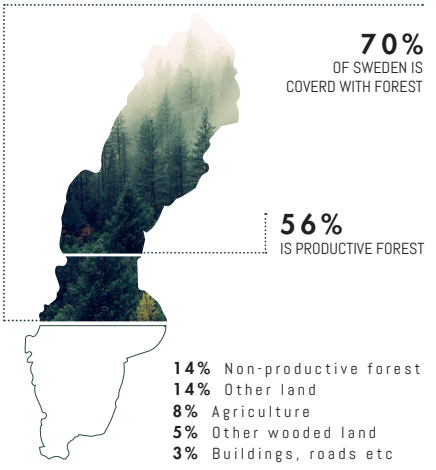
The term reforestation is similar to afforestation, the process of restoring and recreating areas of woodlands or forests that may have existed but were deforested. Reforestation can be used to improve the quality of human and animal life by soaking up pollution and dust from the air, rebuild ing natural habitats and ecosystems, mitigate global warming and provide resources for todays society.

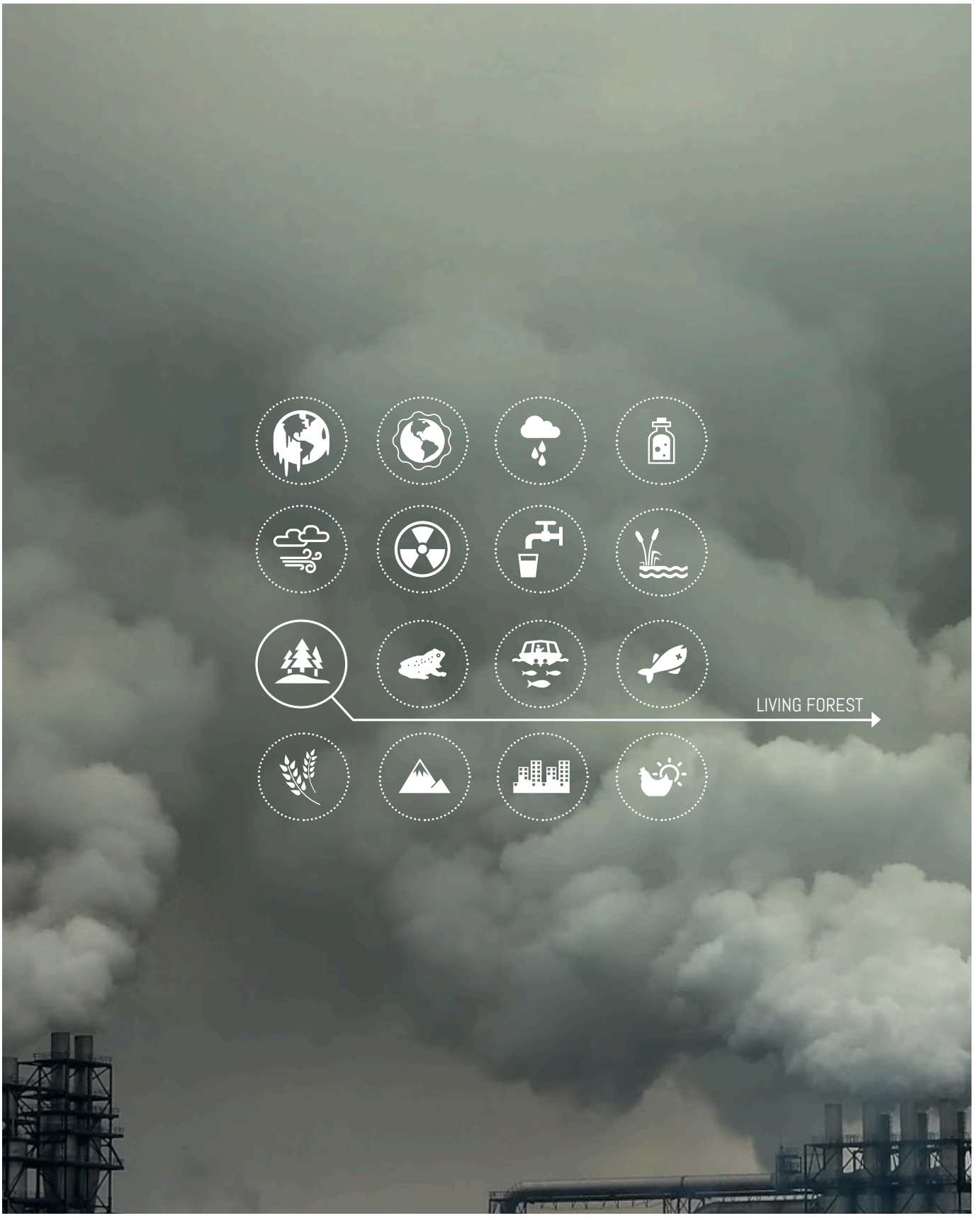
There are essentially three options of reforestation, sometimes even combined. Planting of either bare-root plants or soil-covered roots, sowing och natural regeneration.

REFORESTATION OF THE SWEDISH FOREST

Of Sweden's total land area of approximately 41 million hectares 28 million is counted as forest land. Of these, approximately 23 million hectares is so called productive forest.
50% of the forest in Sweden is owned by private forest owners, nearly 330,000 individuals in the country owns forest.
In Sweden, unlike other countries, there is a law on replanting forests after logging called the .

Natural reforestation is becoming increasingly rare. Because it's difficult to ensure the new forest after harvesting. The greatest change has occurred in the Northern Norrland and Svealand, a reduction of 50% in less then ten years. Instead, the proportion of planting and in some parts of the country and also the sowing share has increased.
Seen across the country the proportion of natural reforestation is 18% and the proportion of planting 75%. There are several reasons for this change, that natural reforestation is time consuming and contains more operations, seedlings are placed unevenly in nature and greater risks that trees blow down or grow poorly. Today trees are planted on almost all land surfaces, this is done either 1-3 years after harvesting by using mechanical scarification of the area immediately after harvesting.
Soil conditions, location, surface and knowledge determines whether the plant survives.




LIVING FOREST

ENVIRONMENTAL GOALS

"In Sweden we will solve our environmental problems now and not leave them to future generations". This is what the parliament has decided. Sweden's environmental goals are benchmarks for the environmental work ahead.
The Swedish environmental system contains of a generational goal, sixteen environmental quality goals and twenty four milestones.
The purpose of the environmental goals is to clarify the environmental dimension of sustainable development.

One of the sixteen enviormental quality goals is "Sustainable Forests".
The Parliamentary definition of the environmental goal is:
"Forests and forest land for biological production must be protected at the same time as biological diversity, cultural values and social values."

The Government has established nine specifications of the environmental goal for Living Forests.

Forest properties
The forests physical, chemical, hydrological and biological properties and processes are maintained.

Ecosystem services
The forest ecosystem services are retained.

Green infrastructure
Forest biodiversity is conserved in all natural geographic regions and species have the ability to spread within their natural ranges as part of a green infrastructure.

Favorable conservation status & genetic variation
Habitats and indigenous species associated with forest landscapes have favorable conservation status and sufficient genetic variation within and between populations.

Species & Habitats
Endangered species has recovered and habitats have been restored in valuable forests.

Alien species
Alien species and genotypes does not threaten forest biodiversity.

Genetically modified organisms
Genetically modified organisms that may threaten biodiversity are not introduced.

Preserved natural & cultural values
Natural and cultural values in the forest is preserved and the prospects for continued conservation and development of values available.

Outdoor Recreation
Forest values for outdoor recreation are defended and maintained.

METHODS OF REFORESTATION

While technology and machines has advanced in the forest industry in recent years the planting process is still manually done. Mostly because the economic pressure on the reforestation industry hasn't been as big as on the logging industry.

There are essentially three ways of reforestation as I meantioned earlier.
Planting, sowing or natural reforestation.
Today, natural reforestation is not an option beacuse of the slow regrowth but on clearings natural reforestation is going on by itself, in small scale.

Manual planting of containarized seedlings are most common and about 300 million are planted every year.
Today this method is proven to work and it has over time become a standard way of reforestation.
Sowing on the other hand is a method now beeing introduced to the forest industry as an alternative to planting. It is a possible method to meet the demands of the future.

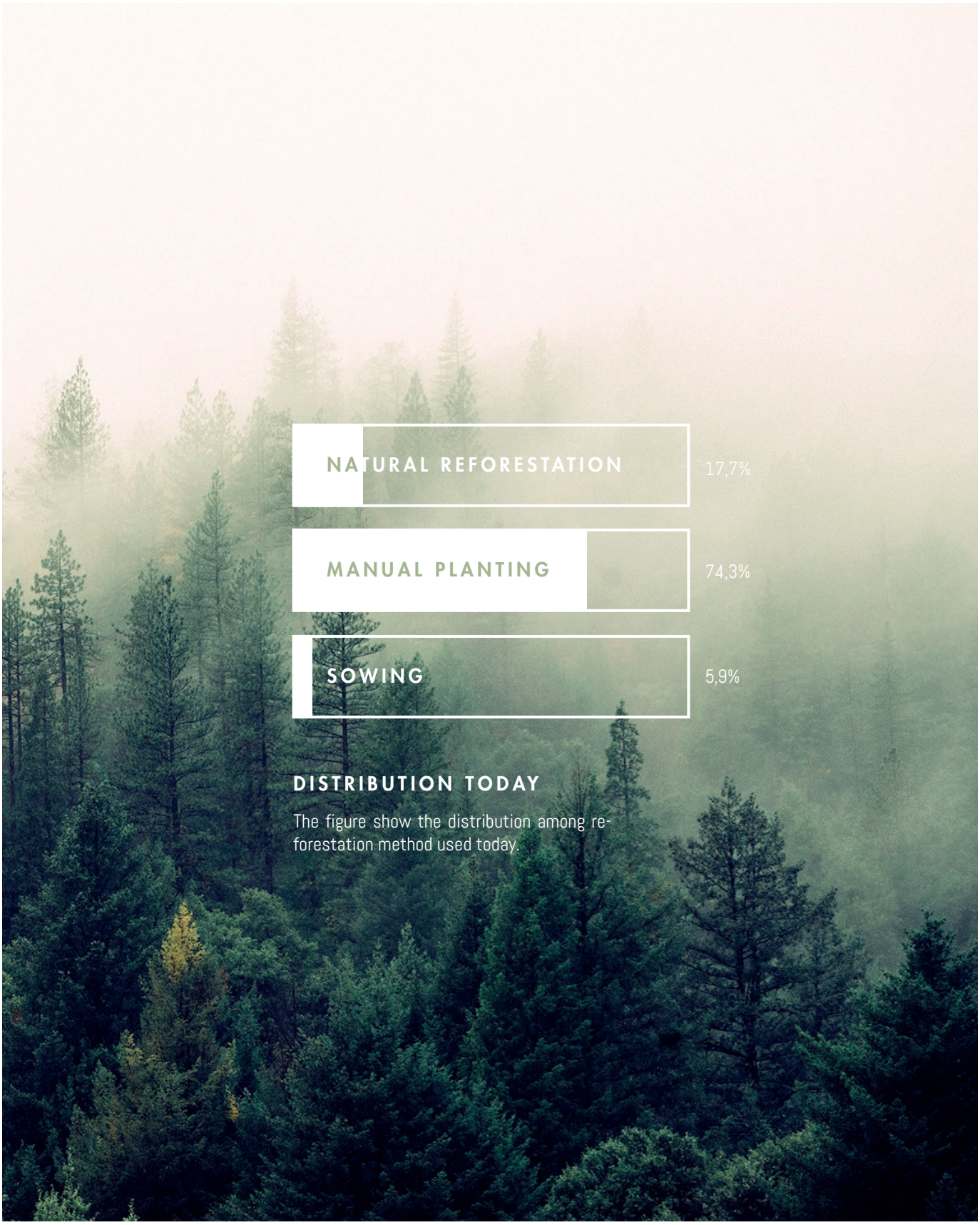
I will go into detail on the method of planting with seedlings and sowing.

SUSTAINABLE REGROWTH

Independent of regeneration method the planted tree needs good conditions for a stable and healthy regrowth. Both factors above and below ground matters.

UNDER GROUND
To ensure good regrowth the plant need a continuously flow of water under the ground. A mineral rich soil of the right quality. Matching soil type and tree sort is important and by placing plants on accurate distance to each other you avoid predators like pine weevils.

ABOVE GROUND
There are various factors that affect the regrowth above ground such as latitude, altidtud, climate, topography, slope and exposure.
The diverse climate zones and will give varying conditions for the regrowth. Both temperture, humidity and energy radiation varies greatly. The topography affects clouds, amount of rain and wind. For example, the probability of cloud formation increases as the water vapor rises up the mountain crests.
The slope and exposure is one of the most important factors to take into consideration. The more perpendicular to the sun's rays towards the ground, the more heat is applied. Southern slopes have shown an earlier start of vegetation.



DISTRIBUTION TODAY

The figure show the distribution among re-forestation method used today.

MANUAL PLANTING

Containerized seedlings or bare root plants being planted today have been raised in a plantage for about 2 years and are then transported out to sites all over Sweden.

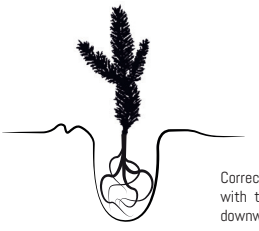
The actual process is manually done and very time consuming. It's becoming increasingly difficult to find labour for manual tree palnting due to the fact that reforestation is a hard job and involves hard work for long hours with repetitive movements which causes great strain on the body. It might seem easy, but it's not. The work is often carried out by cheap labour such as students or foregin workers.

Many plants is currently placed out unnecessarily and die because they are not placed correct after fertility and terrain. The knowledge of the planter is important to ensure a good growth of the plant. A good planter equals surviving plants. Placement and spacing with eachoter and other vegetation on site also contributes to the growth and today it's difficult to know how densely you plant by just looking around. A better planning of the area would help effecivise the process and minimize loss of plants.

The work means that you go on clearcuts that has been scarified and plant small plants consisting of either spruce or pine, these should then be placed into the ground in a proper way so the plant can grow into a tree.
Today either a planting tube or a shovel is used to carry out the planting process.
The planting tube is used to plant containerized seedlings. The tool is slamed down into the ground and the pant is place in the tube and slides down to hole. The struggle here is to avoid stones and other unbreakable surfaces underground.
The shovel is used to plant bare root plants bacuse you have to bee more careful with the placement of the root system. During this time you wear a supporting harness or belt where you hang the boxes or bags of seedlings at the side of the body. The stronger you are, the more boxes of seedling can you carry. Then you avoid walking back to the base to refill with seedlings. But these boxes affects your postior and back, is gives enourmus preassure on your body.

The work is monitored by a planting leader that also supply the planter with plants and tools on site. An experienced planter set up to 2000-2700 seedlings during a day of approximately 12 hours. The amount varies as it depends on the area but also the attitude of the planter since they get paid per plant.

The work takes time, it involves alot of deadwalking around the site to avoid obstacles and to refill plantboxes. You also have to make decisions along the way and look out for plants so you don't step on them.



Correct planted seedling with the rootsystem striving downward.

SOWING

Sowing is done both manually and by machine, though the maschines is very simple. The cost of sowing is usually considerably lower than planting. Besides the labor the cost of soil preparation and seeds is cheaper. The reforestation phase are a few years longer than at planting but at least on year can be saved because you can sow directly after scarification.

Seeding is a well functioning method and is preferable to the natural regeneration. Partly because you can make use of the refined plantation seeds and are not dependent on a good seed years or quality seedlings.
Trees that has been sown have showed a greater strenght in the root system than planted ones.

Seeding typically provide a better regeneration results in plant numbers. However, it can lead to a post-process of the land, such as thinning. But with the right choice of sowing machine, the amount of post-process can be reduced.

The process is done by first scarifying the land to bring up the minerals in the soil.
When using the mechanical technique the seeders are usually designed to sit directly on the ground preparation machine. Sowing at the same time as preparing the land.
The technical sowing technology has proven to save more seeds than the manual and the risk of so-called lump sowing can be minimized.

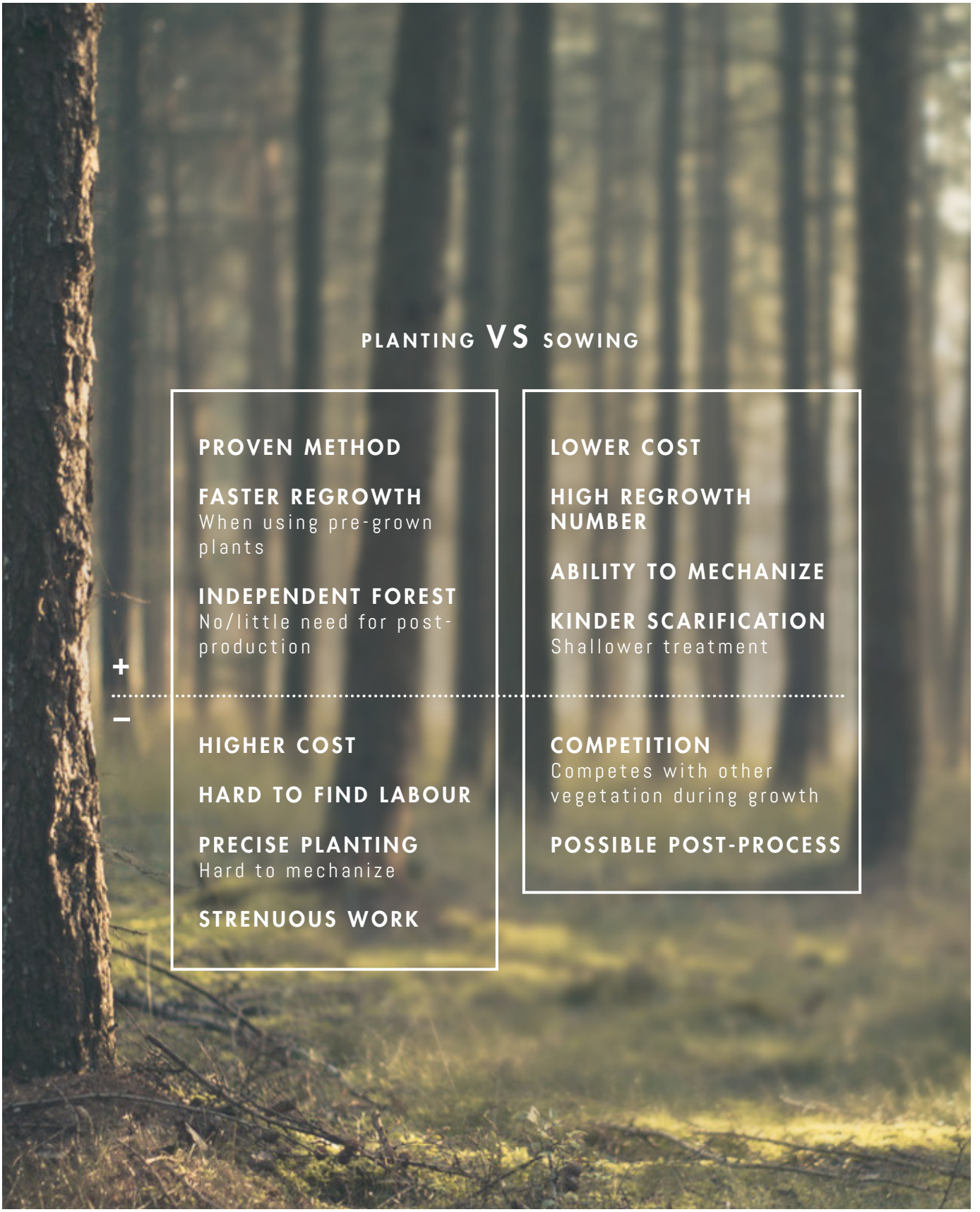
The manual technique allows a more precise work and you are able to make sure that the seeds fall on soil with good condition for growth and establishment.
The equipment that is used is simple and consists of a seed rod or seed wheel. A soil preparation shoe can also be used on scarified land, it is pressed against the ground and creates a waffle pattern that you then place the seeds in, this is to come closer to the capillary water in the soil.

This process is much more ergonomic towards the person doing it. However, it's still a time consuming work when you have to walk across these uneven areas.

Seeds placed in wafflepatterns.

MANUAL VS MECHANICAL
When using manual seeding you can be more precise and influence where the seeds will be placed to get a more accurate result which leads to less waste of seed.

The downside is that labor costs will be greater than with the mechanized sowing.It can also be difficult to get hold of skilled labor to perform a good job.


PLANTING VS SOWING
PROVEN METHOD
FASTER REGROWTH
When using pre-grown plants
INDEPENDENT FOREST
No/little need for post-production
LOWER COST
HIGH REGROWTH NUMBER
ABILITY TO MECHANIZE
KINDER SCARIFICATION
Shallower treatment
+
−
HIGHER COST
HARD TO FIND LABOUR
PRECISE PLANTING
Hard to mechanize
STRENUOUS WORK
COMPETITION
Competes with other vegetation during growth
POSSIBLE POST-PROCESS

CONCLUSION

Rejuvenation of forests is a necessary but costly process and therefore it is desirable to find a more cost-effective regeneration method. One way is to use sowing as a method.

The society is moving towards a biobased economy and the pressure on a high efficent forest- and reforestation industry is increasing. Although planting is a proven method to ensure regrowth of the forest sowing is a potential method to meet future demands for the forest industry. A lot of research and testing has been done which shows that a successful seeding could bring greater amount of forest in the end than planting will. And by making the right choice of seeding machine a costly post-process may be reduced. Which makes seeding a much cheaper method of reforestation than planting. Something that the forest owners strives for.
When it comes to scarification of the land the process can be much more shallower then at planting and your able to seed directly after scarification. This means you save 1 year of regrowth time.

With the possibility of a mechanized process in this area the reforestation process can be more efficient and precise.
Therefore, I choose to develop a concept based on seeding as a reforestation method.

SOWING TODAY

Today, bare processed seeds from nursery gardens is used when sowing.
"More and more people realize the benefits of forest sowing and the IDS-treated[1] seeds. The seed amount can be lowered and you get a more uniform regeneration, which in return leads to higher growth and lower future clearing costs" says Ulfstand Wennström.

Seeding allows for a wider distribution of tree species in the forest, something that we strive for. The efforts of bringing different kinds of seeds to the felling sites is much less than to bring plants, both in terms of size, handling and distrubition.

The equipment for manual sowing is as I mentioned earlier a simple seed rod or seed wheel with a soil preparation shoe. Bare seeds are then placed directly on the surface.

The mechanical seeders are placed directly on the ground preparation machine. In this mechanized process there is a risk of so-called lump sowing, but with the right machines and technology this can be avoided.

[1] The seeds are vitalized and dried, dead and poorly developed seeds are then sorted out.

MANUAL

+ Decision based
  Light work

- Risk of lump-sowing
  Knowledge based

SEMI MANUAL

+ Decision based
  Specified placement

- Time consuming
  Risk of lump-sowing
  Knowledge based

MECHANICAL

+ Efficient

- No specified sowing
  Standardized scarification method

NEW TECHNOLOGY

AUTONOMOUS MACHINES

Driverless machines have now begun to establish itself in the market, especially in the field of agriculture. The machines are working remotely and goes on autopilot through the designated trails. The technology saves both time and labor, and the work is so precise that they can ensure a good end result. More and more research has then begun in the forest industry who see that they can benefit from these remote controlled systems to streamline and specify the work.

A technology that has had a rocket rapid development is the drone system. These systems provides a cheaper and easier way to read and assess areas. A quality noticed by the forest industry. A drone can work quickly and independently and then send detailed information to the operator.

"With the help of modern digital technology and drones for aerial photography there are great gains within reach," says Hans Thunander. He has developed a new concept for reforestation through drones where the vision is to have a 50 percent efficiency in ten years. The concept is based on using drones and GPS to photograph and analyze forest areas. Forest owners is then able to make precise measures for certain areas.

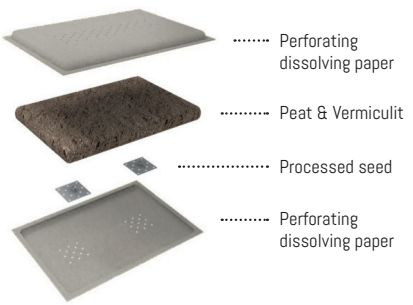
SEEDPAD

SeedPad is a new type of method for direct seeding. The goal was to create a more economical seeding and reduce the number of seeds that go to waste. Today approximately 10 seeds is required for growing one tree, with this method the amount is reduced to 2 seeds. The SeedPad has been tested with good results and shows good regrowth numbers. Tests show a regrowth of 70%, the general objective is to have at least 50%.

The SeedPad is placed directly over the scarified surface. It consists of an enclosing dissolvable paper that decays after time. Inside is a pressed block of peat and vermiculite and in the bottom two processed seeds.

The idea is that the paper will decompose and the blocks swell to protect and then provide nutrients to the soil around the seed.

This method of treating the seed enables us to specify the reforestation.



PROBLEM DEFINITION

To sum up what I've talked about, you could say that the current method is time consuming and uncertain. Uncertain in such a way that it's difficult to ensure the wanted regrowth. There are many factors that come into consideration, knowledge of the planters, soil conditions etc.
The method used today has been extremely stationary and few changes have occurred through time. The reforestation method has been simplified (because of the economic pressure) and standardized. First of all you prepare the land and then manually plant seedlings.
Soil conditions and other factors are seldom taken into account anymore and the forest's natural characteristics are forgotten.

Progress towards sustainable forest management has in some ways been forgotten but the ability to take the environmental goals into account are now possible with new technology.

A change needs to happen in order to meet the future demands for production but also to ensure a healthy and prosperous forest to fight against global warming.

Below I have listed some problem areas with today's process, these problem areas are also the development areas as I see it and I will development concepts around them.

DEMANDING FUTURE
Economy / Production Amount

STANDARDIZED
Same approach regardless of condition

MANUAL WORK
Physically demanding / Knowledge based

TIMECONSUMING

UNCERTIAN OUTCOME

UNEXPLORED
Stagnant development

MONEY OVER QUALITY
Tree quality is threatened


Maintain the efficiency of the machines but applying the knowledge and precision of man.
ACCURATE
?
TIME CONSUMING
EFFICIENT
UNACCURATE


HOW?
WHAT?
Action
Perform sustainable resforestation.
WHO?
Target group
Forest owners.
WHERE?
Context
Scandinavian forest areas.
WHEN?
Time
15 - 20 years from now.
WHY?
Vision
Meet future challanges.

VISION / GOAL

My number one goal is to performe a sutainable reforestation and meet the future demans of society.
The concept shall achieve the same precision as with the planting method today and it will show innovation and inspiration for the forest indsurty. I want to combine the effiency of todays machines with the knoledge of the human brain.

Nothing have changed in a long time and I want to make a differens, 15-20 years from know perhaps this is the future.

DEVELOP A CONCEPT THAT LIVES UP TO FUTURE DEMANDS

TAKE ENVIRONMENTAL GOALS INTO ACCOUNT

STREAMLINE THE PROCESS

ENSURE CONSISTENCY

COUNTERACT PHYSICAL STRAIN

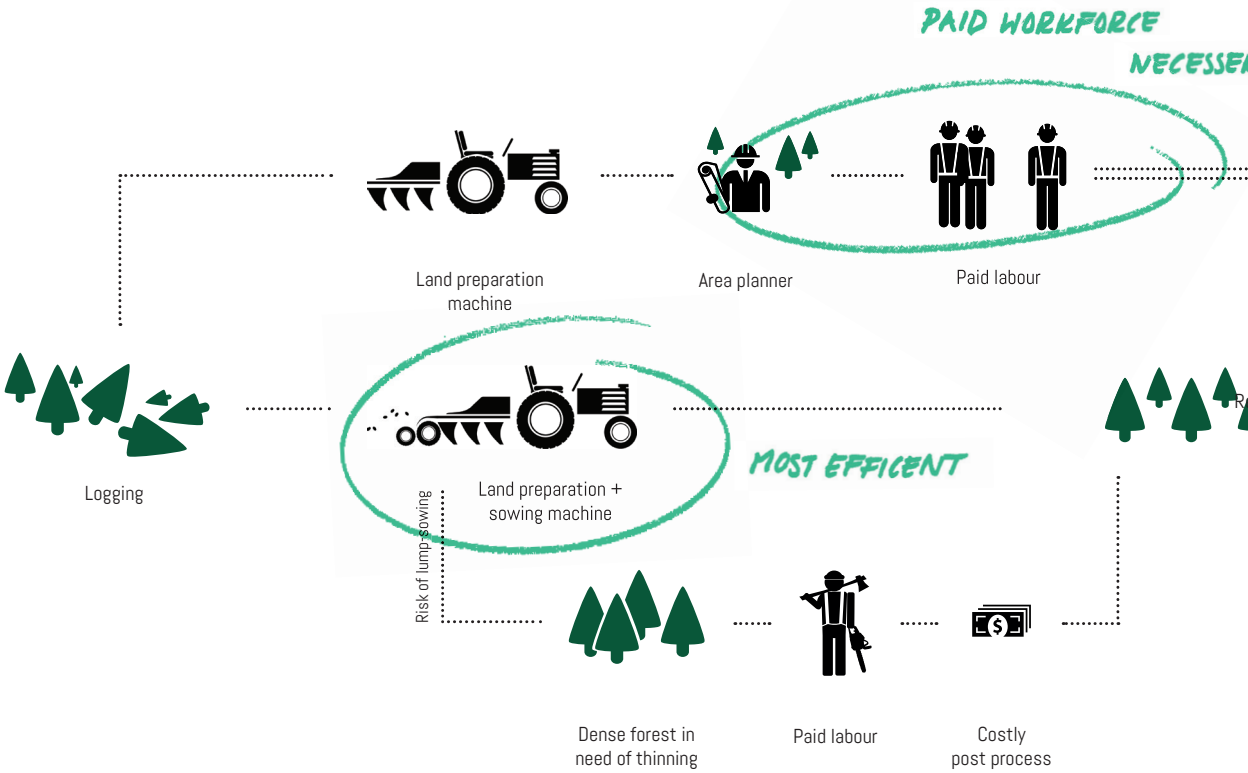
ACTIVITY CHART

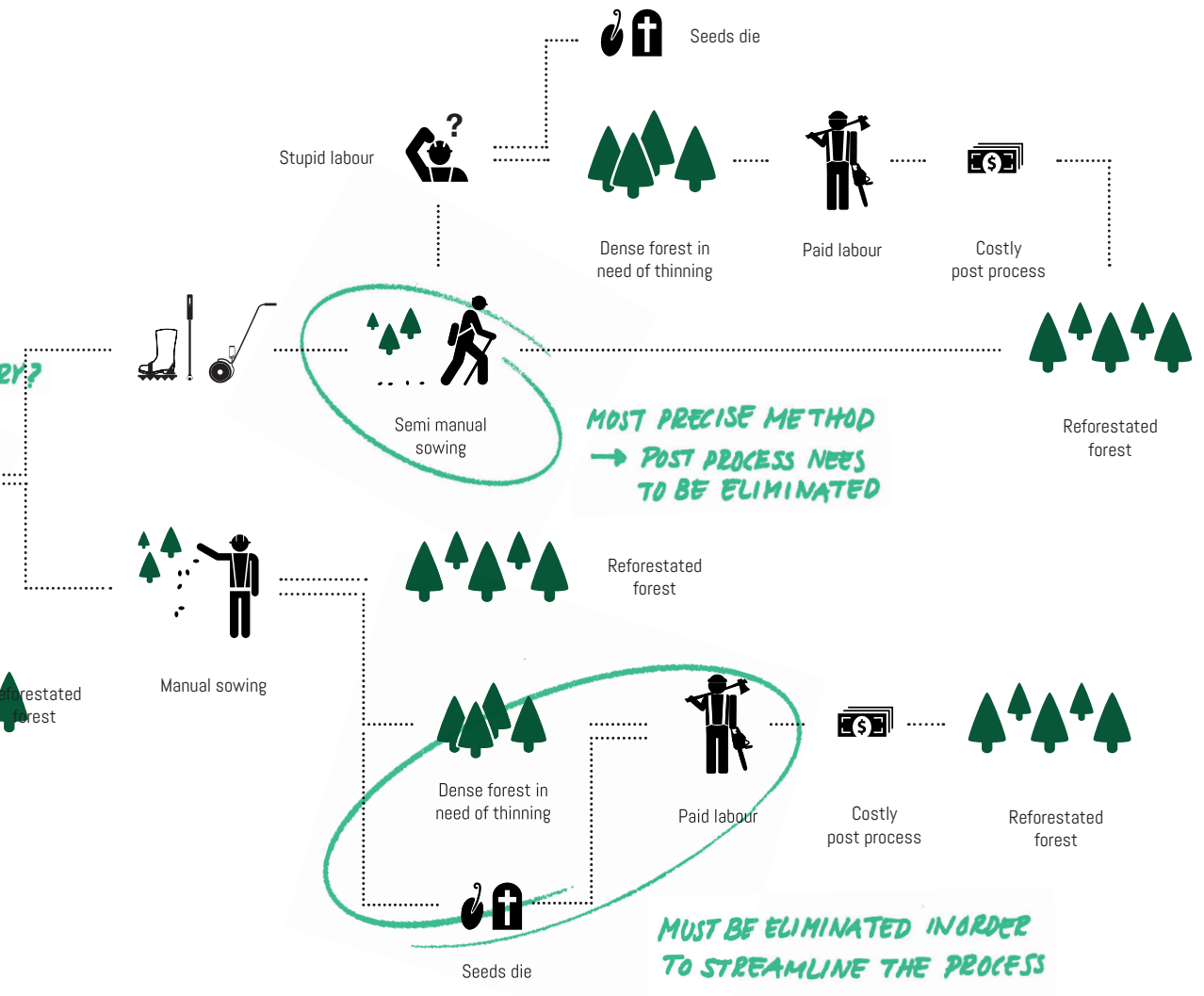
The activity chart shows the different steps in the methods used for sowing.

One can clearly see how the process for manual seeding contains several elements and is more time consuming than the mechanical. In all methods, there is a risk of lump sowing and the precision is determined by the person or machines own intelligence.

The mechanized sowing process is effective but the risk of costly post process greater. The manual method is time consuming but the risk of post process is not as great if one is correct with the seed placement.

In order to make sowing an efficient methot for the future the risk of post process work must be eliminated. Today, post process work is recurrent in every method. Wich leads to a higher cost for reforestating land areas.




Seeds die
Stupid labour
Dense forest in need of thinning
Paid labour
Costly post process
Semi manual sowing
MOST PRECISE METHOD
→ POST PROCESS NEES TO BE ELIMINATED
Reforestated forest
Manual sowing
Reforestated forest
Dense forest in need of thinning
Paid labour
Costly post process
Reforestated forest
Seeds die
MUST BE ELIMINATED INORDER TO STREAMLINE THE PROCESS

HOW TO SAVE TIME

Time is money and since the sales from biomass and timber services will almost double in the upcoming future time management is crutial.

Time is saved, as in every task by planning and preparing the work carefully in advanc and having consistensy while performing it.

I have studied activity charts and used interwievs to create a list of ways of saving time in the process of reforestating forest.

STRATEGICALLY APPROACH AREAS
Obstacles/ Bagging up the correct amount of seeds

MOVING QUICK AND SMOOTH

PREVIOUS KNOWLEDGE

NOT HAVING TO MAKE DECISIONS

RETAIN CONSISTENCY

AVOID COMPLETED ARES
Not having to move between microsites

WHY MECHANIZE?

The mechanization in agriculture and forestry has had great development in recent years. Remote-controlled machinery and drones have started taking place in the process. Tests and experiments show that remote control and robotics can do as good a job if not better than humans because of it's ability to be consistent. The technology saves both time and labor, and the work is so precise that they can ensure a good end result.

Simultaneously with the new development of technology the cost has dropped.

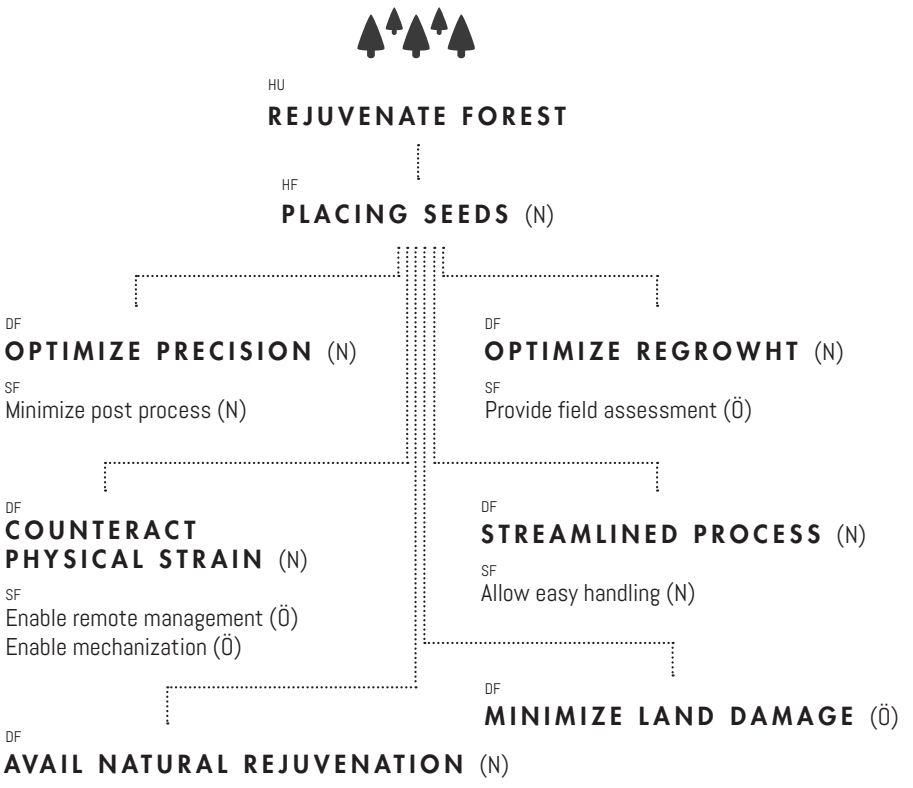
NOT DEPENDENT ON LABOUR KNOWLEDGE

HIGH PRODUCTIVITY

SYSTEMATIC APPROACH

ABILITY TO MULTITASK

ELIMINATED PHYSICAL STRAIN



FUNCTION ANALYSIS

The functional analysis is based my vision and problem definition. It will be used as a tool to examine and question the execution of my future concepts. I will also use it as a basis to strive for higher levels of functionality.

The different demands is ranked with either N (necessary) or D (desirable). And marked with PF (part function) or SF (support function). This creates a easy-to-read ranking of functions.

IDEATION

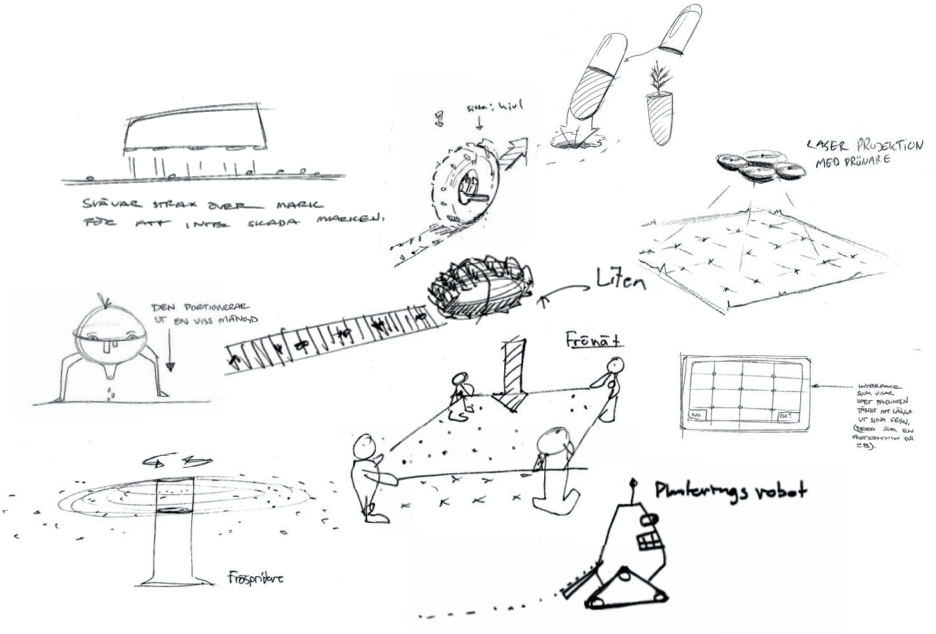
During the ideation phase I used the research and the specifications to develop concept ideas. These concept ideas have an innovative height and have been evaluated against my contacts from the industry before the final the concept is carried out.

START-UP BRAINSTORM

Brainstorming is a group or individual creativity technique which aims to find a conclusion for a specific problem.
Ideas are spontaneously contributed by its members. I put together a group of seven people from Umeå Institute of Design. The goal was to start a generation of different ideas that I could continue to work against in my own ideation process when creating future scenarios of reforestation.

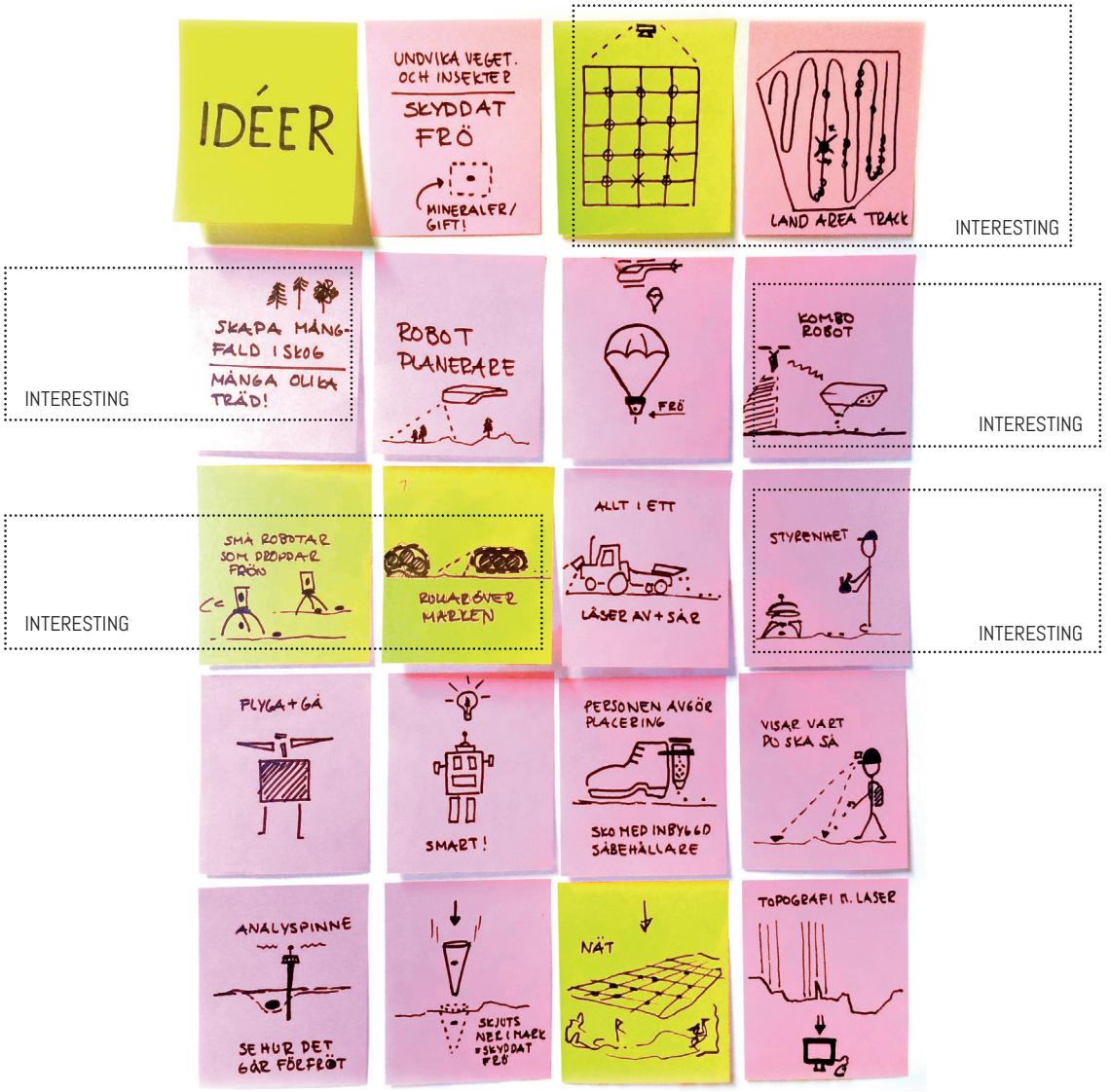
I asked the group tree rather open questions and gave them a time limit of 5 - 10 minutes on each question to sketch/ write down ideas on paper. The questions was:
"How can something move smoothly?"
"How can you place seeds?"
(Fastest/Most precise)
"How do you know that the seed is located correct?" (Before you place it on the ground)

Drafts from the brainstorm



PERSONAL BRAINSTORM

Before evaluating the results from the start-up brainstorm I did my own personal brainstorm based on the same questions. This was to get additional ideas without being influenced by the others results.



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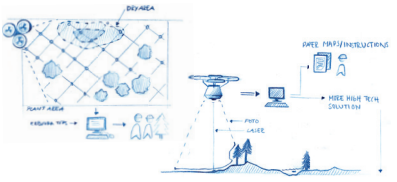

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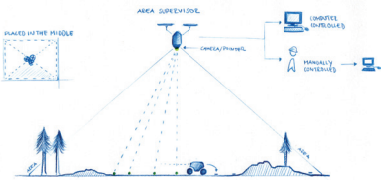
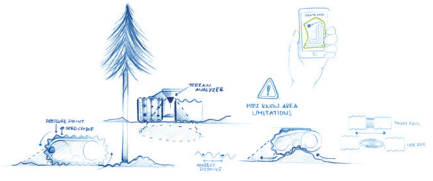


CONCEPT IDEATION / FIRST EVALUATION

Based on the group brainstorm and my individual brainstorming I started my Ideation, focusing on different principles for an holistic solution. It resulted in five concepts.

These principles was then evaluated by Urban Bergsten, Claes Fries, Jens Näslund and myself. After deciding on the principle I could start my form ideation.

3



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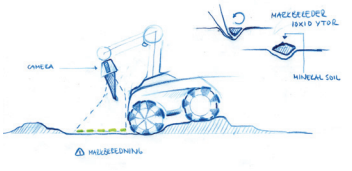
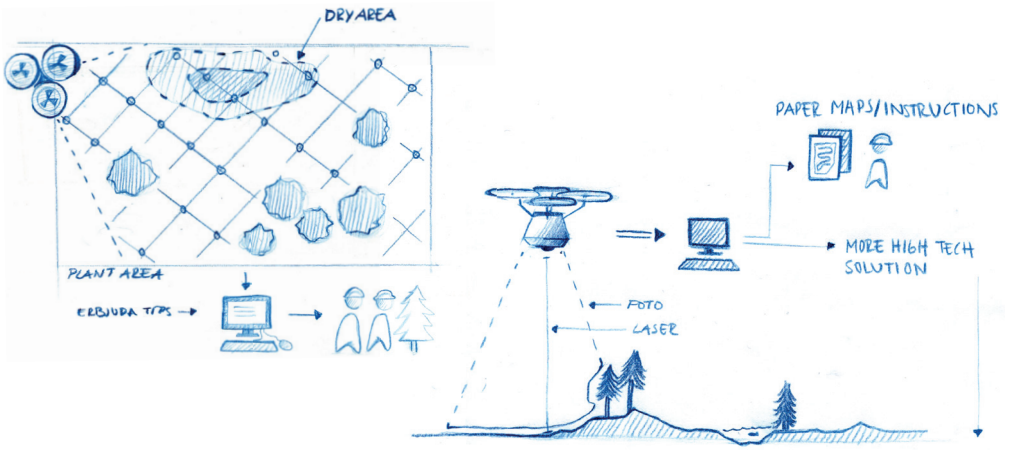


Can fly lower than airplane or helicopter
> Possibility to measure information closer to the surface.
> Measure natural regeneration and be able to avoid these areas to get a natural regrowth.

Drones are available in the market
> Professional equipment costs about 20 000 kr



Concept 1

DRONE PLANNING

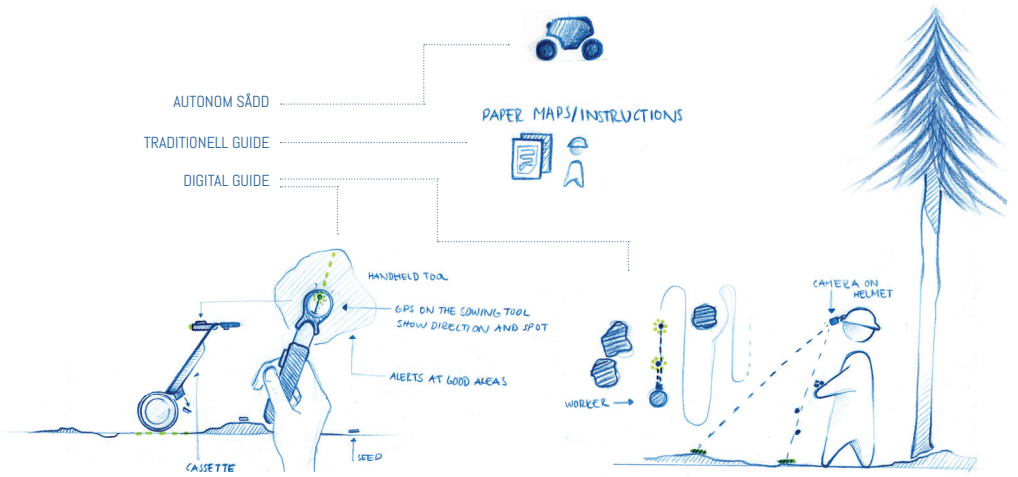
The area is scanned by the drone, which then sends data to the manager.
The data can be used to plan the scarification/quantity of seeds/kind of seeds/location/distance, etc.
The drone helps to create a precise planning of the area, wich will save time.

Measures with laser
> Provides topographic map
> Easy to measure the land and its conditions

Photographs surface
> Provides good overview of the ground and its vegetation

Automatic estimation > Give Tips to manager

Good tool for providing information about where you have been. That information is almost more important than where to go next

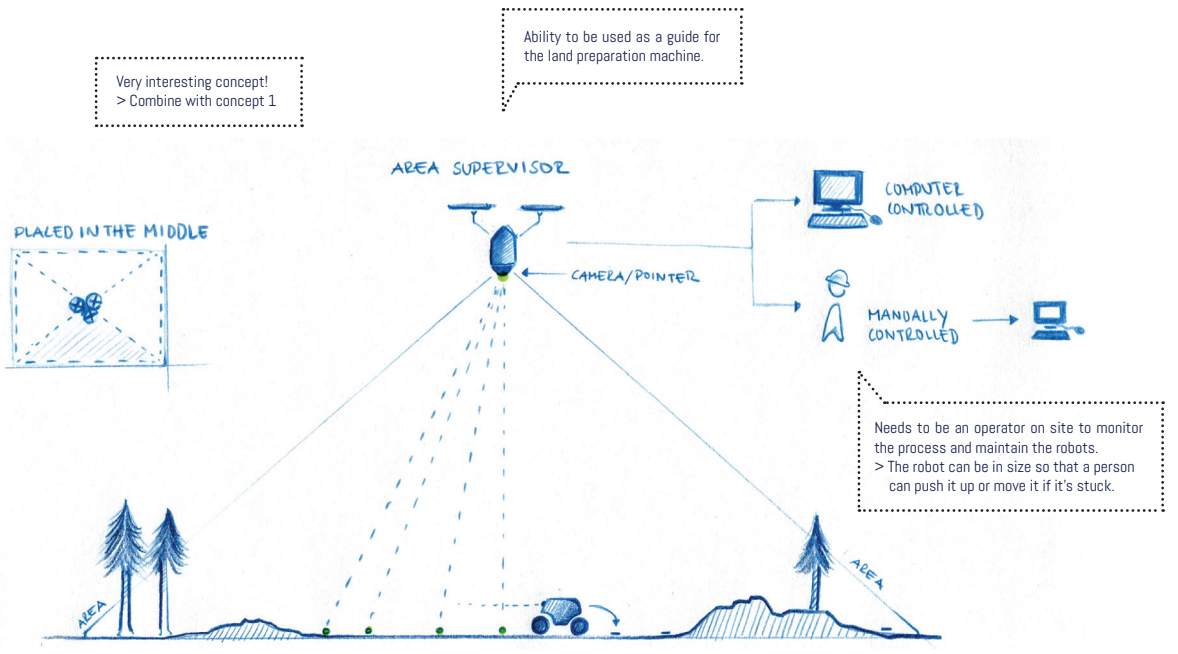


Concept 2

SEEDING GUIDE

The person who sows in a manual way follows a guide during the work (similar to a GPS). The guide is supplied by the planner who used the data given by, for example, the drone to create surtain routes. The guide is linked to a computer program and updated continuously during the work. So you can see where you have been and should be heading.

> The person who sows do not need to take decisions
> Seeds are placed correctly and the amount of seeds can be calculated before work started

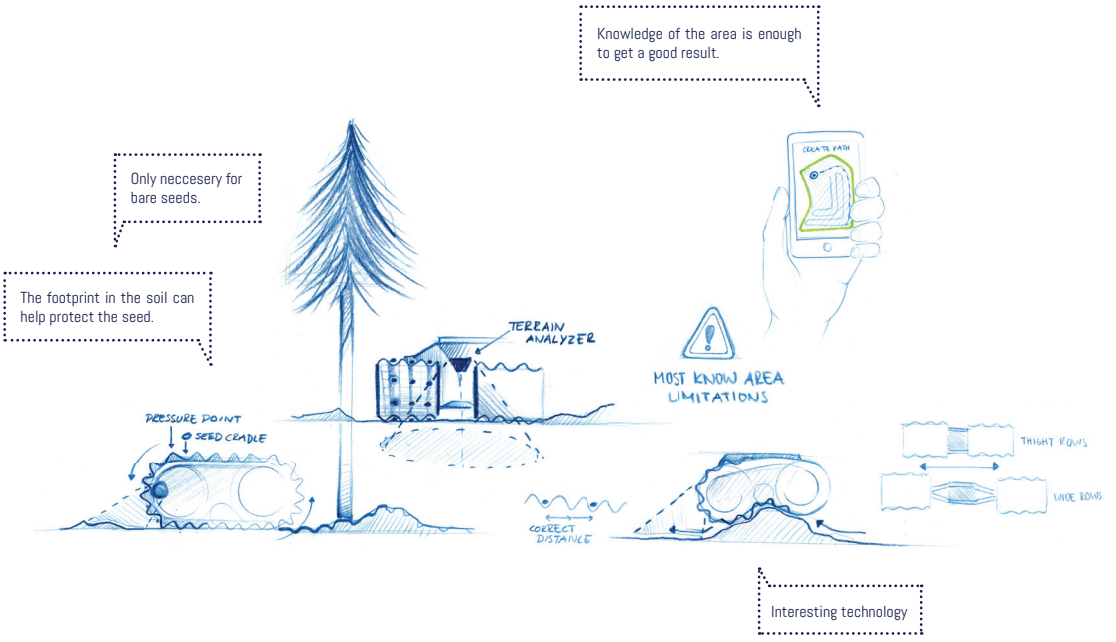


Concept 3

REMOTE CONTROL

A "monitor" is floating in the middle of the clearing site and acts as the "brain". It's either controlled entirely via a computer or a operator on site. It monitors/photographs/films and mark points (with laser) where the seeds should be placed. A sowing robot then moves over the surface and follows the laser beams from the monitor and releases the seeds at marked points.

Autonomous work
> Can be controlled by a planner at a distance
> Can control multiple robots simultaneously
Works with concistency



Concept 4

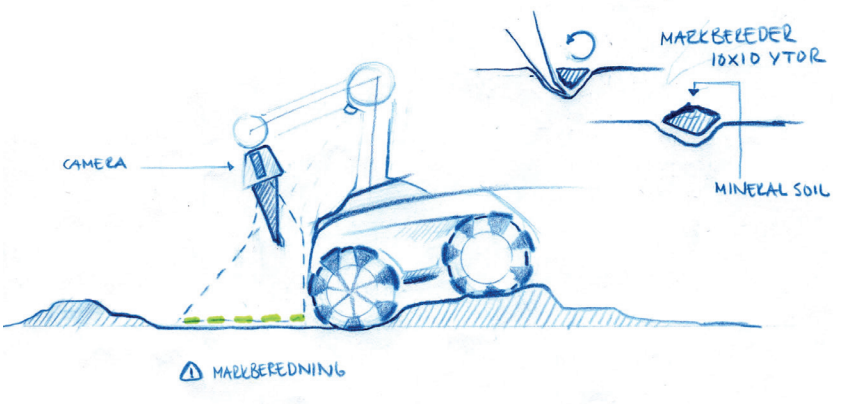
AUTONOMOUS ROBOT

The area is defined in a program (possibly an app). A robot with caterpillar tracks then moves across the surface and drops seeds at a fixed distance, with a terrain analysis camera it moves across the area in a smart way. Each track makes an impression in the ground (waffle pattern) to bring the seed down a level in the soil (to reach the capilar water).

Mild land preparation
> Good treatment for the seed
Concistent work
> Efficient/accurate > Independent

Interesting concept if the machine has enough power to treat different surfaces.

No need for deep digging.



Concept 5

MICRO SCARIFICATION

A seeding robot sows and prepares the land on small surfaces. It moves over the area with a camera that scans the ground surface through a route.
On the surfaces where the seeds should be placed the robot prepares the land, by scraping the surface (20x20) with shovel/blade and drops a seedpackage.

Assessment of surface > Gentle scarification

CHOSEN CONCEPT

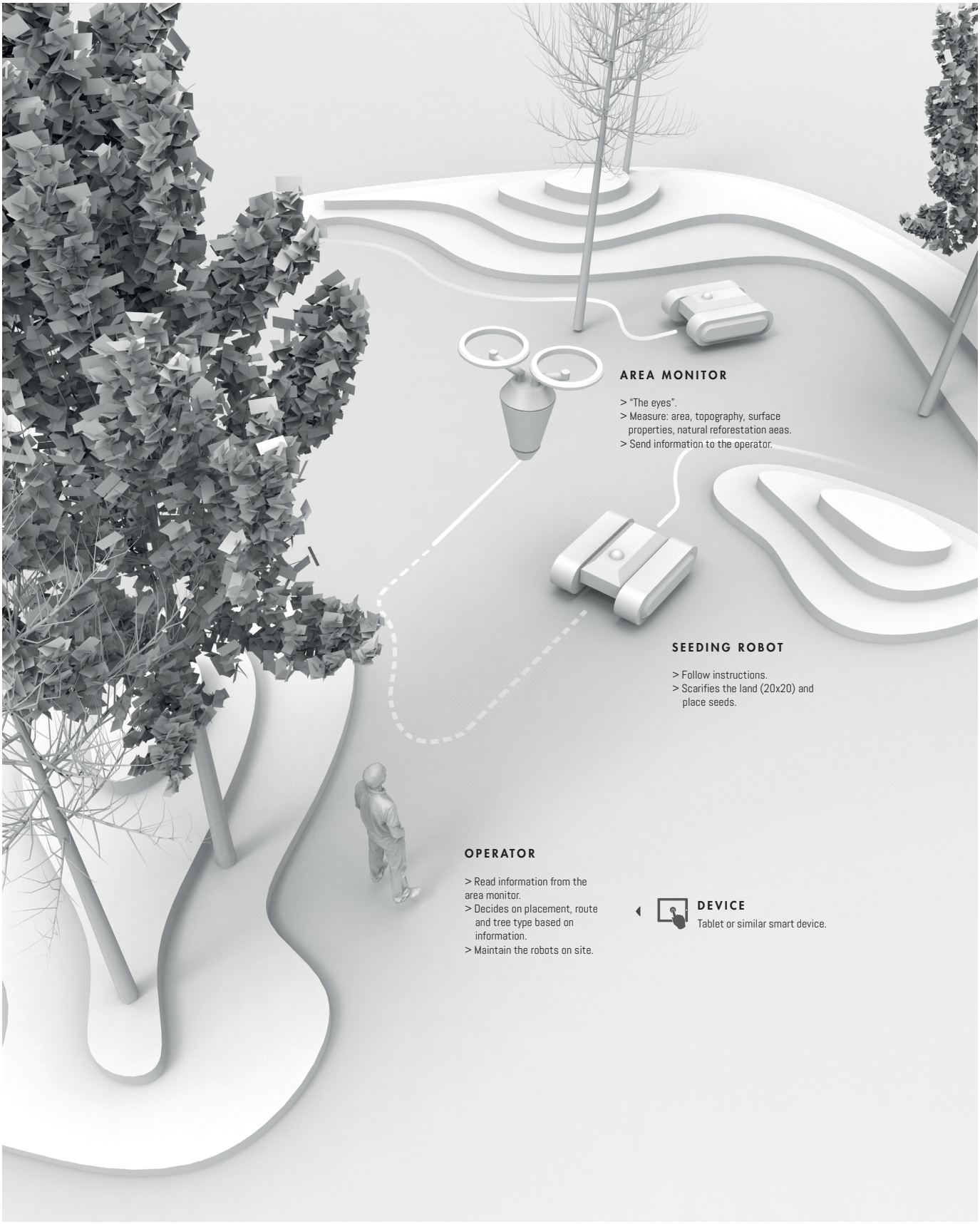
The selected concept I will continue to work with is a combination between "remote control" and "micro-scarification". The concept will consist of three components: area monitor, seeding robot and operator. The decision has been discussed with my collaboration partners and supervisor.

The technology to implement this is on the market and it is possible to put it in use today, at reasonable costs.

A concept such as this provides an opportunity to conduct a detailed pre-planning. Wich leads to the possibility of a new regeneration method that takes the natural processes in the forest into account. Something that is set in my goals and in the Swedish environmental goals.

The function list below shows the concepts fulfilled functions towards my vision and my requirements.

Optimize precision	N	✓
Optimize regrowth	N	✓
Counteract physical strain	N	✓
Enable remote management	Ö	✓
Provide field assessment	Ö	✓
Streamlined process	N	✓
Enable mechanization	Ö	✓
Minimize post-process	N	✓
Minimize land damage	Ö	✓
Avail natural rejuvenation	Ö	✓
Enkel att hantera	Ö	✓ (The concept requires prior knowledge of the operator)



AREA MONITOR

> "The eyes".
> Measure: area, topography, surface properties, natural reforestation aeas.
> Send information to the operator.

SEEDING ROBOT

> Follow instructions.
> Scarifies the land (20x20) and place seeds.

OPERATOR

> Read information from the area monitor.
> Decides on placement, route and tree type based on information.
> Maintain the robots on site.

DEVICE
Tablet or similar smart device.

TECHNOLOGY - SEEDING ROBOT

TRACKS

The seeding robot will use tracks to move around the surface. There are many advantages of tracks even though the cost of wheel verses tracks are smaller.

Tracks are able to distribute the weight over a larger area, and by that reducing the pressure on the ground. It's more suitable for softer grounds then wheels.

The high traction of the tracks makes it approach obstacles better than wheels. It can for example move over wet surfaces like snow och concrete.

In order to achieve maximum grip and maximum balance in the terrain a solution is to have 4 tracks or/and a jointed machine preferable to a compact machine with 2 tracks. You then have the option to use different amounts of force on different tracks to get around obstacles, but also to stabilize the machine with different ground pressure.

Example of a jointed machine:
https://www.youtube.com/watch?v=zpbQeSGBR10

BATTERY DRIVEN

The seeding robot will be powered by battery. The type of battery I had in mind is the type used in newer electric cars such as Tesla or BMW i3. The range of a battery in a BMW i3 is about 300 kilometers, other energy losses is included in that range such as air conditioning etc. Tesla has a range around 350-460 kilometers. I'm making an assumption here that the batteries have enough power to handle a working day of 8 hours of work for my seeding robot. If the battery runs out, there will be an operator on site to replace it if necessary. Optionally the equipment can be maintenance charged during transportation by linking it into the car or truck.

The choice of using battery as a power source is based on that a battery emits no carbon based emissions during operation and it's silent. Something that is suitable for an environment in the forest where different types of animals lives. Most common battery in today's electric cars is a lithium-ion accumulator.

TECHNOLOGY - DRONE

BATTERY DRIVEN

The unmanned aerial vehicle (UAV), commonly known as a drone is a remotely piloted aircraft/helicopter, in my case controlled by the operator on site. It will be designed function wise towards a helicopter. It is powered by the same batteries as the robots how ever in smaller size. The smaller sized battery doesn't mean that the working time decreases drasticly since the drone doesn't requires as much power to function as the robots.

SEED HANDLING

After a discussion with Urban Bergsten, professor at SLU, a teardrop shaped seed sack is a good option for precision placement and treatment of the seed.

The teardrop shaped sack consists of a dissolvable paper filled with a pressed mineral soil mass and two fixed seeds. The shape makes it land correctly on the ground and cover the surface terrain regardless of surface type.

"The seed sack" will build on the same principle as the SeedPad but designed in a softer and more mobile sack. It will give equally good conditions for the seed to grow and survive.

FORM EXPRESSIONS

Before I started my sketch fase I needed to create moodboards to visualize different design expressions that I could strive for in my sketches. I created three moodboard symbolizing different areas. Each moodboard has an explanaition and two extra describing words. Each word represents a shape, a material or exempl a color choice that I want to implement my concept.

These moodboards is used as reference during my sketchfase and also to evaluate around later in the sketch phase.

STRUCTURE **AESTETHIC** **COLOR & TRIM**

STRUCTURE MOODBOARD

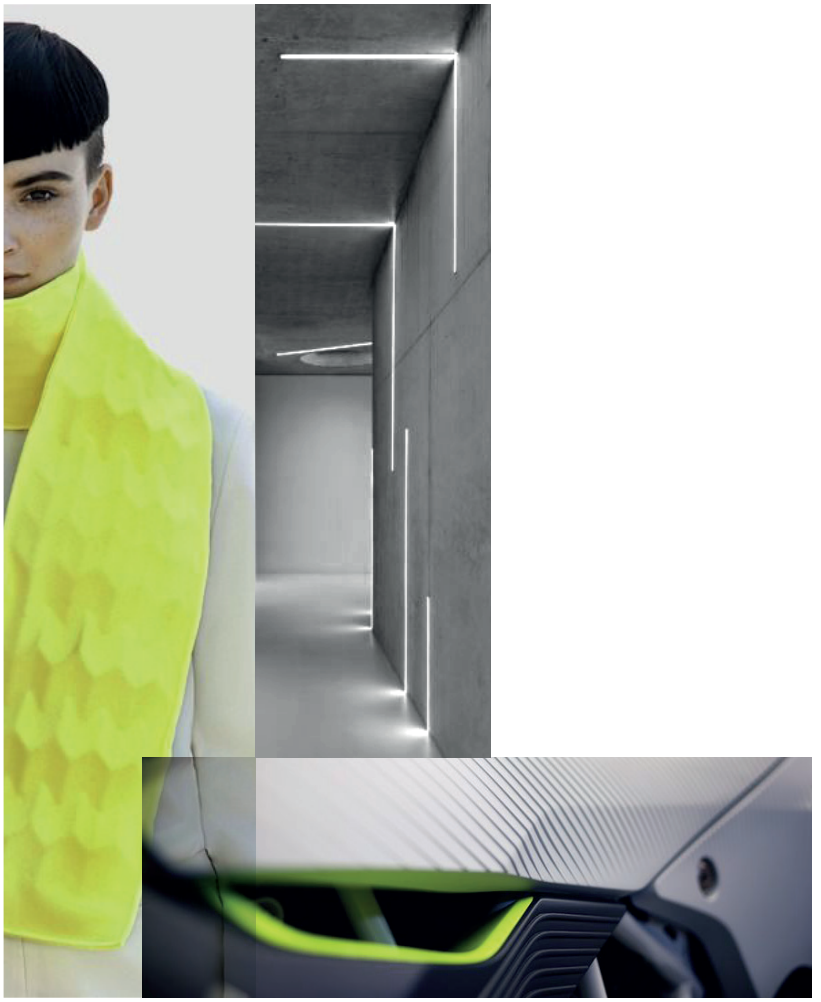
Clear center of gravity and protective surfaces to create a reliable expression.
Thoughtful transitions between materials/surfaces to get balanced proportions.

RELIABILITY
BALANCE

AESTHETIC MOODBOARD

Dynamic and calm shapes with defined surface transitions.
Intellegent structures and visibility of significant functions.

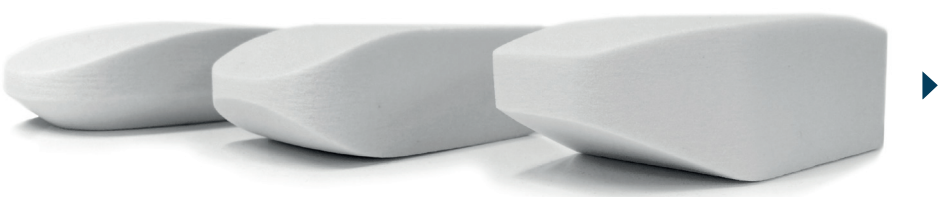
DYNAMIC
INTELLGENT



COLOR AND TRIM MOODBOARD

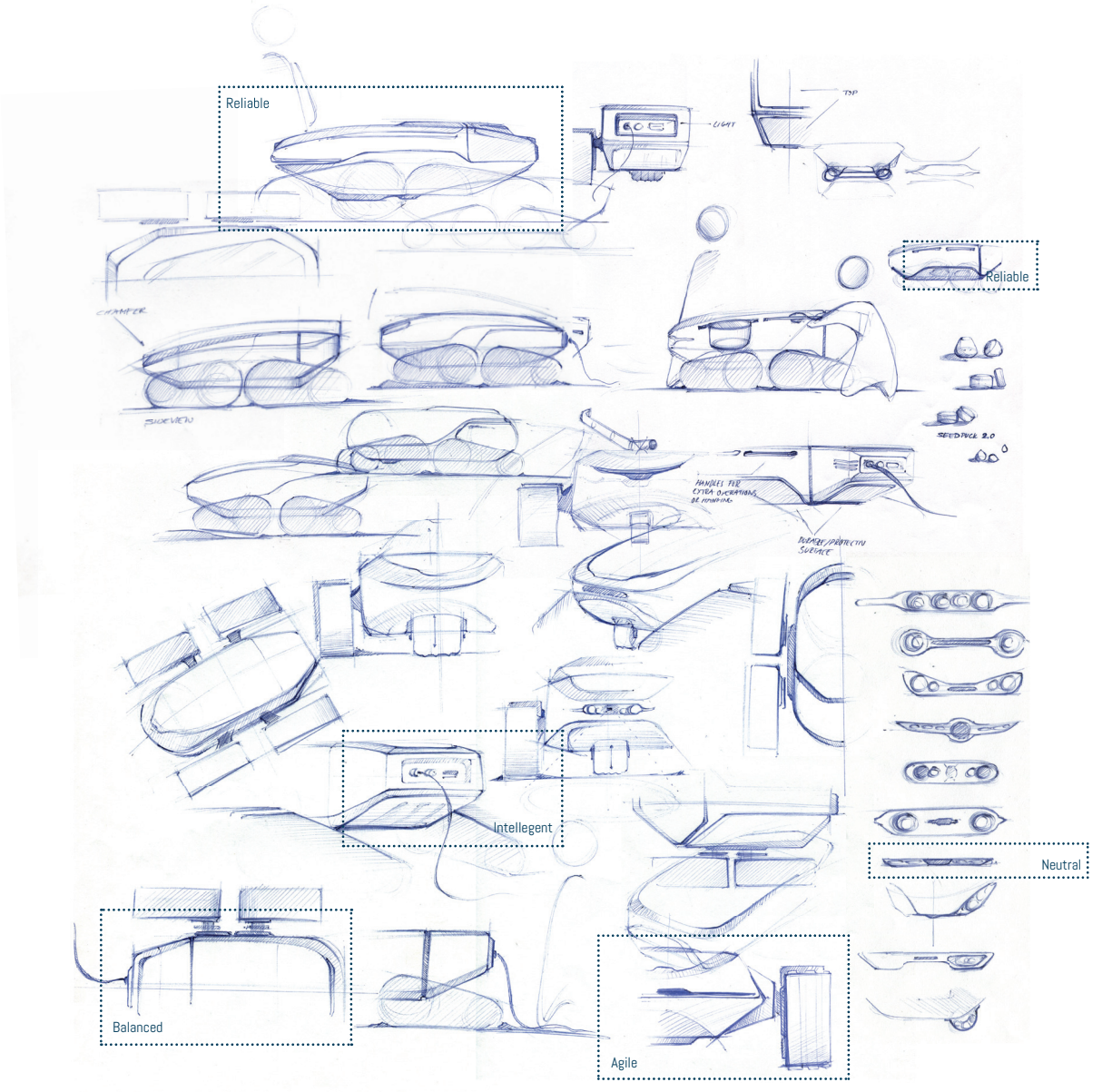
High visibility and fast identification of functions.
Visible and intuitive indication of technology and construction.

VISIBILITY
DETAILING



FRONT
Soft round and pinched shape

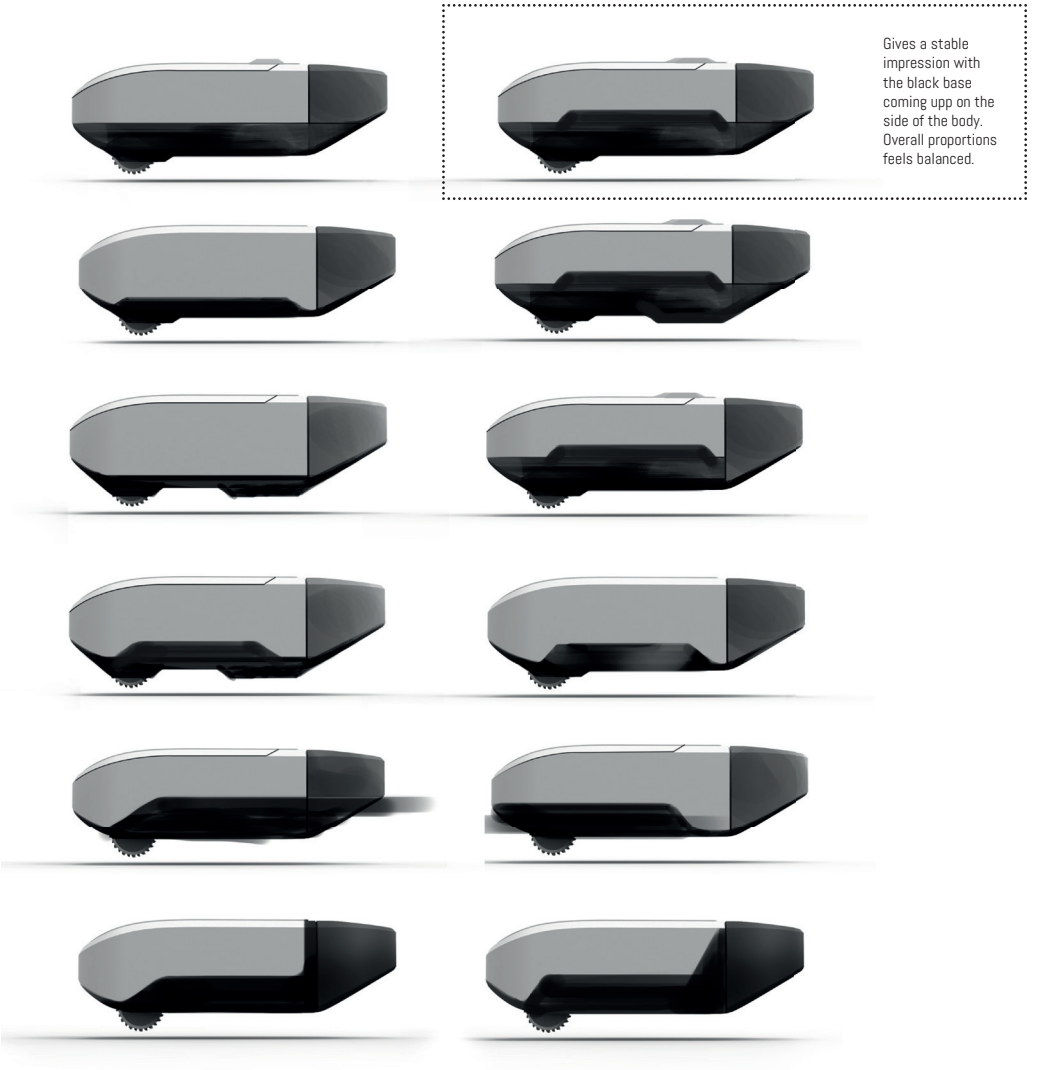
BACK
Raised rear part (battery)



FORM IDEATION ROBOT

I started by sketching side views to get a sense of the expression for the machine. I then tested some of them in foam to get the a volume and a 3 dimensional on my expressions. The 3 dimensional shapes then gave me a direction to sketch further on. I evaluated the sketches and concluded that everything that is based on geometric and equilateral profiles feels stable and reliable. Splitlines and separations feels intelligent and shows several functions. The protective surfaces make the product reliable and durable.

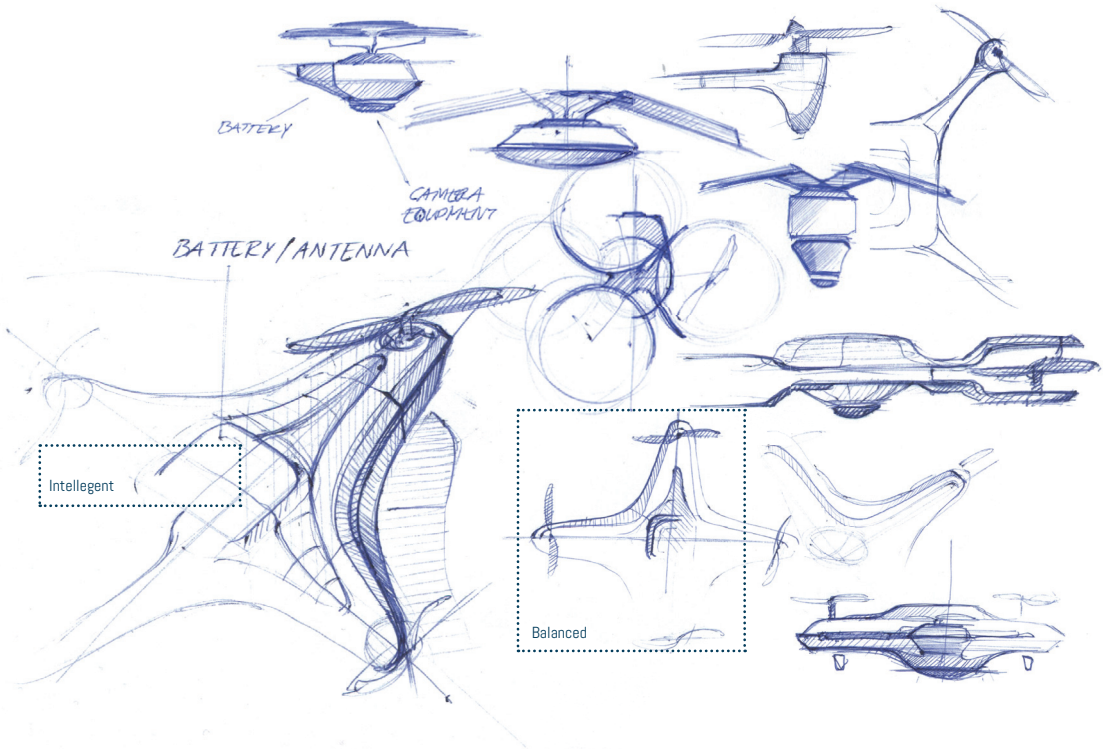
The sketches have been evaluated with a group of people and markings around the sketches show the parts that were worth to combine into a final shape.



Gives a stable impression with the black base coming upp on the side of the body. Overall proportions feels balanced.

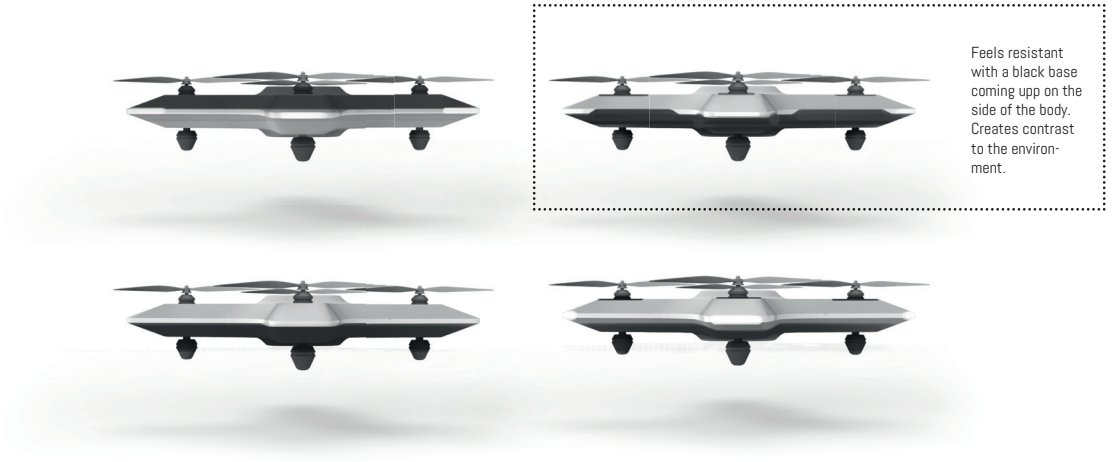
PROPORTIONS ROBOT

After I had decided on shape and profile I created a simple profile in CAD to test splilines and material substitutions in order to see the proportions on the body. The selected consists of a stable base that is moving up on the side to give an embraced expression. The battery is located on top and is also slightly enclosed by the base. On top of the surface is a split to separate the cover from the body.



FORM IDEATION/ PROPORTIONS DRONE

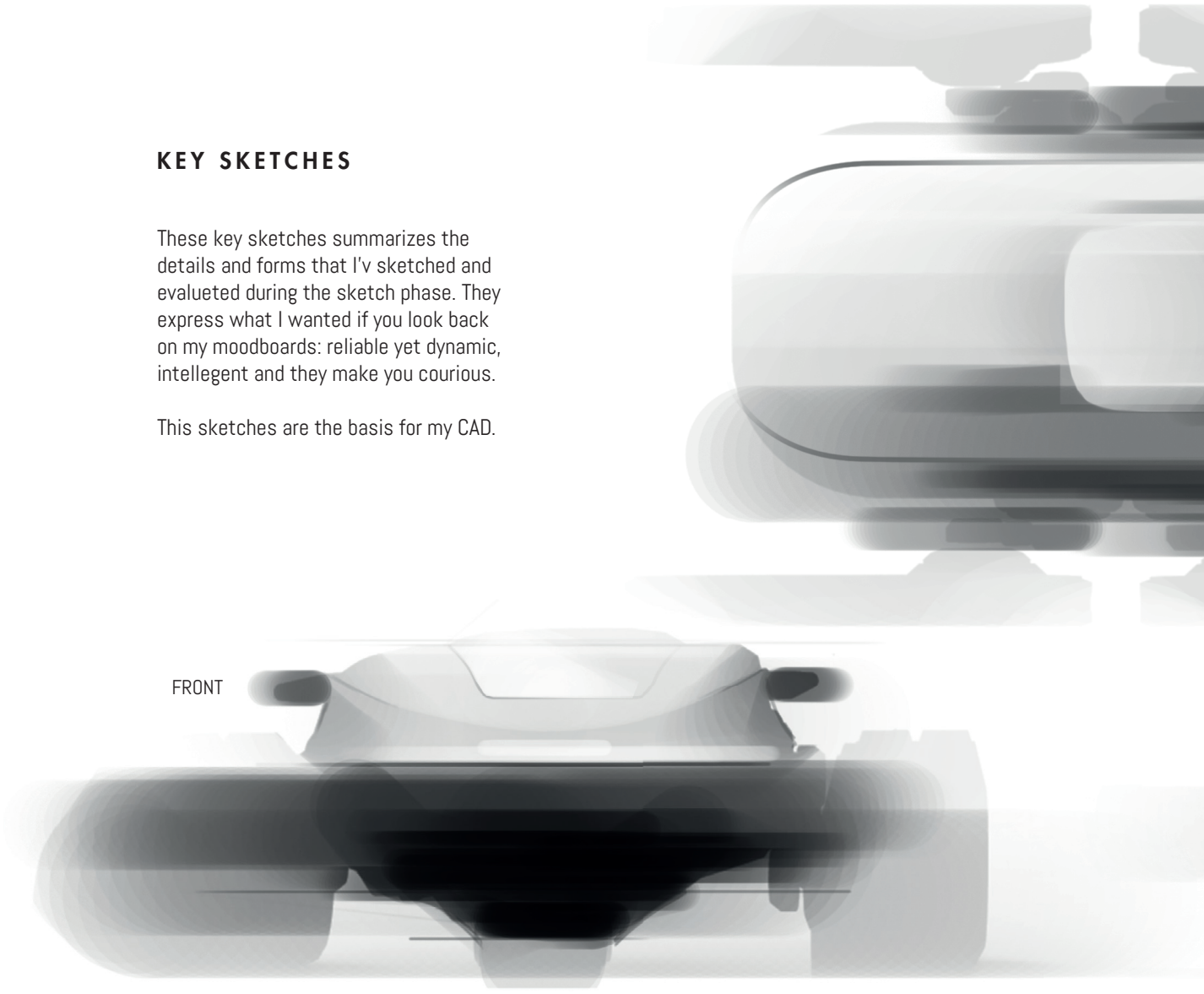
I have chosen to use a four-armed drone as they have good stability and a smoother and more stable expression. The drone uses form elements from the robot to create cohesivness in the concept. With color and proportions it should express durability and stability yet lightness and intellegence.



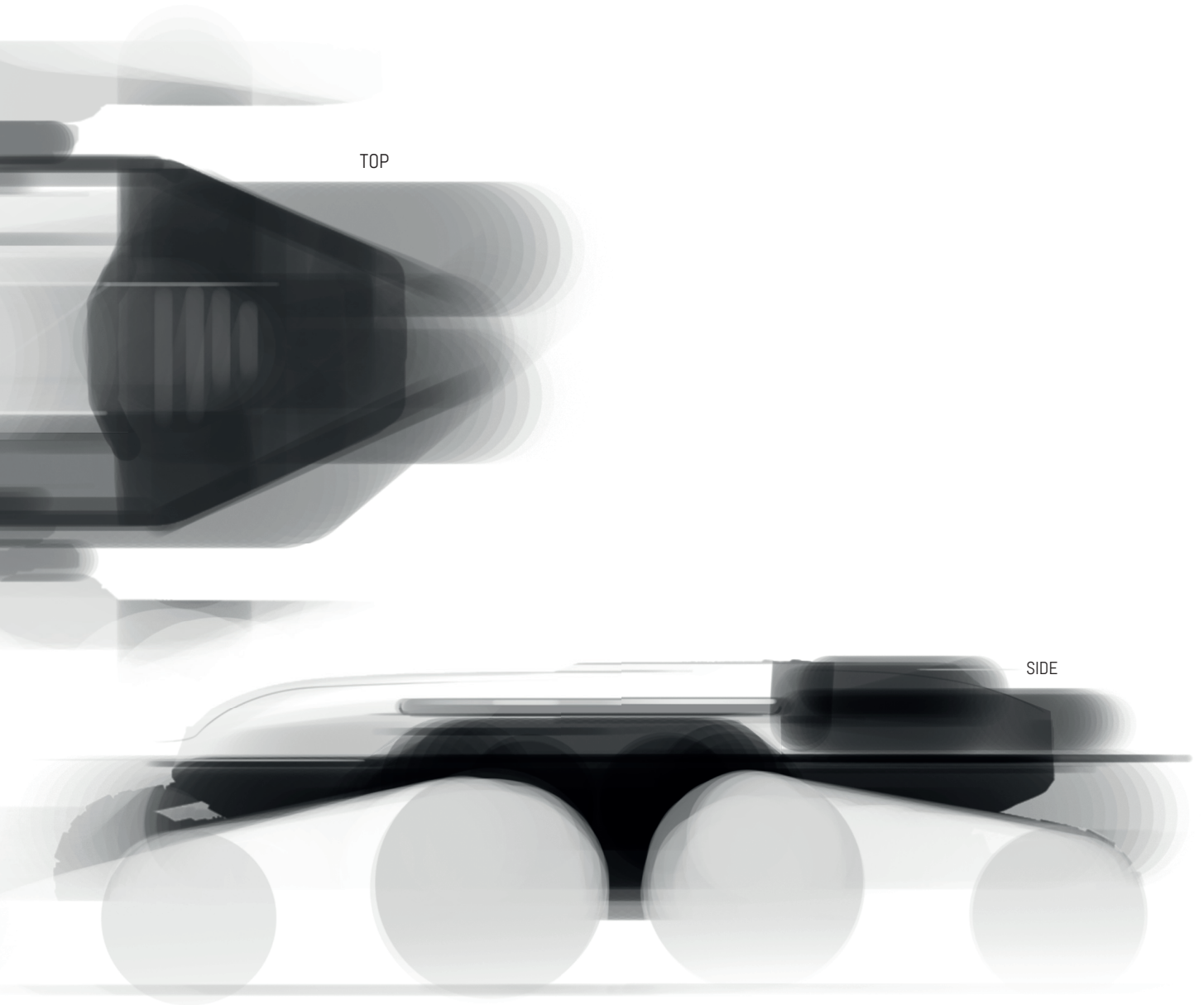
KEY SKETCHES

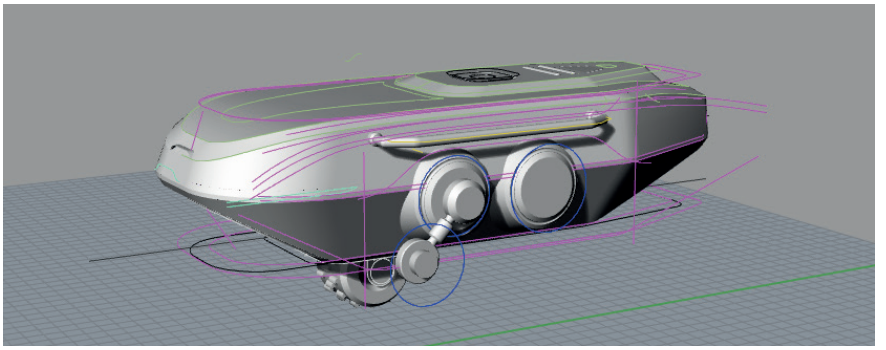
These key sketches summarizes the details and forms that I'v sketched and evalueted during the sketch phase. They express what I wanted if you look back on my moodboards: reliable yet dynamic, intellegent and they make you courious.

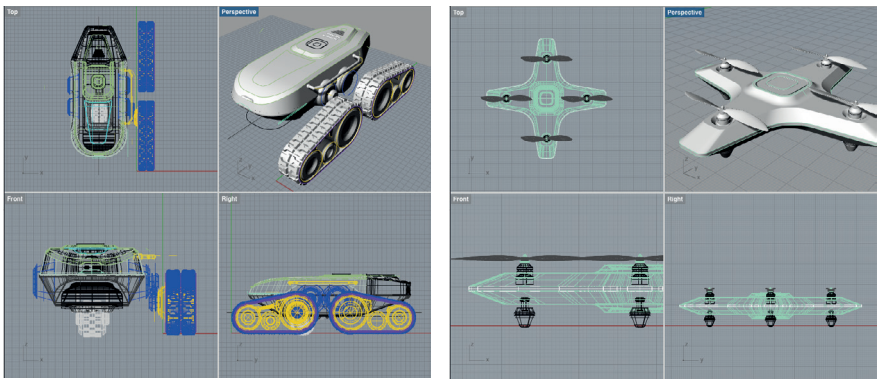
This sketches are the basis for my CAD.



FRONT

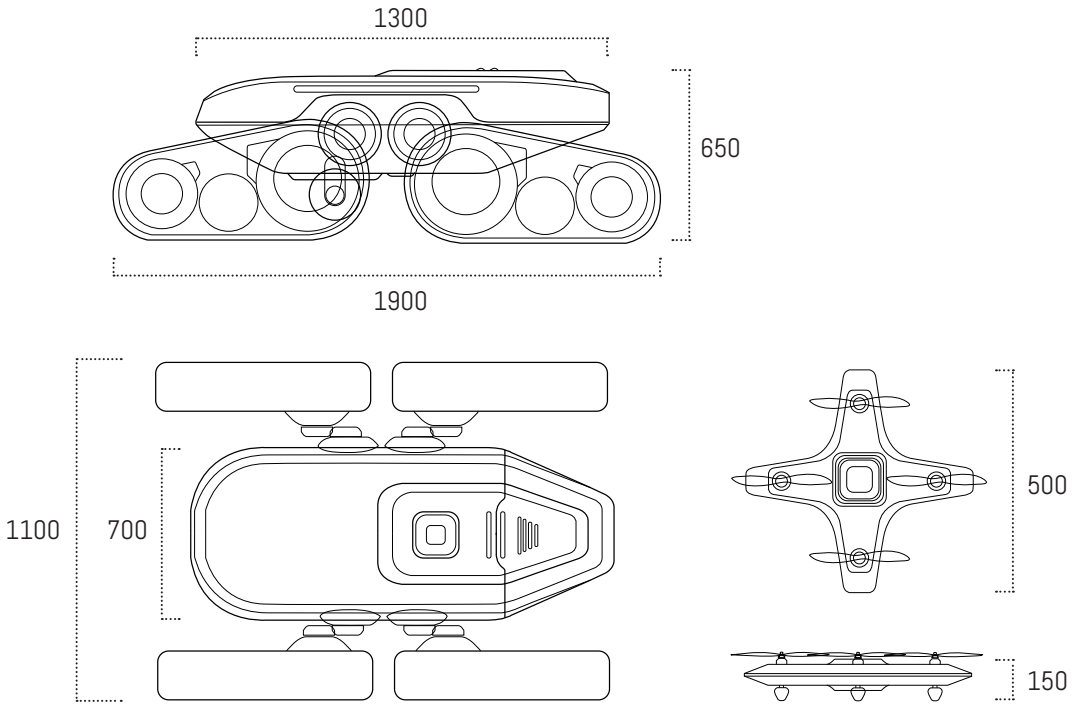

TOP
SIDE





RHINO CAD

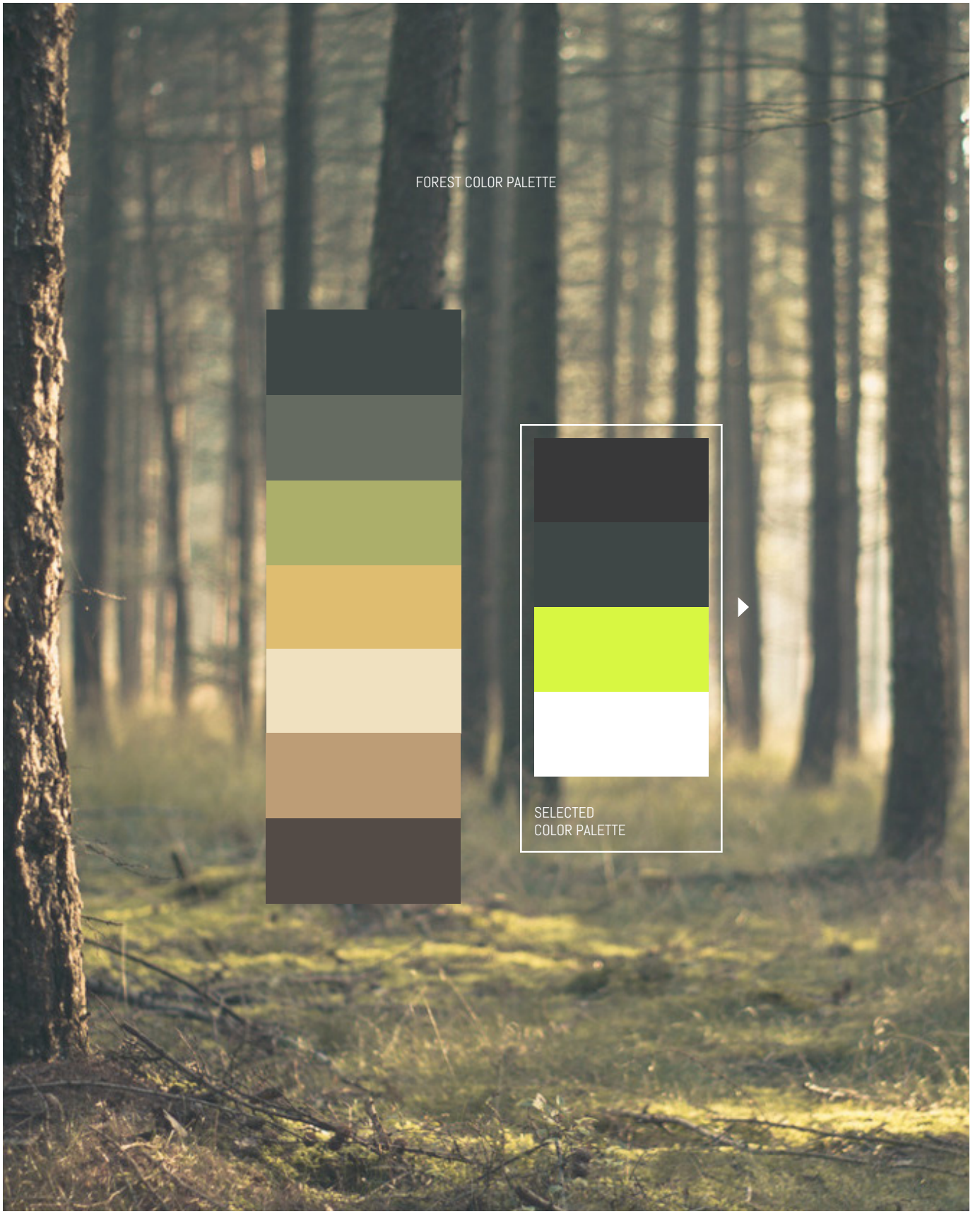
When I had the different profiles set I could start the work in Rhino to get a 3 dimensional shape to work with. At this stage it was clear that some parts of the model had to be tweaked in order to get the expression I was looking for. In this step I also added the technical parts, such as the scarification wheel, the joints between the body and the tracks and the cylinders inside the tracks.
I experimented with different details and ad-ons that would benefit the koncept.



MEASURMENTS

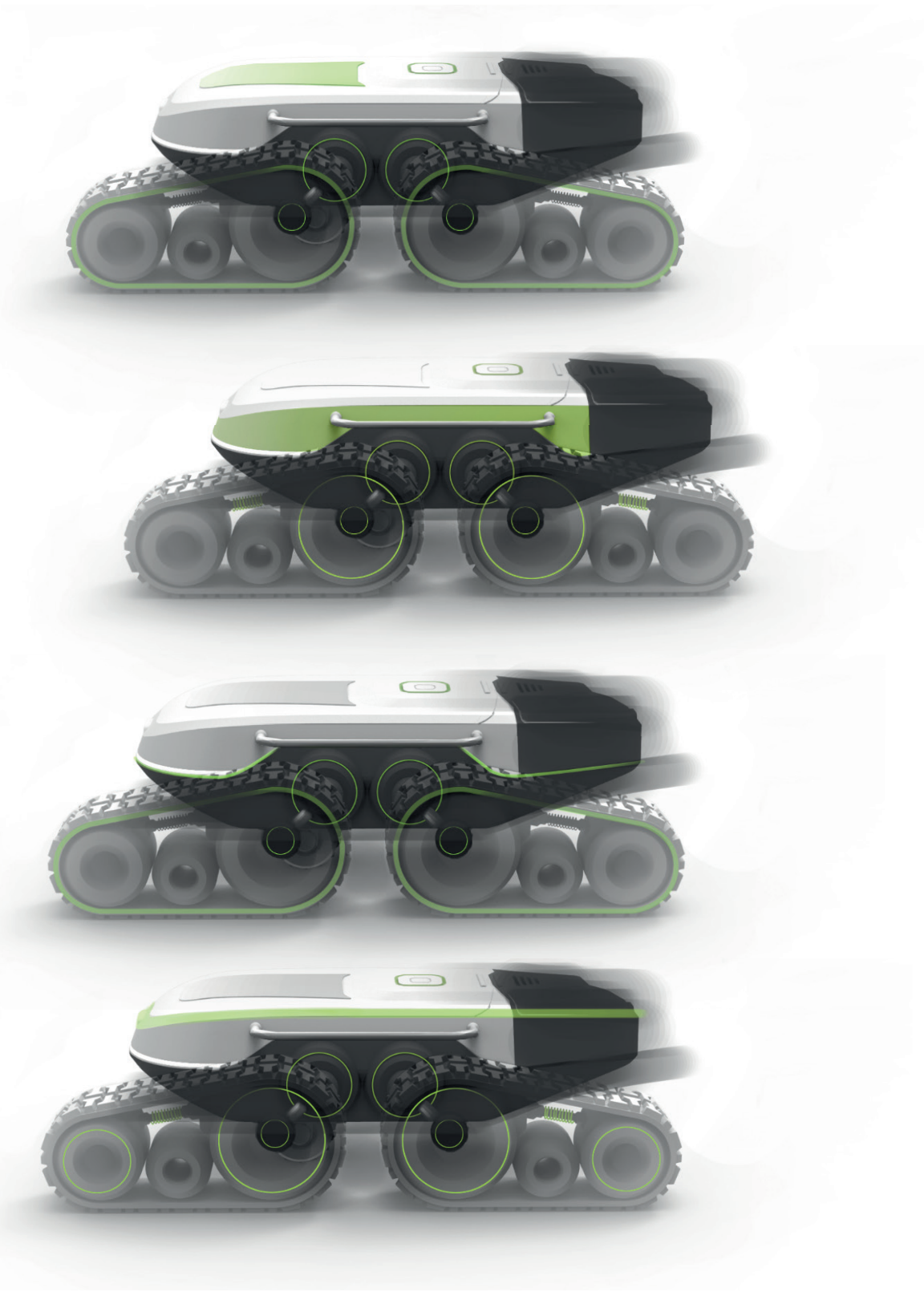
The robot has a size range of 1900x1100 mm this allows the operator to perform simple and short interactions with the robot. For example, if the robot would have bogged down in a ditch and requires a nudge in the right direction. The robot does not exceed the dimensions of a standard trailer because the idea is that the robots are transported with trailers or an other cargo solution.

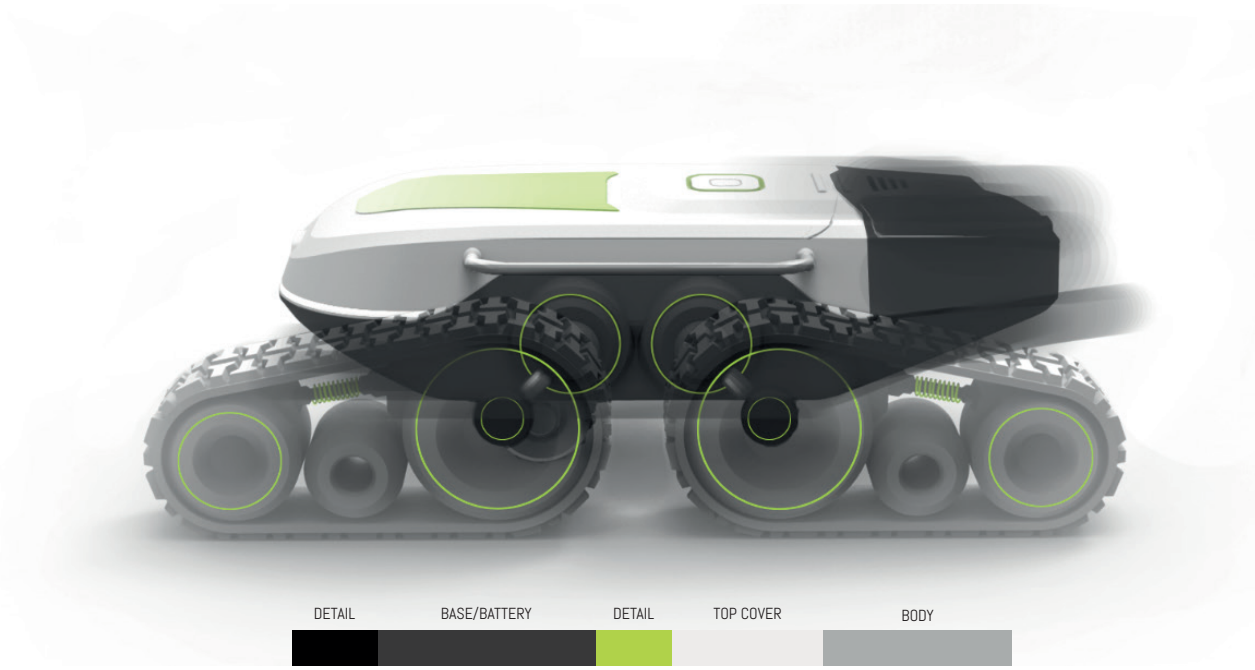
The drone have the dimensions of 500x500mm this to be easy to handle and carry for one person, the operator on site.


FOREST COLOR PALETTE
SELECTED
COLOR PALETTE

COLOR

The product should be visible in the environment it performs in but still express solidarity with the environment. It must be clear that the product belongs to the forest and not water for example.
If you examine the forest's own color scheme it varies in dark/deep warm colors from yellow to brown to green.
I've chosen to go with a dark green/black color in contrast to a light gray almost with color. And for special features and functions use a bright green to stand out from de calm and dark forest. The green creates a more intuitive product and shows important part.
Below is a set of different color combinations to explore balance in order to get the right expressions in the product.





CHOSEN COLORING

The selected color scheme reflects my vision and makes the product show innovation and strenght.
Dark and muffled tones cover the bottom part which then extends up the side to provide an embracing and stable expression. A matte rubber mat covers the "belly" for a sustainability.
Details are colored in the bright green color to indicate function or interaction. The top part of the product is covered in a light grey tone to create contrast against the dark ground.

The drone will also have a dark bottom part to create contrast against the bright sky and vice versa. Details and features will be colored in the bright green.

The color combinations are fresh and rich in contrast. They show the product as an innovative new product on the market.

FINAL RESULT

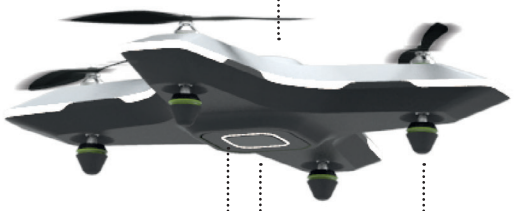
In the last phase I reveal the final form and concept. I describe the features in a simple and comprehensible way and also demonstrates the concept in its proper context with a scenario.

VISION 2030
FUTURE FORESTS

My vision for the future forest industry 2030 consists of a holistic solution that allows for a thought out and calculated reforestation with the goal of keeping the forests natural properties in mind.

My vision consists of three parts. A planning tool that sends responsive information to an operator who then takes the important decisions about the reforestation. And finally a seeding robot that carries out the work in a consistent and effective manner. how many robots that are working depends on the size of the area.

With this concept, I hope to open the eyes of the forest industry, which has been standing still in progress and need to take a step forward in order to meet the future demands awaiting.



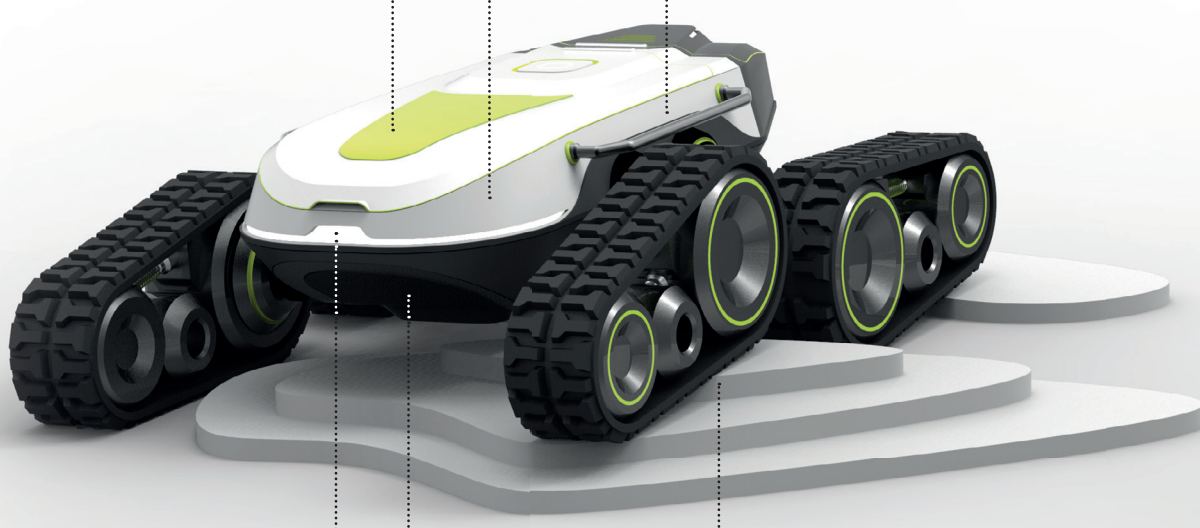
Propeller
Lightweigt

Antenna
For connecting to the interface

Light indicator

Feet
For landing on the ground

Camera equipment
For analysing the ground



Seed container

Handle
For shorter interaction
with the robot

Transparent window
To see amount of seeds left in container

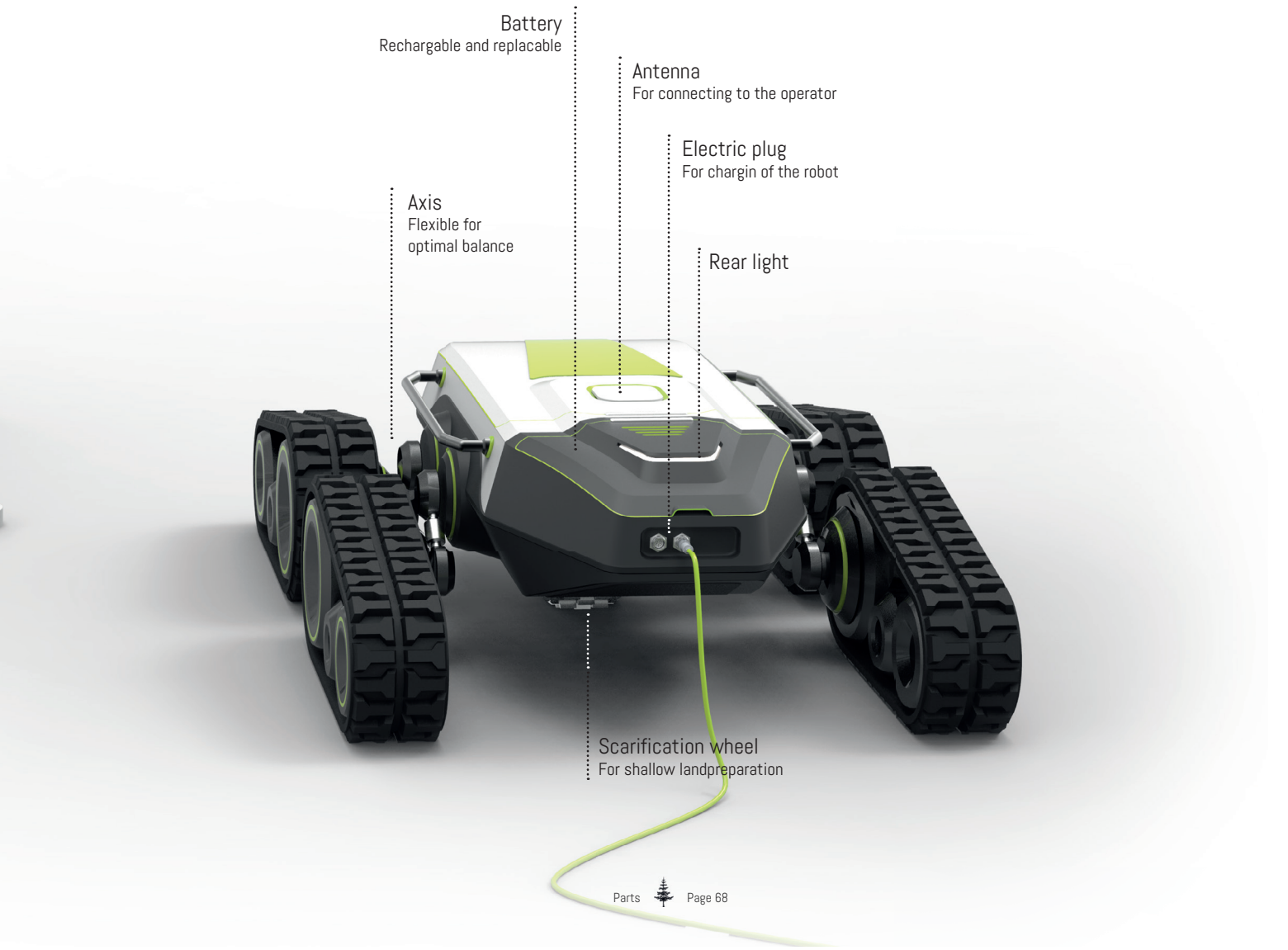
Rubber cover
For extra protection

Flexible tracks
For optimal balance

Front light
Illuminates when active

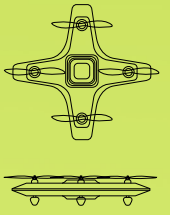
FUNCTIONS / USERS

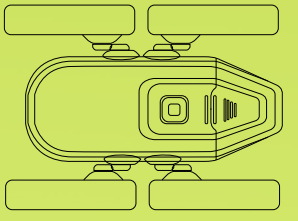
In these pictures you can see the final product with comments on functions and components.
To implement this concept would not be a huge step into the future, much of the intended technology is available ont he market, and has also been tested in various pilot projects. The biggest transformation would take place among the users, to dare to take the step into a new path in their forest aWpproach. What is seen as a huge opportunity right now is that a clear generational shift is taking place. Younger forest owners is taking over the forest from parents or grandparents. This younger generation is much more familiar with modern technique, and probably more open to change.

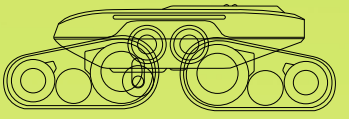


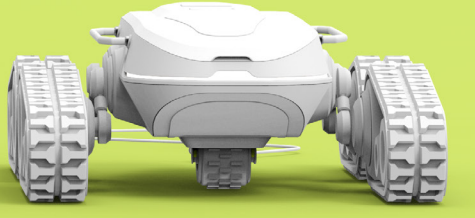
PROPORTIONS

On the picture you can see a comparison of scale and proportion. The robot and drone is set up against an average man, a larger car (a model often used in the forest) and a tree. The idea is that the operator should be able to interact with both the robot and the drone. With the robot the idea is simpler interactions such as helping it out of a pit or push it in the right direction if it gets stuck. The drone is manageable for one person and can easily be carried.

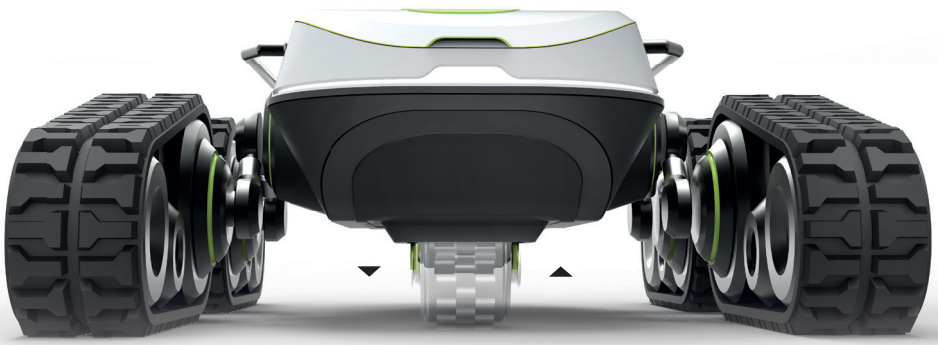








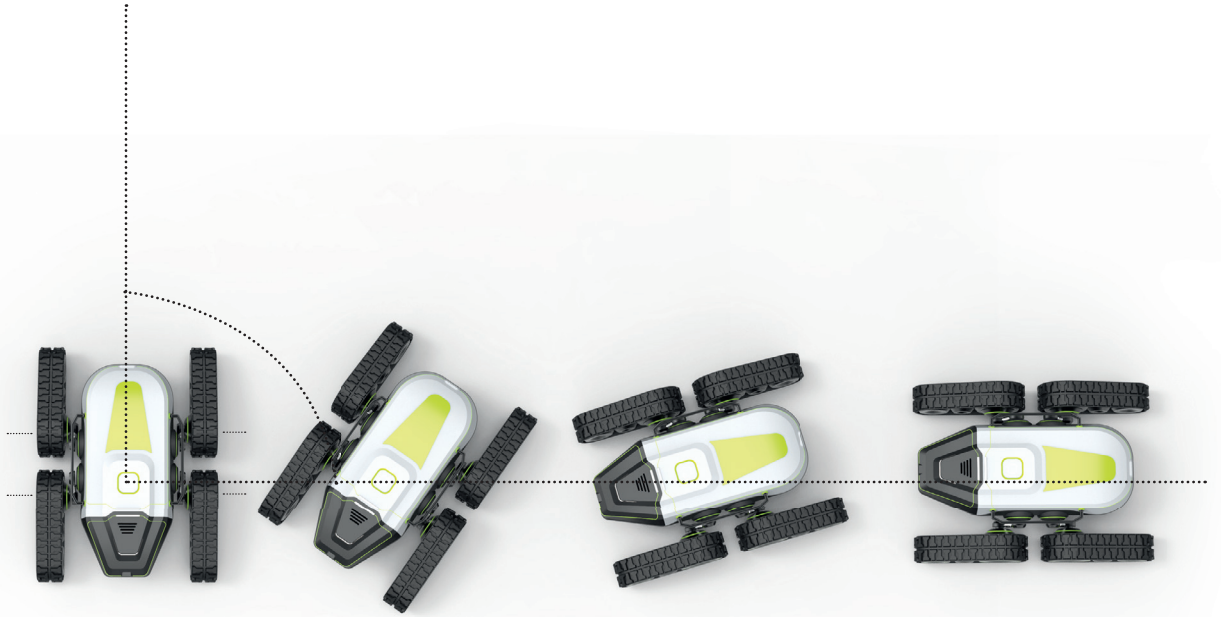
SCARIFICATION WHEEL
Raised and lowered
with on a rail



SCARIFICATION

Soil preparation is carried out on the specific points determined by the operator. These spots is suitable for the planting of trees according to the analisys. The machine starts by lowering the wheel until the robot senses with a simple sensor when it has reached the ground.

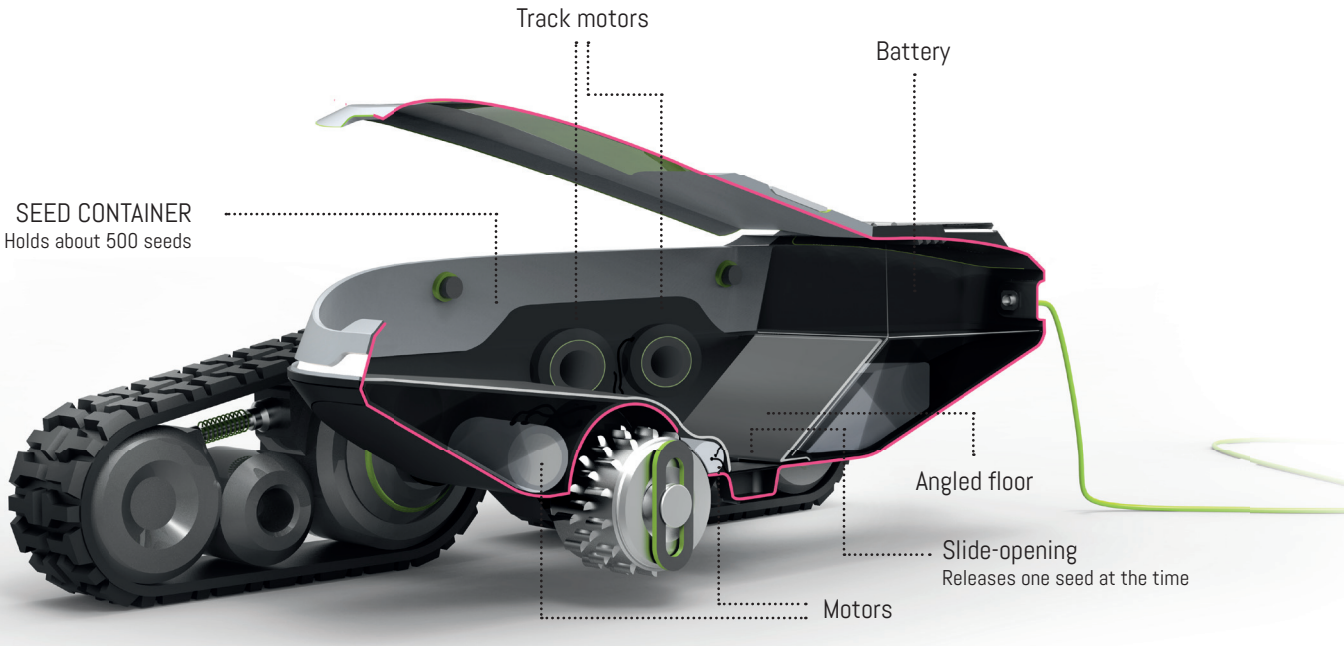
The wheel then starts its rotation and begins to scratch the surface of the hummus layer. A constant ground pressure is maintained during rotation to ensure a good preparation of the surface so you reache the capillary water.



MOBILITY

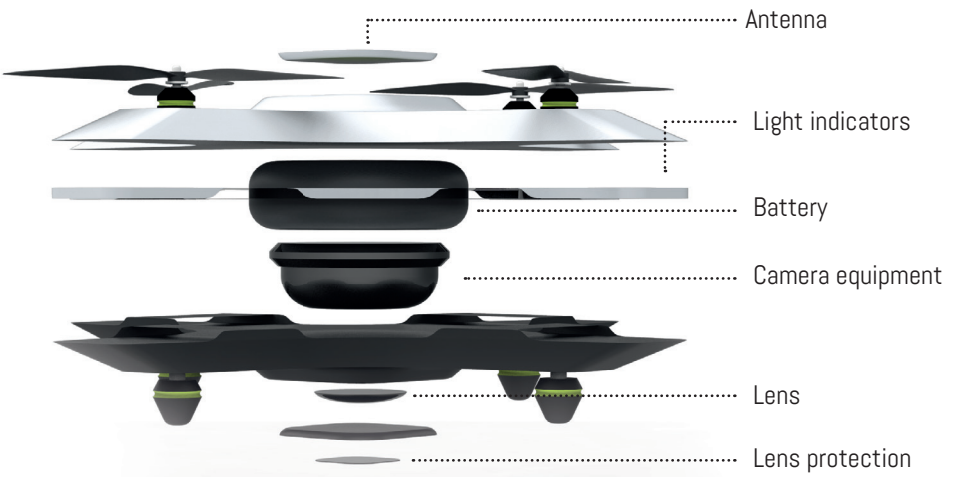
The robot makes its way with four small tracks. The tracks contributes to a good distribution of weight and is very suitable for soft ground surfaces. It also provides stability and balance to the product when in progress.

Each track is driven by its own engine, this makes it possible for the robot to turn almost around its own axis. When doing this the engines various in amount of force used on the different tracks.



TECHNICAL ROBOT

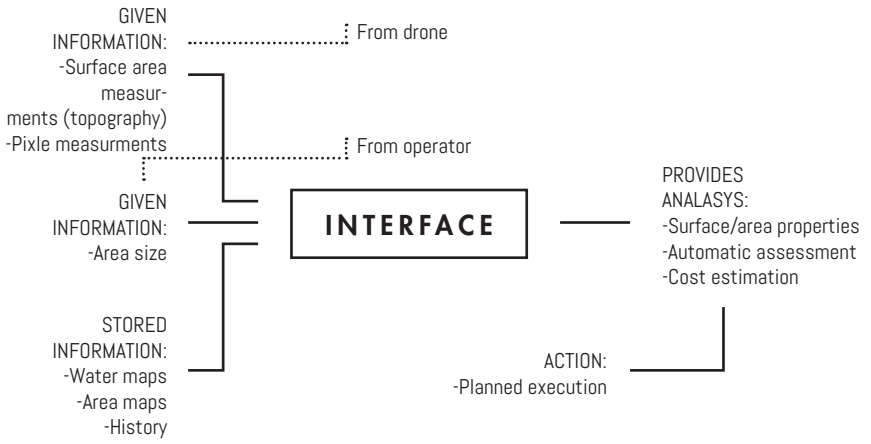
As I mentioned before the robot is driven by rechargable batteries. Each track has its own motor placed in the cylinder joining the track to the body. The joints of the tracks moves in two different directions, x and z direction. It makes the machine able to stay balaced om bumpy surfaces.
When performing the seeding process the robot starts the scarification wheel with the help of a seperate motor and lowers it to the ground. When touching the ground the wheel starts to spin. To place the seeds a lid is open on the pipe behind the wheel that lets one sack of seeds out at the time, this requires a small motor right next to the lid. The seed container is leaning down towards the opening. To make sure one sack of seed is released at the time a seed sack is first placed into a small box that then releases that single seedsack when needed.



TECHNICAL DRONE

The technology to measure distances with small cameras in high quality phots is about to come to market. Proffessor Shafiq Ur Rehman is one of those right now that are developing a technology that makes it possible to measure distances at a pixel level of a picture with a regular camera phone. In this way one can recieve information about for example small natural regeneratet areas as the drone is able to get closer to the ground to shoot. In addition to the camera a laser pointer is installed in the drone, it creates a topographic map in the software where you can get information on soil properties. The laser sends out rays at a steady pace, which then sends information about the distances when the beam has hit the ground.

The body also contains of a rechargeable battery, a transmitter and a motor to run the propellers.



INTERFACE STRUCTURE

Information from the drone and executed actions and planning by the operator is collected in this interface. The idea is that the interface either can be operated on a smart tablet or computer.

What you see on the image to the right is an example of how the interface can be designed.

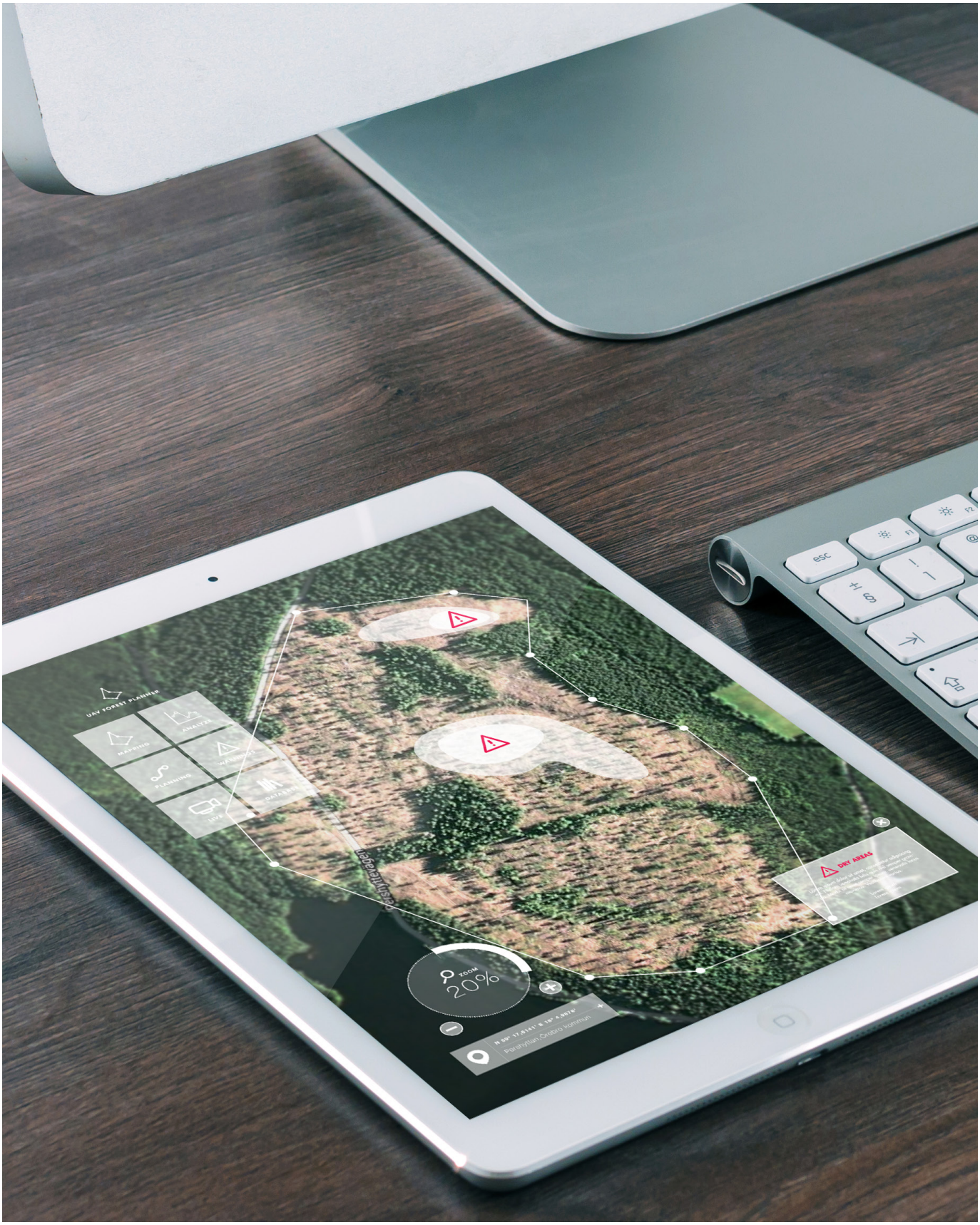
The main task for this interface is to enable a thorough and easy planning of the area for the operator.
Information from water maps (which gives a picture of how water flows in the soil, thus giving wet / dry areas), and area maps are stored in a database. These are included in the analysis made of the area before planting is carried out.

The drone perform measurements with laser and camera and collects information on natural regenerated areas and land surfaces. Combined with the information in the database, an analysis can be performed.

With this information, the operator can see if for example, there are areas that should be avoided or treated differently. This makes it easier for the operator to plan what kind of tree sort to be planted and were to contribute to a diverse forest.

It also allows for a calculation of the costs in advance and an estimation of exactly how much seeds need to be placed, so as little seeds as possible is wasted or positioned incorrectly.

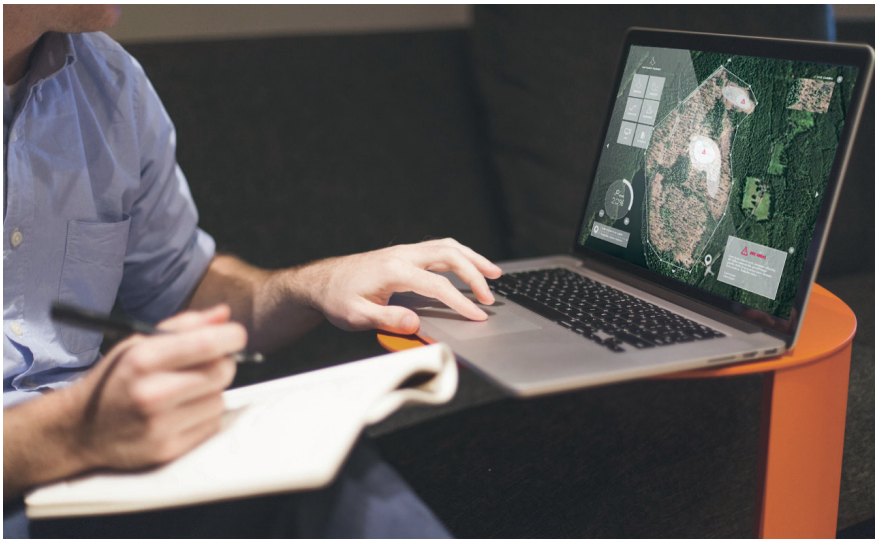
If the operator does not have much knowledge and feel unsure about deciding everything manually the software can provide an automatic assessment and implementation.
There are also stored history available, where you can see the actions been performed in earlier stages.


UAV FOREST PLANNER
ANALYZE
MARKING
WARNINGS
PLANNING
DATABASE
LOG
DRY AREAS
ZOOM
20%

SCENARIO

My concept has specified the method of reforestation in the planning stage and streamlined the execution of reforestation through a mechanization.

Here I will explain with pictures and text how the process works and what steps you go through to perform a new kind of reforestation.



SCENARIO STEP 1

1. Logging or decisions to reforest the area has been taken.

2. A plantation leader is put as responsible for the reforestation.

3. The planting leader uses the drone to make an analysis of the area.

4. The planting leader receives data and can process it right away or at any other place and prepare for reforestation.

Optionally, the operator can choose to go out with all the equipment directly to the site to analyze and then instantly sow, this would be more feasible with a small-scale site.

SCENARIO STEP 2

5. An operator takes the robots to site and can self-manage the loading and unloading.

6. Before the robots move to the reforestation area they are filled with seeds and undergoes a simple control.

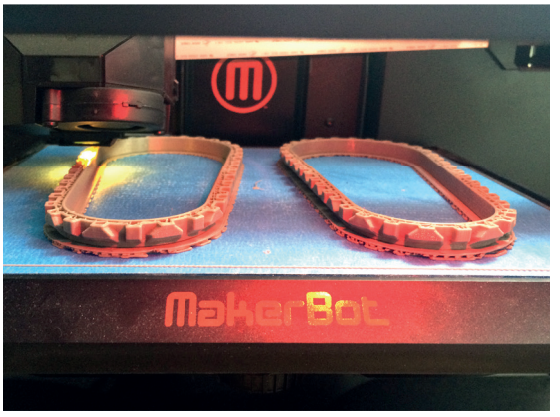
7. The robots are manoeuvered with a simple tool in the interface or automatically via a preset destination in the interface.

SCENARIO STEP 3

8. The robots is started at the site and begins to reforestate after the planned route and instructions.

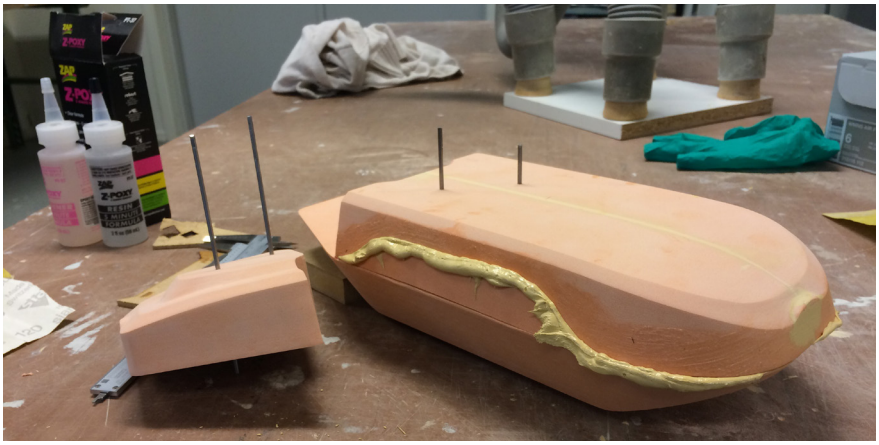
If the area is large and it's a extensive project there may be a good idea to use several robots and use the drone as "the eyes" to keep track of all components.

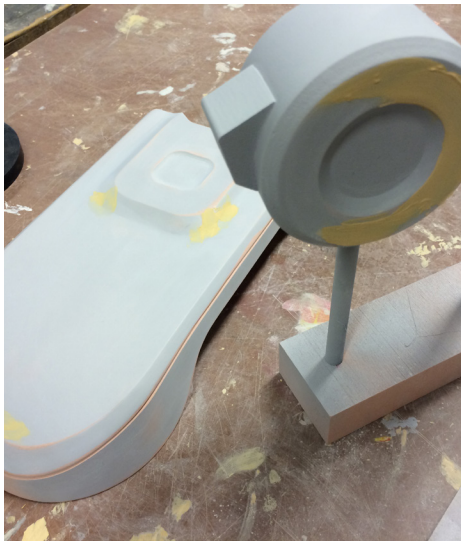
9. When the process is complete, they are loaded back on the truck and taken back to the company.



MODELMAKING

The final model is built in a scale of 1: 4
A basic model has first been made in yellow foam to confirm the 3 dimensional form. Subsequently, the product has been drawn up in CAD and sent to milling and 3D printing. Other details are lathe and/or created by hand.





DEGREE THESIS
FUTURE FOREST

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INDUSTRIAL DESIGNER


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STEP 1 ANALYSIS
STEP 2 PLANNING
STEP 3 EXECUTION
PLEASE DON'T TOUCH THE MODEL

CITATION

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Zero Mission:
http://www.zeromission.se/faq/skogsprojekt/
Wikipedia:
http://en.wikipedia.org/wiki/Reforestation
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NoltFox:
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Rain:
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Sensors:
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Boston Dynamics:
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Reports:
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"Sådd av tallfrön med vattenryggsäck: En laboratoriestudie" - Carolina Sundin
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Ingegerd Backlund, Urban Bergsten
"Harvesting in the Boreal Forest on soft grounds" - Jeanette Edlund

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