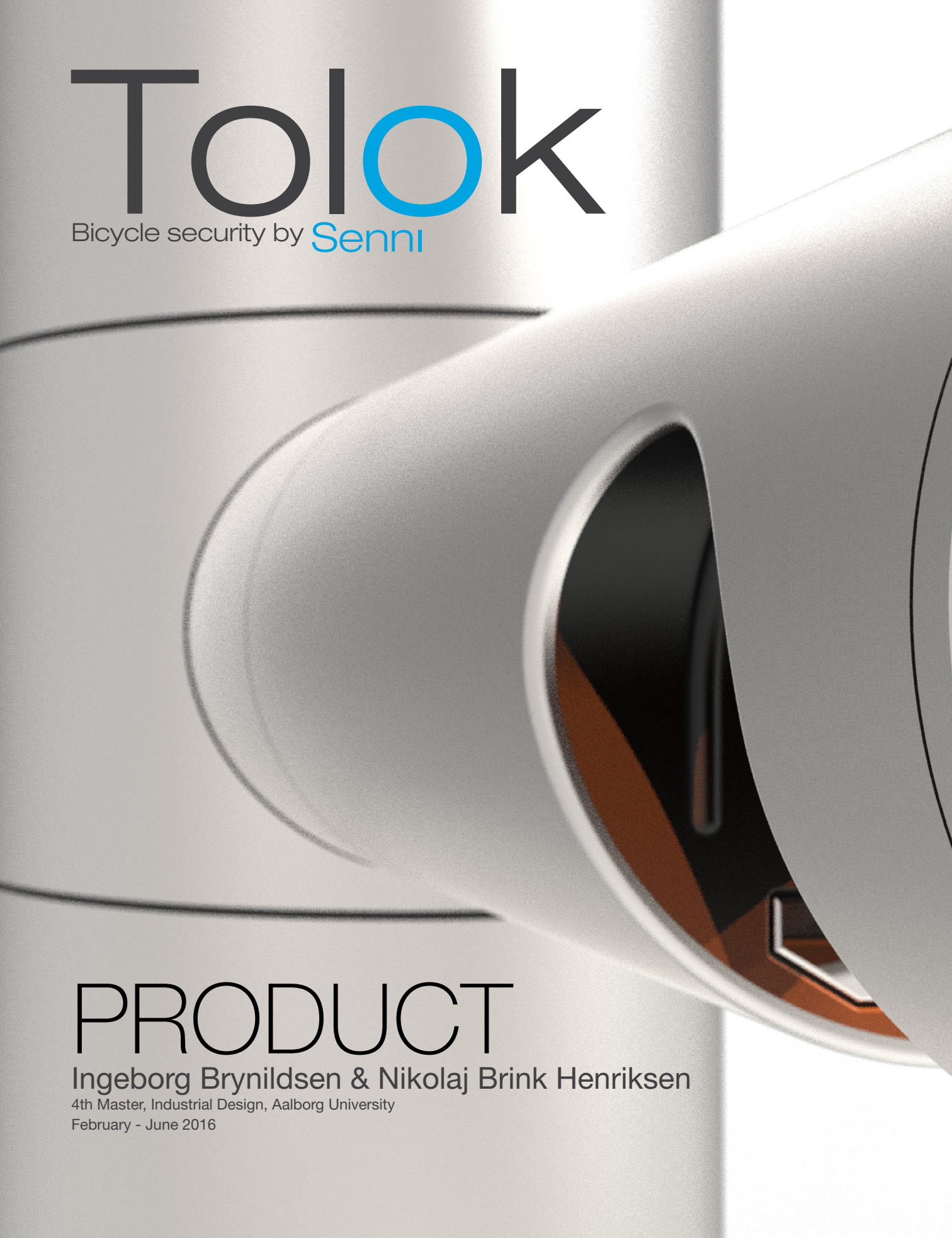
Tolok

Bicycle security by Senni



PRODUCT

Ingeborg Brynildsen & Nikolaj Brink Henriksen
4th Master, Industrial Design, Aalborg University
February - June 2016

TITLE PAGE

PROJECT TITLE
Tolok, Bicycle security by Senni

PROJECT THEME
Bicycle security system

SEMESTER
Master Thesis (MSc04)

PROJECT PERIOD
01.02.2016 - 25.05.2016

MAIN SUPERVISOR
Finn Schou

TECHNICAL SUPERVISOR
Jørgen Asbøll Kepler

NUMBER OF PAGES
20

NUMBER OF CHARACTERS
8,977

NUMBER OF REPORTS
2

Ingeborg Brynildsen

Nikolaj Brink Henriksen

TABLE OF CONTENTS

INTRODUCTION

This is the product report for the bicycle security product Tolok. The product report is intended as a brochure to present the design and the functions of Tolok for possible investors or customers.

Bicycles are a popular means of transportation for a lot of people around the world and a lot depend on their bicycle for transportation. Unfortunately the result of cheap locks, bad bicycle racks and poor information on proper locking techniques, results in bicycles being an easy target for bicycle theft. In Denmark alone 190 million Danish crowns are paid out in insurance claims each year as a result of the more than 60 thousand bicycles stolen.

Tolok is a bicycle rack, specifically designed to allow for both easy and secure locking of the most common bicycle types in the urban environment, with an integrated lock and easy interaction Tolok is the new design of the outdated bicycle racks.

CONVENIENT BICYCLE LOCK

Bicyclists in the urban environments are plenty and each year more than 550 thousand bicycles are sold in Denmark alone, but unfortunately more than 60 thousand bicycle are stolen each year as well, because bicycles are in fact very easy to steal, as they do not weigh that much and high security locks are both heavy and unhandy to bring along, so people do not use them that often.

Bicycle users therefore need a solution to provide their bicycle with security and themselves with an easy to use, clean and comfortable locking solution, that can keep their bicycle from being stolen and give the thieves a harder and more time consuming theft.

Tolok is a bicycle rack designed to provide bicyclists with a locking solution for their bicycles that is both user and bicycle friendly. Tolok has an integrated locking system that enables users to avoid having to carry around heavy locks to secure their bicycle, when parking their bicycle in the urban environment.

Tolok is the new and easy to interact with bicycle rack, Tolok ensures that the user can safely leave their bicycle in Tolok's care, while they enjoy the city.

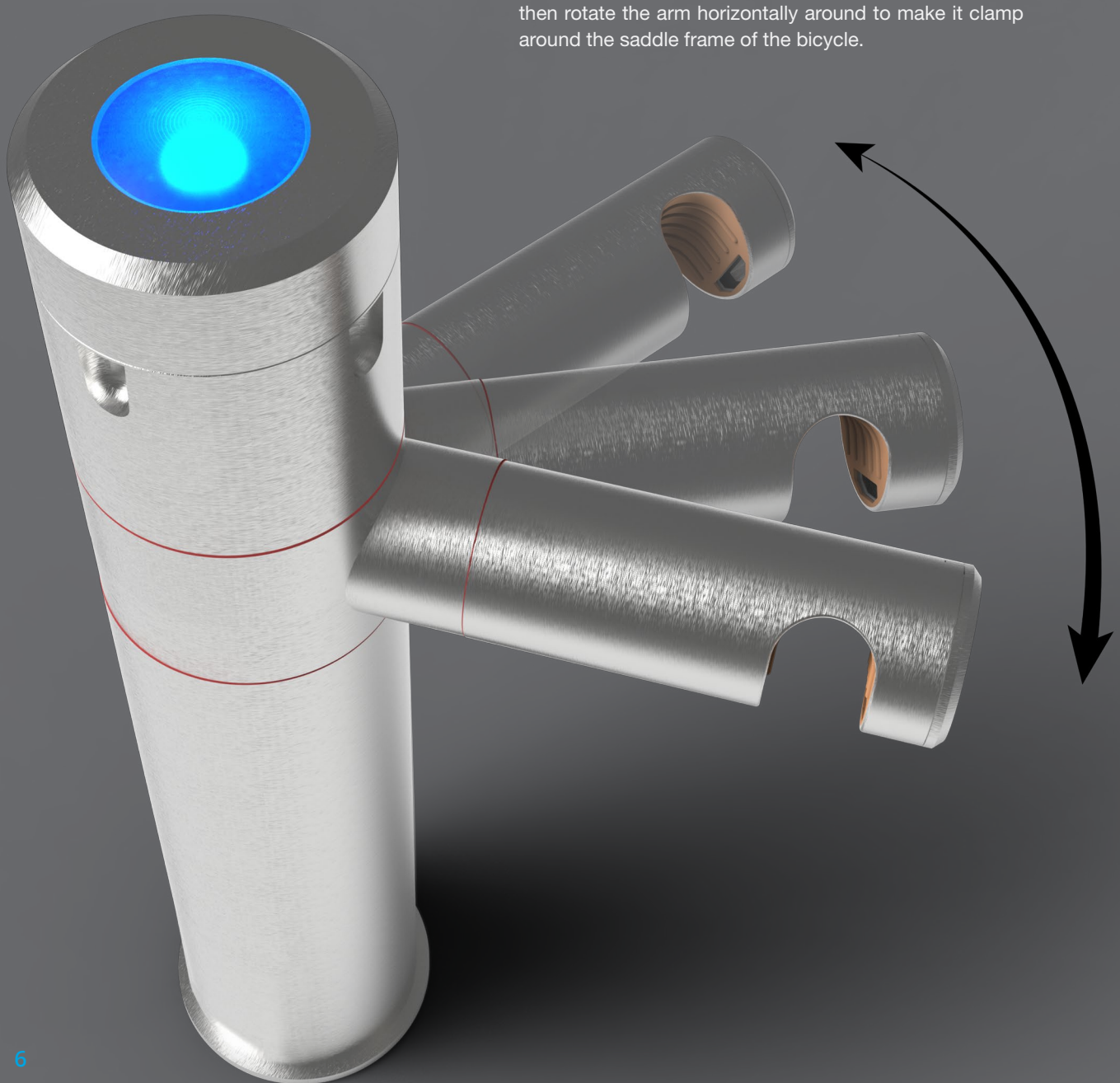
Tolok makes it quick and easy for the user to lock their bicycle in only three steps, just as many as when locking a bicycle with a normal mounted bicycle lock; tip the arm over the bicycle frame, twist the arm and scan your travel card and the locking bar is activated.

With the simplistic design of Tolok it would be possible to apply coating in different colors in order to enhance its function and make it stand out in the cityspace. By changing color on Tolok, it would be possible to gain relatable colors themes, which users would recognize and associate to certain brands and in that way gain commercial space. With the possibility to apply colors to Tolok it also opens up for the ability to provide the users with certain feelings when using it. As example dark blue with is associated with safety and authority.

ADAPTIVE

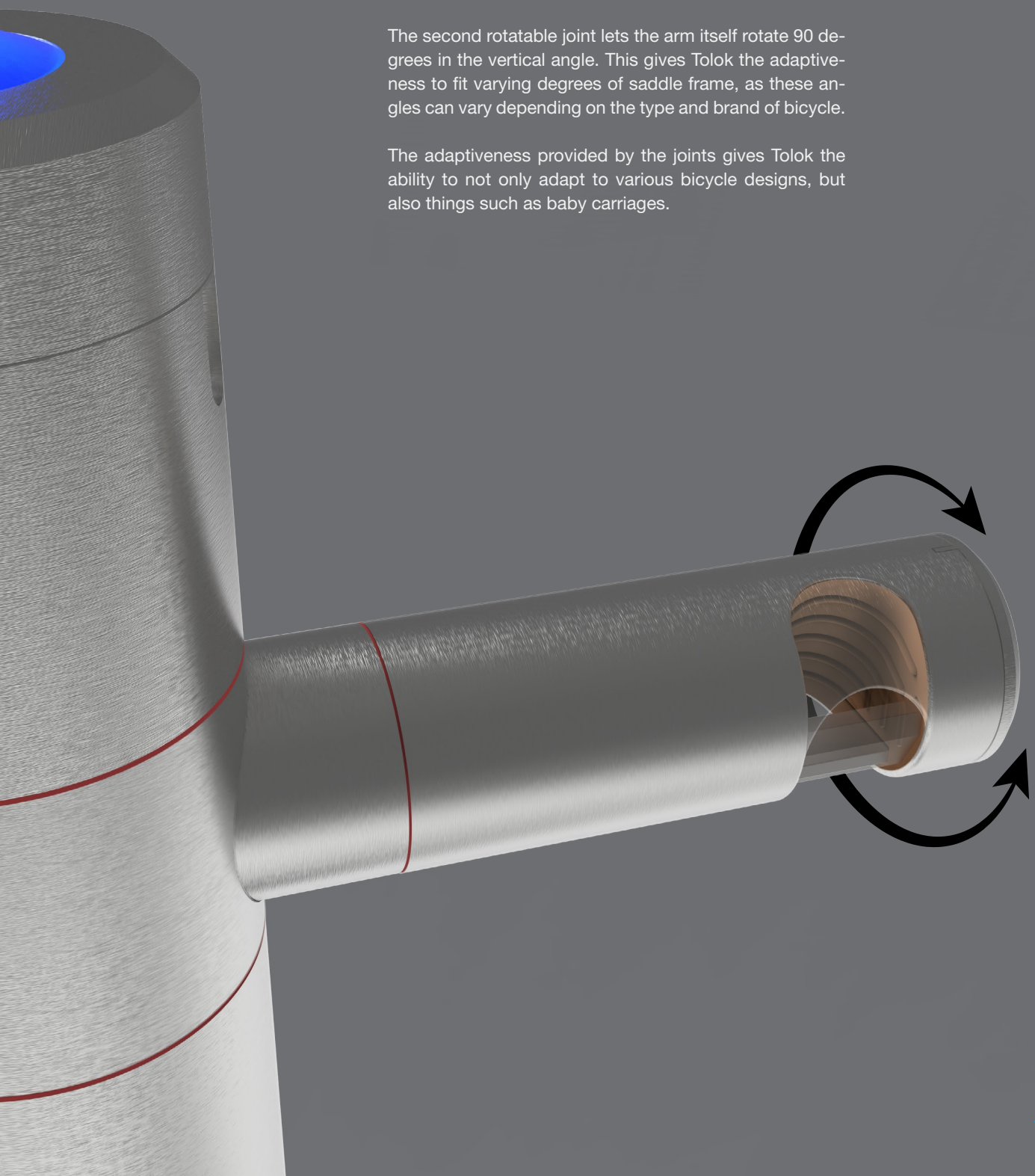
Tolok is equipped with two rotatable joints to add both user friendliness and adaptability to various bicycle types and varying saddle frame angles.

The biggest joint is mounted on the main body itself. This joint allows the users to drive up to the side of Tolok and then rotate the arm horizontally around to make it clamp around the saddle frame of the bicycle.



The second rotatable joint lets the arm itself rotate 90 degrees in the vertical angle. This gives Tolok the adaptiveness to fit varying degrees of saddle frame, as these angles can vary depending on the type and brand of bicycle.

The adaptiveness provided by the joints gives Tolok the ability to not only adapt to various bicycle designs, but also things such as baby carriages.



VISIBILITY

Tolok is equipped with high quality LED lights that glows in the familiar blue color of the travel card check-in and check-out devices.

These lights are turned on when it is not occupied, which makes the free bicycle racks easily visible during both day and night.

The blue light makes it recognizable by indicating that the bicycle rack's locking mechanism needs activation in form of the travel card. Equipped with an NFC system users can quickly activate Tolok with their their travel card by holding it up to the blue light, as with existing travel card equipment.

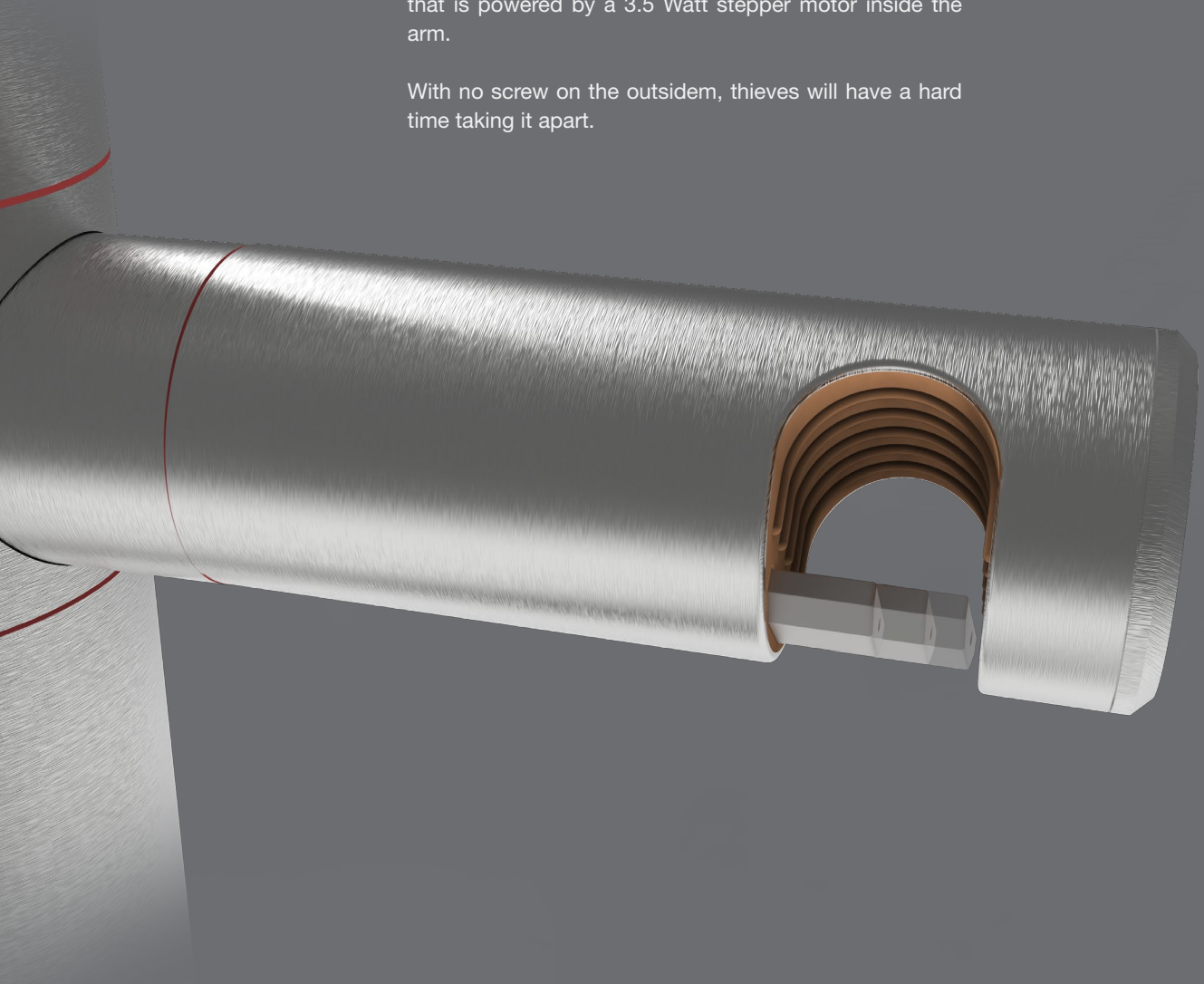
SECURITY

Tolok provides its high security with its 12mm thick by 44mm wide polished stainless steel locking pin.

The lock moves collinear to the direction of the arm and will in its locked state close off the hole in the side of the arm. The hole allows parking of bicycles with a saddle frame of up to 46mm, which is more than enough for the average 35mm of city bicycles.

The lock is motorized and will activate upon scanning of the users travel card. Once activated the lock itself will be pushed out of its socket by the spindle gearing system that is powered by a 3.5 Watt stepper motor inside the arm.

With no screw on the outsidem, thieves will have a hard time taking it apart.



MATERIALS & EXPLODED

Tolok's corrosion resistant stainless steel, type 316, construction ensures a long life time in satly environments like those found along the Danish coastlines.

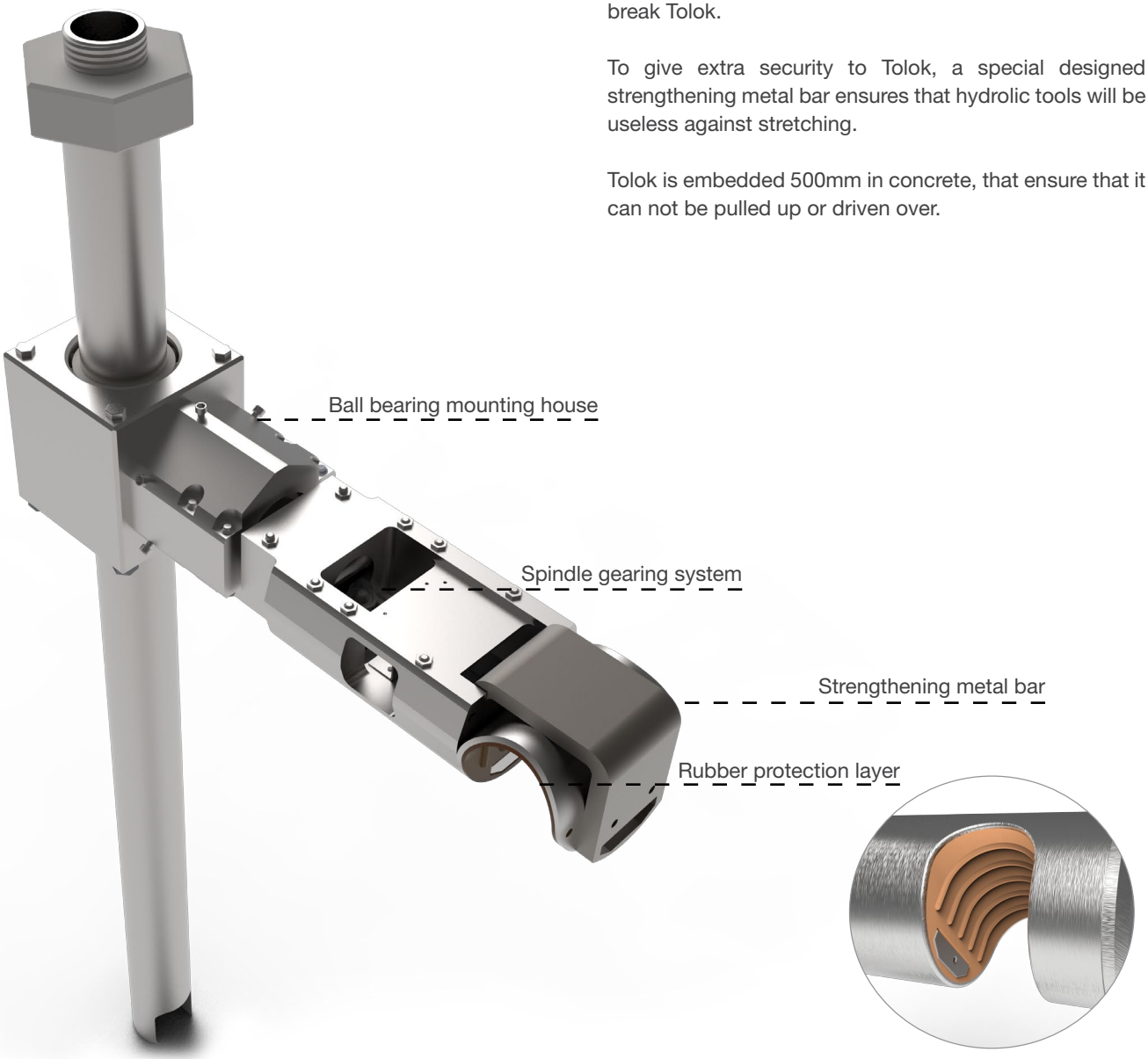
A rubber protection layer guarentee that the user's bircycle remains unscratched while using Tolok.

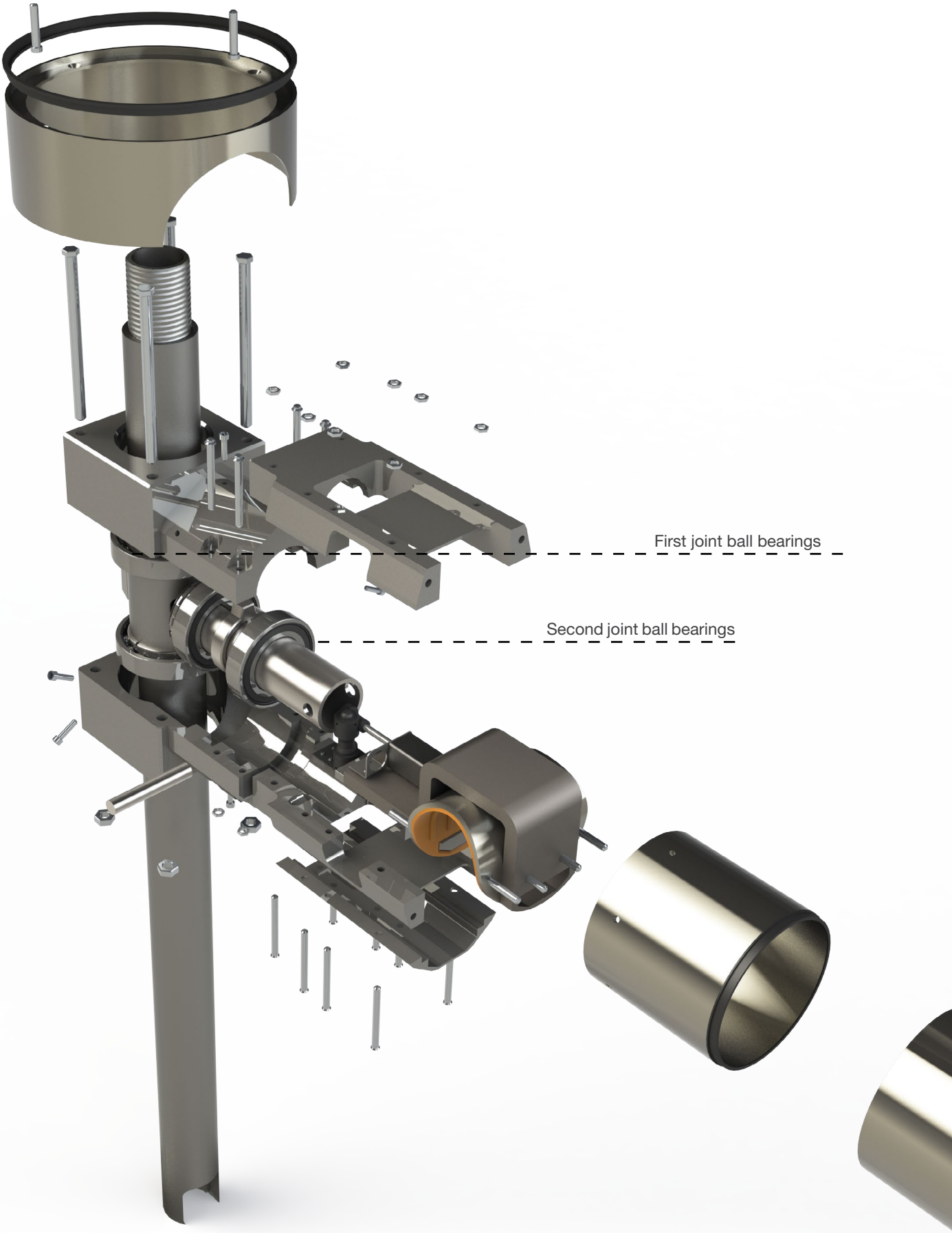
Ball bearings in the rotational joints gives a smooth and comfortable interaction with the arm.

Tolok's size makes it impossible for bolt cutters to reach around so thieves will think twice before attempting to break Tolok.

To give extra security to Tolok, a special designed strengthening metal bar ensures that hydrolic tools will be useless against stretching.

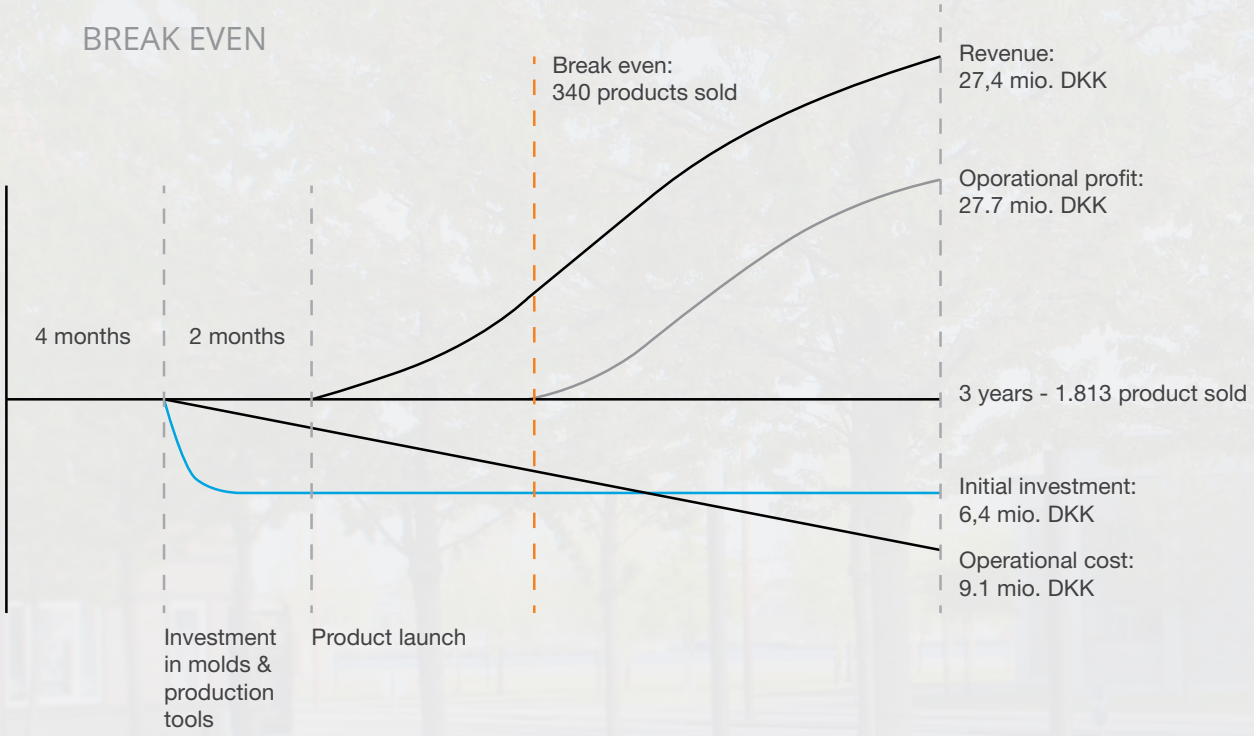
Tolok is embedded 500mm in concrete, that ensure that it can not be pulled up or driven over.




First joint ball bearings
Second joint ball bearings

BUSINESS

BREAK EVEN



Tolok is ideal to place at bus stations, train stations, schools, apartment buildings, parks and other public places where bicycle are often parked and where thieves are always on the hunt.
The production price is estimated to DKK 9,411. This accounts for things such as molds and assembly. When adding tax and coverage the retail price is DKK 35,290.
This price is very competitive when comparing to products within the cityscape.
It is estimated that around 1,813 product will be sold within the first 3 years on the Danish marked, this could be expanded significantly if the rest of European was considered as a sales marked. The break even would be reached within a year and a half. Above the break even can be seen.

BRANDING

Tolok will be showcased on different fairs in Denmark and in other countries to create awareness about it.

It would be ideal to have a collaboration with insurance companies, because of the large amount of insurance claims that are paid out each year as a result of bicycle theft.

Some of the insurance companies payouts could be prevented by installing Tolok around the cities.

In order to properly explain and create attention around Tolok a campaign could be held, similar to previous campaign where people are reminded to use their bicycle helmets. By making a collaboration with Senni in order to publicize Tolok, the insurance company express to their customers that they care about their everyday problems and could gain more customers.
It could also be possible for the insurance customers to gain some benefits by using Tolok, as cheaper parking prices or notification on special offers.

Another approach could be guerrilla marketing, where Tolok is installed temporary on highlighted spots and made available for testing by potential users. An ad on it could be to allow free parking for a limited time.

EXPANDABILITY

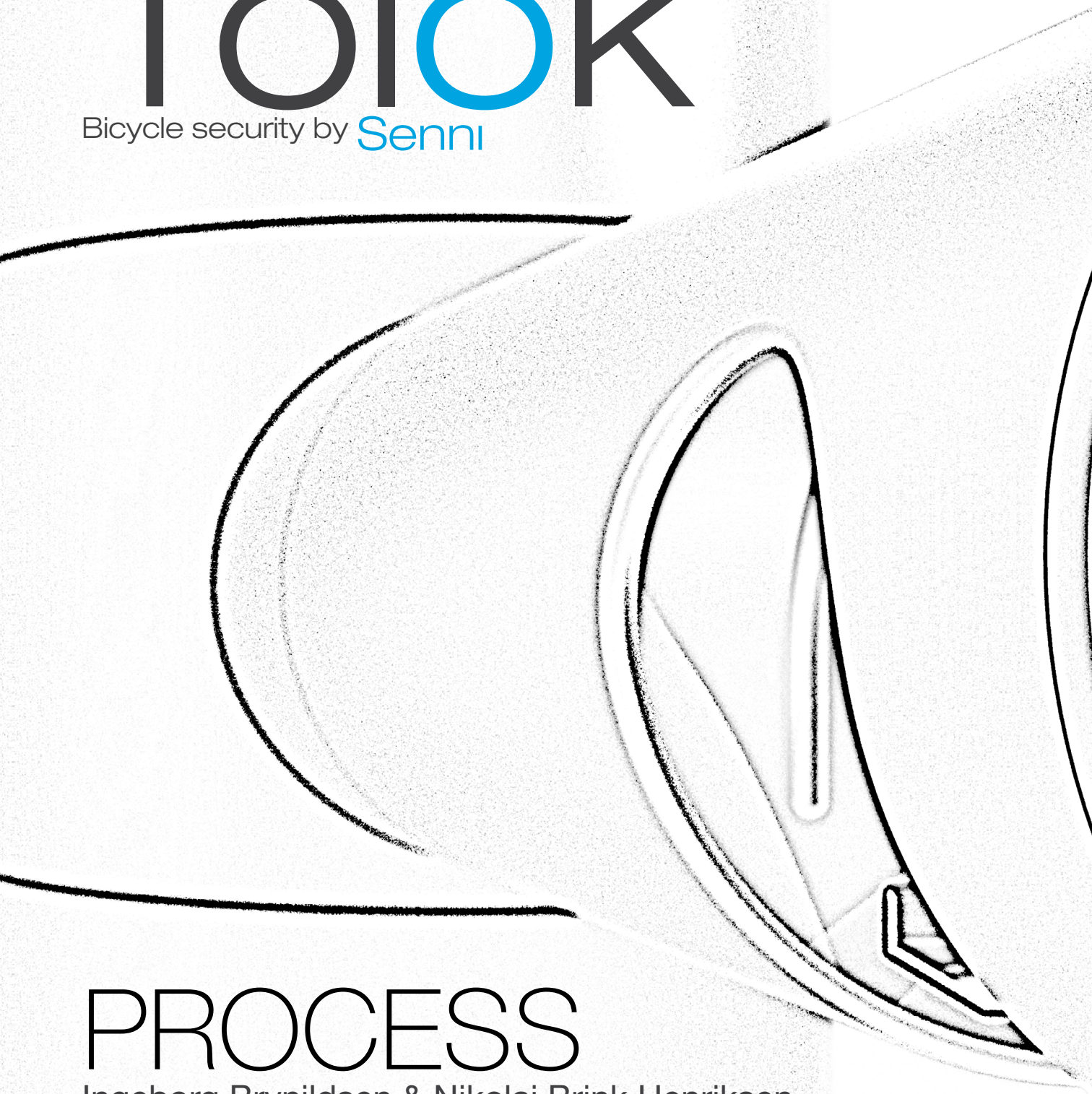
There are many possibilities when expanding the use of Tolok. Tolok is a security product, which the users will immediately recognize, therefore it would be obvious to continue in the same theme. There are many object, which users place in public areas where the chances for theft is high. Some of these objects could be prams, boat trailers, motorcycles and kindergartens trolleys.

By expanding Tolok there could even be the potential to target the private marked. In order to do so Tolok needs to evolve into a product series, which offers various security solutions for the various tasks.

ARKITEKTUR & DESIGN

Tolok

Bicycle security by Senni



PROCESS

Ingeborg Brynildsen & Nikolaj Brink Henriksen
4th Master, Industrial Design, Aalborg University
February - June 2016

TITLEPAGE

PROJECT TITLE
Tolok, Bicycle security by Senni

PROJECT THEME
Bicycle security

SEMESTER
Master Thesis (MSc04)

PROJECT PERIOD
01.02.2016 - 25.05.2016

MAIN SUPERVISOR
Finn Schou

TECHNICAL SUPERVISOR
Jørgen Asbøll Kepler

PROCESS REPORT PAGES
72

NUMBER OF CHARACTERS
139,834

APPENDICE PAGES
70

NUMBER OF REPORTS
2

PREFACE

This report documents the process of the 4th master thesis project Senni - a bicycle security product for the urban environment. In addition to the process report, both product report and technical drawings are printed separately and is handed in as a combined package. In the package is a usb stick which contains an electronic copy of all the hand ins. The appendix is located in back of this report.

A big thanks to:
Finn Schou - Supervisor
Jørgen Asbøll Kepler - Technical supervisor
Henrik Grøn - Schaeffler Danmark ApS
Jan Henriksen - Senior Project Engineer, DIS A/S
Brian Høj - Projektleder, Aalborg Cykelby
Marie Skovgaard Mikkelsen - Cand.polyt

Ingeborg Brynildsen

Nikolaj Brink Henriksen

ABSTRACT

Dette projekt omhandler udviklingen af et produkt med fokus på lettere og sikrere cykelparkering. Mere præsist fokus på problemet med mangel på ordentlige cykelstativer, hvor det er muligt, sikkert og let, at fastlåse ens cykel. Derudover kommer problemet med tunge og uhåndterlige cykellåse, som skal transporteres med cyklen på cykelturen. Dette er der fundet en løsning på ved at kombinere lås og cykelsstativ i én. Produktet er udviklet gennem interviews, analyser og eksperimenter.

READING GUIDE

The process report is structured based on a the Stage Gate model where phases divert and spread out to gain more knowledge in certain areas and then convert when conclusions are drawn based upon the research conducted and the knowledge gained.
Each phase consists of a section of idea and concept generation and a section of research and investigations.

References are written using the Harvard method. In-text sources are either presented by the authors name or by the name of the company/organization that has provided the knowledge followed by the year of publication, i.e (author, year of publication). The full references will be found in the end of the report.

Throughout the process report small boxes, which is illustrated below, will be used to sum up upon important knowledge gained during the various subjects.

Headlines are giving different colors in order to make it easy for the reader to navigate. Beneath is a example of the different headlines.

PHASE HEADER

SECTION HEADER

TOPIC HEADER

SUB TOPIC HEADER

SUB HEADER

IMPORTANT HEADER

TABLE OF CONTENTS

PROJECT PHASE**1.0**

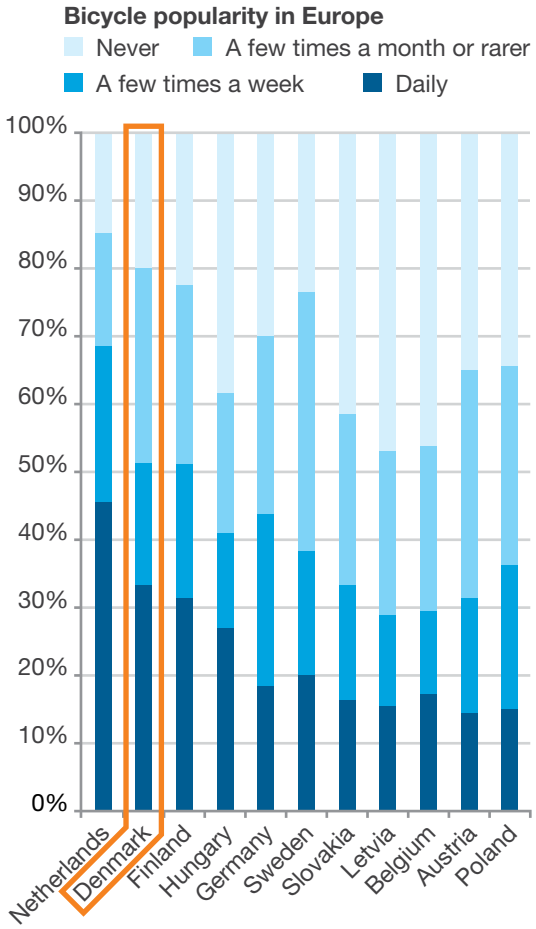
This phase was the foundation of the project work. It contains the initial research, knowledge regarding statistics, thievery and overall problem.

1.1 PROBLEM

Through external sources and discussions between the group members, it was initially decided that the master thesis should evolve around redesigning the existing bicycle locks, with the intention of making a more intuitive and user friendly version.
The bicycle have become such a popular means of transportation in Denmark, that the use of the bicycle and its functions not only include transportation. Usage scenarios can also include transportation of groceries, children, pets and many other items, but a problem often arises when the user are to lock or unlock the bicycle as they may already be using their hands for other purposes. Having occupied hands in this case means that the user have to put down the items, pets or children on the ground, because the bicycle locks are often designed to be locked or unlocked with two hands.

INITIAL PROBLEM STATEMENT

How can we reinvent the bicycle lock, so it will be possible to lock the bicycle with only one hand, while integrating it into some of the other features on the bicycle, such as lights?



Ill. 1: Bicycle transport habits of European countries.

Ill. 2: Carrying things can make it hard to unlock the bicycle.

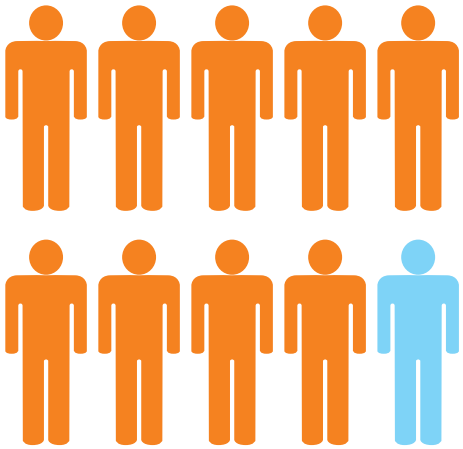
1.2 INITIAL RESEARCH

The initial problem statement surrounding the use of bicycles, led to further investigations into various aspects of bicycle usage and the impacts there of.

In Denmark bicycles are a very popular means of transportation, which can also be seen from the amount of Danish people that own a bicycle, as nine out of ten people in Denmark own a bicycle [See ill. 3] (Andersen, 2013). This means that for many people their bicycle is a part of their everyday life.

As a result of the many bicycles, Denmark was awarded the second place among all European countries in a large investigation done by TNS Opinion for the European Commission [See ill. 1] (Nielsen et al., 2015).

Unfortunately for a lot of people however, is that bicycles are a very common target by thieves, as they are often very easy to steal and the Danish police does in most cases not follow up on stolen bicycles (Dilling, 2013), (Lavendt, 2016), (Kalstrup, 2016).

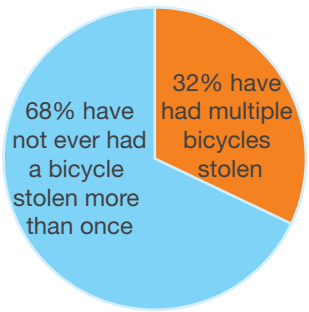


Ill. 3: Nine out of ten Danish people owns a bicycle.

STATISTICS

Gallup reports that every second Danish citizen have tried getting their bicycle stolen, or more precisely between 52-54% [See ill. 4] (Andersen, 2016).
32% of the Danish citizen have even tried getting more than one bicycle stolen [See ill. 5] (Gjensidige Forsikring, 2013), (Andersen, 2016).

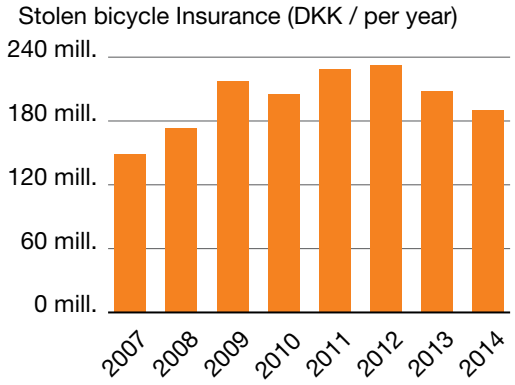
Ill. 4: Percentage having had their bicycle stolen.



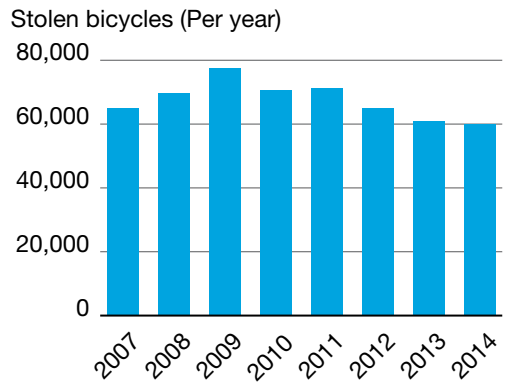
Ill. 5: Percentage having had two or more bicycles stolen.

According to statistikbanken.dk, the number of stolen bicycles have been decreasing in recent years, but considering there were stolen more than 55 thousand bicycles in 2015 the number is still very high (Danmarks Statistik, 2016).

If the number from 2015 is compared to the number stolen in 1994 then there has been a significant decrease in the theft of bicycles, because in 1994 there were reported more than 125 thousand bicycles stolen (Carstensen, 1996).
The numbers begun decreasing afterwards, but have at periods gone up again. The latest case was in 2009 where around 79 thousand bicycles were stolen, after which the number began decreasing again and continuously (Danmarks Statistik, 2016).



Ill. 6: DKK paid by insurance companies for stolen bicycles.



Ill. 7: Stolen bicycles each year.

FINANCIAL IMPACT

For many years the insurance companies have had to pay increasingly more to their customers as a result of stolen bicycles. The amount that were paid out as insurance claims in 2014 were 190 million. The increase in insurance claims can come as a surprise to many, because the amount of stolen bicycles have been and still are decreasing like mentioned previously.

The increase in insurance claims getting paid out to the customers are in fact increasing at a rather alarming rate. In 2010 the insurance companies paid DKK 32.7 million more in compensation than in 2008 as a direct result of bicycle theft. The number continued to increased until around 2012 where the insurance paid DKK 27 million more compared to 2010. However from the investigations and research conducted it was found that the insurance started to pay out less after 2012, but not because the amount of stolen bicycles suddenly decreased a lot more than previously [See ill. 6] (Stephansen, 2008).

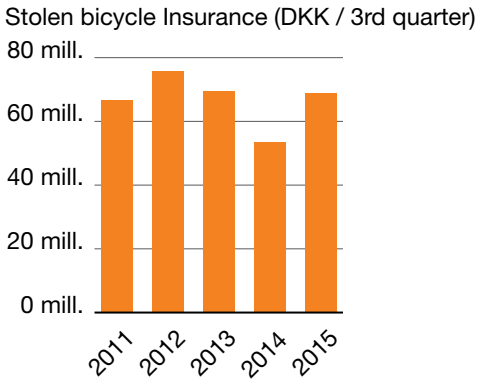
If compared to the amount of stolen bicycles then it can be seen from the graph [See ill. 7] that the amount of stolen bicycles are slowly decreasing at a steady pace, which means that the sudden drop in insurance claims must be a result of another change.

The newspaper Berlingske wrote in 2014 an article about bicycle theft and the security thereof. The article mentions that people in Denmark have become tired of having their bicycles stolen, which has resulted in an explosive increase in bicycle insurances being created. Between 2010 and 2014 the amount of bicycle insurances have increased by 376% (Andersen, 2016).
The article also mentions that people have begun buying more effective and more expensive bicycle locks to secure their bicycles, which could be part of the explanation to the drop in bicycle insurance claims.

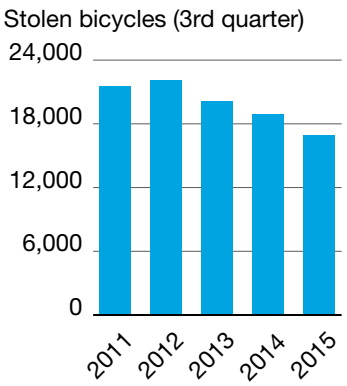
In the third quarter of 2015 the payouts, from the insurance companies, for stolen bicycles appear to indicate that the amount of money getting paid out have increased again in 2015 [See ill. 8], although the number of stolen bicycles continues to decrease [See ill. 9]. A scenario of the reason behind this could be that the bicycle thieves have begun targeting more expensive bicycles than they have previously.

This theory is also supported by an article written by Politiken in 2013 where a consultant at the Insurance Information office within the branch organization, Forsikring &

Pension, mentions that the individual amount of compensation per bicycle have increased over the recent years (Sørensen, 2013).
This can also be seen from the statistics published by Forsikring & Pension, where it is shown that in 2004 the individual compensation per bicycle was DKK 2,570 while in 2014 the number have increased to DKK 3,918 (Stephansen, 2008).



Ill. 8: Bicycle insurance claim per third quarter each year.



Ill. 9: Bicycles stolen per third quarter each year.

SUB CONCLUSION

From the initial research it was found that the security surrounding the parking of bicycles is a far larger problem, than the usage scenario with the lock from a user stand point.
Because of this the focus of the project expanded in an attempt to investigate both the security and the use aspect of the bicycle parking scenario, so that an combined solution that would bring the user both user friendliness and security for their bicycle could be designed.

DEFINITIONS OF BICYCLE THEFT

To help define the project and get a clearer picture of bicycle theft, the previous findings led to questions such as; “Why do people steal bicycles and for what purpose are bicycles stolen?”. This led to the following investigation into the types of bicycle theft that exists.

Bicycle thievery is currently one of the most risk free crimes in Denmark. In fact less than 1 percent of all thieves that steal bicycles are caught, which means that in 2012, there were only 313 people caught stealing a bicycle. Of those 313 people, 275 of them were fined for their act, while the last 38 went to prison as a result of the thefts (Dilling, 2013).

Through the investigations into the different types of bicycle theft, two were discovered and is described here below.

SITUATIONAL THEFT

The first one is when a bicycle is stolen in order to use it as transportation from point A to point B. This is called usage theft or situational theft. The thief might even deliver the bicycle back one of the following days, depending on their conscience (Gjertsen, 2010).

If the theft is done out of situational use or in other words, because the thief needs some transport to get from one point to the other then the punishments are a little different. Situational theft done between one and two times will result in fines, while theft from three and above can result in anything between a fine and one year of prison (Dilling, 2013), (Det Kriminalpræventive Råd, 2016) [See ill. 10].

ORGANIZED THEFT

The second type is when a bicycle is stolen in order to gain a profit from it, in other words theft for the value of the bicycle. This is often associated with organized crime (Dilling, 2013).

Investigations into this type of theft led to the TV program, ‘Krimimagasinet’, which have had two episodes with organized theft of bicycles.

The first case was about theft of cargo bicycles, as these are quite expensive and are gaining popularity in Denmark.
In the program the cargo bicycles were installed with GPS tracking systems and it was in the program discovered that they were stolen and sold again in Copenhagen. The thieves went around Copenhagen looking for easy cargo bicycles to steal, when they found one, they would load it into their van and drive off with it. Afterwards they would replace the bicycle lock with a new one and change the frame’s VIN number, which is the registration number for bicycles. At the same time they would upload an ad of the bicycle and try to sell it. When they were going to sell the bicycle they showed a fake receipt to the costumer (TV 2 PLAY, 2010).

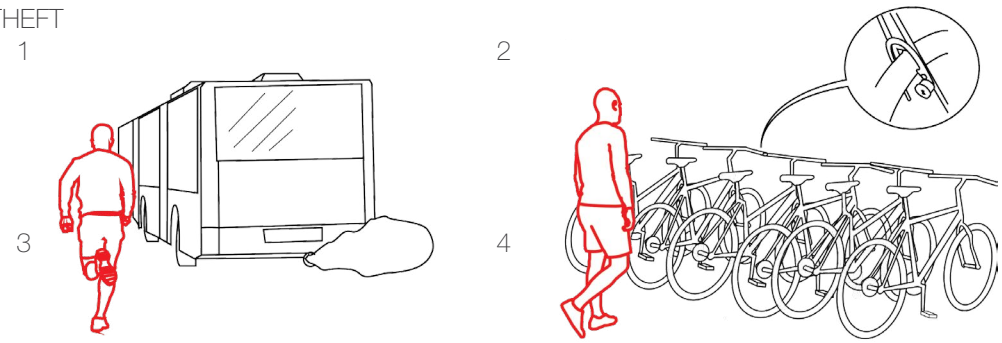
The second case focused on stolen Danish bicycles getting sold in Lithuania. These crimes were organized by a large group of people, who drove around Denmark, looking for expensive bicycles to steal.
The group had a leader among them, who decided where they should steal the bicycles from, which is a typical group setup. In the show they inspected schools, public bicycle racks or other exposed areas, looking for bicycles to steal. They then took the bicycles and placed them behind in their vans and drove them to Lithuania.

In both cases it did not matter, how the bicycles were locked, because the thieves typically had the right kind of tools with them.

The punishments for stealing a bicycle with the intention of making a profit from it, can result in various charges depending highly on the value of the bicycle stolen. The more the bicycle is worth from new, the more severe the punishment gets. If a bicycle with a value as new lies between DKK 0 and DKK 8,000 then the thief will receive a fine and if the bicycle’s value as new was worth over DKK 8,000 then the thief can risk a prison sentence of up to one and a half year (Dilling, 2013), (Det Kriminalpræventive Råd, 2016) [See ill. 11].

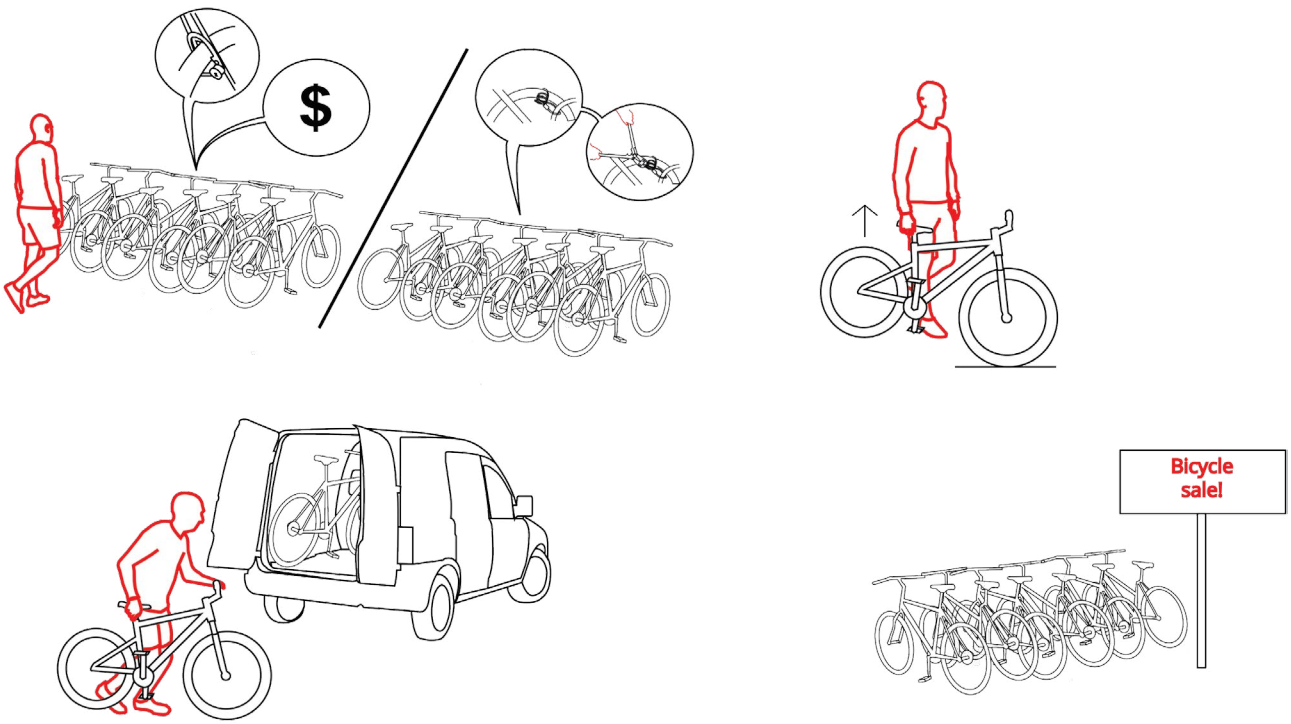
It was evaluated that organized theft often is more planned and they therefore have a higher experience with breaking bicycle locks. If this kind of thievery could be prevented it would result in prevention of situational theft as well.

SITUATIONAL THEFT



ORGANIZED THEFT

Ill. 10: Situational theft.



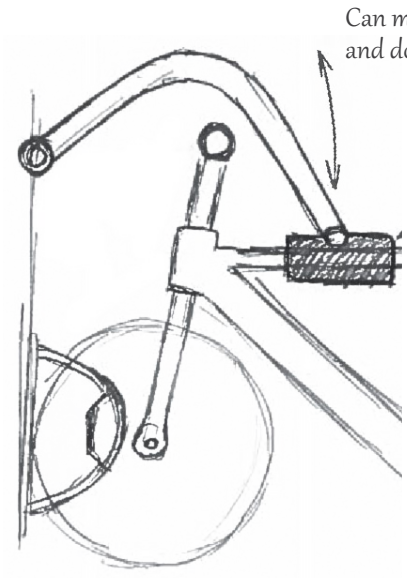
Ill. 11: Organized theft.

1.3 CONCEPT DEVELOPMENT

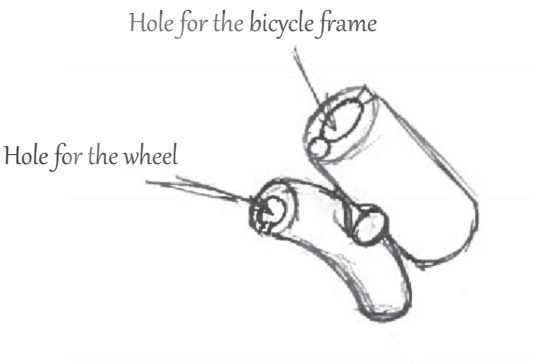
SKETCH ROUND 1

This sketching round was done in order to gain a quick alignment of ideas and to get a common ground of which direction the project was headed.

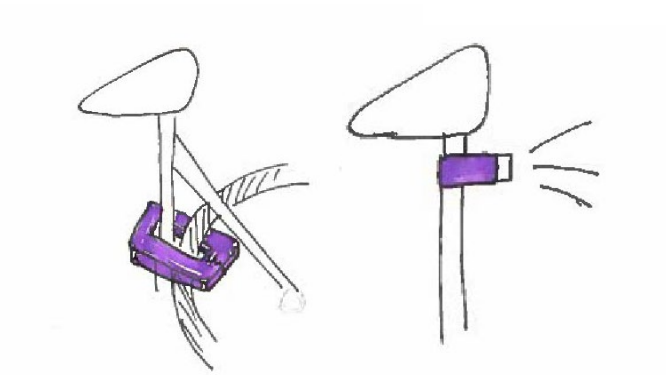
The sketching round was done relatively early in the process, therefore the sketches are not based on any demands.
There where many different ideas like bicycle racks, locks with two functions and redesigns of regular bicycle locks. As a result of the many divided ideas, a common direction was difficult to chose, therefore it was decided that a new concept round should be done when more research had been carried out, after which the new concepts would be evaluated to decide a direction for the project.



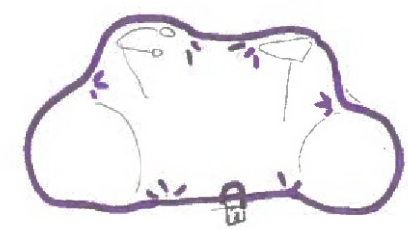
Ill. 14: Bicycle rack with arm that locks the frame



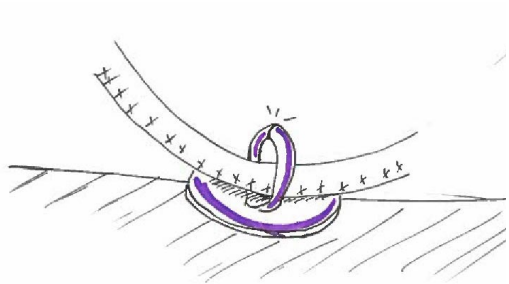
Ill. 12: Bicycle lock which lock frame and rims together



Ill. 15: Two step bicycle lock; both a lock and a rear light.



Ill. 13: Safetycover for the entire bicycle



Ill. 16: Hook which is placed in the ground

PROJECT PHASE**2.0**

In this phase the basic knowledge was expanded regarding bicycle types, locks, the thieves' tools and market analysis. From this a more specific problem was found.

2.1 RESEARCH

Most of the information in this research section gathered in Aalborg, as Aalborg is one of the many cities that puts a high value on the comfort of bicyclists and have an entity department of the municipality dedicated to improving the bicycle conditions. The municipality have already completed many improvements and are planning on introducing more in the future. Therefore future additions to the bicycle conditions in Aalborg makes for a good starting point when it comes to designing a bicycle security product.

A field investigation was conducted in order to gain some basic knowledge regarding bicycle locks and ways to secure them properly, as well as some general information about, which bicycles are the most popular. This information was gathered by use of interviews with employees at bicycle stores, police departments and insurance companies to get information directly with people that has a daily contact with bicycles in more ways than the common user.

INTERVIEWS

BICYCLE STORES IN AALBORG

Through interviews with two bicycle stores (Løbekompagniet BIKE og Aalborg Bicycle Store), it was discovered that the employees recommend using a folding lock, which has been created by Abus, as it is a tough and flexible lock, instead of the typical mounted lock. Flexible locks like the folding lock allows the bicycle to be locked onto another stationary object. This results in a more secure locking method than just having the bicycle locked with a mounted lock (Lavendt, 2016), (Kalstrup, 2016).

It was further mentioned by the employee at Aalborg Bicycle Store that another way to further secure a bicycle is to place a GPS in/on it, but during the interview it was also explained that they were rarely used and when they were it would typically be on the more expensive bicycles that is sold for more than DKK 15 thousand.
The interviewed mentioned that one of the tracking companies, called Diims, use the Danish postal trucks to map the location of bicycles when they pass one of the trackers, which is standard equipment in the postal trucks. Aalborg Bicycle Store have tried selling these but they have not been a success, as only 7 have been sold over 3 years (Lavendt, 2016).
Research into the Diims tracking device also confirms that the location of the device is tracked through the Danish postal trucks' tracking system. It is however also mentioned that it is not very precise in the tracking, mainly because it is not a constantly active tracking system, but only notes down the location of the device, when near a postal truck. This means that if the thief is moving with the bicycle it might not still be there when the user comes around to pick it up (Ernst, 2013).

The interviews shortly touched upon the popularity of the various bicycle types and it was found that racing bicycles and mountain bicycles are becoming increasingly popular.
It was mentioned that the most popular bicycles during the winter, were mountain bikes, because bicyclists uses

Ill. 17: Bicycles at Lost Property Office.

them to train when they can not drive on the slippery roads. Especially mountain bicycles have increased in popularity recently, but the interviewed also mentioned that it depends on the season (Kalstrup, 2016) [See also appendix 1].

LOST PROPERTY OFFICE

The Lost Property Office (abbreviated as LPO) is the department who handles bicycles, that have been misplaced. When taking to the LPO it was found that they collect bicycles from DSB, the municipality, housing associations and sometimes private people, who have noticed an abandoned bicycle.

When a bicycle gets reported stolen, the VIN number is placed in a database, it is this database the LPO writes down all the VIN numbers on all the bicycle they collect. If they have eg. 50 bicycles, only around 10 of them is reported missing and might get picked up by private people or by the insurance companies. The bicycles that are not picked up, gets sold at an auction (Bøgh, 2016).

It can be concluded that most of the found bicycles at LPO does not get back to their previous owner, but instead a lot of them either get new owners or gets thrown out. Furthermore it was also concluded that most of the bicycles at LPO have been part of situational thefts, as they have not been sold by the thief [See also appendix 2].

MAX LEVIG

Normally one's bicycle is covered by the home insurance, but this insurance only covers damage or theft of the bicycle when it is within a certain price range. If the bicycle's value is more than DKK 17 thousand, the home insurance will not cover it. If an insurance coverage is needed for more expensive bicycles then another specific kind of insurance is needed [See also appendix 3].
The favorite insurance by bicycle enthusiasts with these types of expensive bicycles is the insurance company Tryg's specific insurance for expensive objects called Max Levig.

There are three things that need to be upheld in order to get the bicycle insurance (Feltet.dk, 2016):

1. The bicycle need to have a insurance approved lock.
2. When not in use the bicycle need to be placed indoor (behind locked door) and the bicycle need to be locked.
3. The bicycle need to have a Danish VIN number.

Ill. 18: Examples of mounted locks.

Ill. 19: Examples of flexible locks.

Ill. 20: Example of rack locks.

BICYCLE LOCKS

With some lock recommendations found through the interviews, a deeper investigation into the various types of bicycle locks on the market was conducted. Through the interviews and further desk and field research sessions existing bicycle locks were found.

TYPES OF BICYCLE LOCKS

The investigation was done in order to get an overview, of existing solutions on the market [See appendix 4]
The locks was divided up into five categories:

1 MOUNTED LOCKS

2 FLEXIBLE LOCKS

3 RACK LOCKS

4 ALTERNATIVE LOCKS

5 CONCEPT LOCKS

What was discovered was that it is limited what kind of bicycle locks that are sold in Danish stores, which is, because bicycle locks needs to be insurance approved by the Danish Institute for Informative Labeling (Also known as Varefakta). If the lock is not approved then the victim of the bicycle theft will not receive any compensation by the insurance company [See appendix 5]

Bicycle locks needs to be approved by the Danish Institute for Informative Labeling to allow for insurance claims.

1 MOUNTED LOCKS:

These locks, also called frame locks, are usually installed on the frame of the bicycle, near the rear wheel, so that it can lock around the rear wheel, making the wheel unable to rotate around unless the spooks are destroyed [See ill. 18].

2 FLEXIBLE LOCKS:

These kinds of locks can also be considered external locks, because they can moved around separately from the bicycle, therefore flexible. Many of these locks can also be seen as flexible, because they can be bend or wrapped around various objects with various form factors, thereby locking the bicycle on to another object or different parts of itself [See ill. 19].

3 RACK LOCKS:

This category of locks comes in many different forms and are usually mounted on a wall or into the ground. Their purpose varies greatly as some are meant for storage of public city bicycles and are therefore designed to specifically fit those bicycles. Others are designed so that they allow a person to lock most bicycles, if the person brings her or his own padlock [See ill. 20] .

4 ALTERNATIVE LOCKS:

Alternative locks are considered to be locks thinking outside the box of standard locks. Common for many of those types of locks are that they are often integrated into one of the parts of the bicycle like for example the bicycle seat.

The alternative locks also include locks made of a different kind of material and can include locks with alarms, batteries, solar panels etc. [See ill. 21].

5 CONCEPT LOCKS:

The found locks that not yet have been produced or are purely for conceptual purposes have been put into this category. The majority of the found concept locks are integrated into the bicycle in one or more ways.

The concepts varies from the bicycle peddles, to the seat, to the handlebars etc. [See ill. 22].

Ill. 21: Example of an alternative lock.

Ill. 22: Example of a concept lock.

SECURITY LEVELS

Nearly all the observed bicycle locks are from the producer's side categorized into a security scale, which helps tell the customers, how secure the lock is. Each company has their own security scale, which can make the purchase confusing for the customers.

Basta, who is one of the more common bicycle lock companies on the Danish market, has a scale that goes from 1-6. Level 1-3 is considered basic security for low risk areas. Level 4-5 is good security and can sustain serious attacks. These levels are also the ones getting approved by authorities such as the Danish Institute for Informative Labeling. Level 6 is maximum security, which is also suitable for motorcycles (Basta Cycling, 2013).

Abus' scale goes from 1-15 for bicycles. From level 1-4 the security is considered basic security locks for low risk areas or children/accessories. Level 5-9 locks are recommended to be used in low to medium risk areas, on adult bicycles in the cheaper end of the scale and are also considered to be used, as a secondary lock when used with a high security lock. Level 10-15 offer the maximum amount of security and are in intended to be used on higher-end bicycles in high risk areas.
Abus features an additional extended security scale which goes up to 20 and are intended to be used for motorcycles (ABUS Security Tech Germany, 2016).

Axa's bicycle security levels also range from 1-15 like those of Abus'. What is different about their security scale is that Axa's features an additional five for the motorcycle security so that it goes up to 25 (Axa Security, 2016).

As a solution to the dilemma regarding the multiple different security level systems, a company in England called Sold Secure have taken it upon themselves to test locks from various companies and product fields and give them a rank according to their raking system, but only if the manufacturer submits the lock to Sold Secure for testing. The ranking system has three ranks; Bronze, Silver and Gold, where Bronze is the least secure and gold is the most secure (The Best Bike Lock, 2016).
Sold Secure was established by Essex Police and Northumbria with the backing of the English Home Office and is currently owned by the Master Locksmiths Association. Sold Secure can be seen as the English equivalent of Danish Institute for Informative Labeling, but with an added ranking system and not just an approval that enables insurance claims to be made if the bicycle is stolen (Sold Secure, 2016).

RECOMMENDATIONS

Aalborg Bicycle Store recommended during the interview, to use the folding lock from Abus, such as the Abus Bordo 6500 Granite, as it has one of the highest security levels among the locks on the market. [see appendix 1]

When looking at all the different types of measurements for bicycle security levels, it is easy to predict that the customers must be confused, therefore when designing a bicycle lock it is important to illustrate the security level on an easy understandable way and inspiration can be taken from England were a much simpler security level scale is used.

Ill. 23: Basta security scale

Ill. 24: Abus security scale

Ill. 25: Axa security scale

WEIGHT OF LOCKS

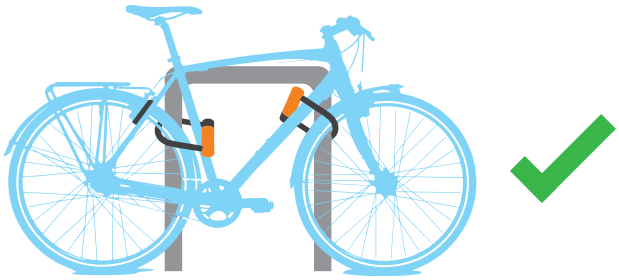
Something that was observed during the initial investigation into the various bicycle lock types and their detailed specifications, was that the security levels has a direct impact on the weight of the various locks. The observation resulted in a more detailed analysis of the connection between the security level and the weight of the locks.

From the observations and the analysis it was found that locks with a higher security level also increases in weight. So when customers need a more secure lock they will also be looking at an increase in the weight of the lock. The higher the weight of the lock the lower the user friendliness, because they will be harder to carry around and might also affect the weight distribution of the bicycles, thereby making the bicycle ride less enjoyable. An example of this can be seen from the graph below, where various Abus locks have been compared in their 1-15 ranking system [See ill. 26].

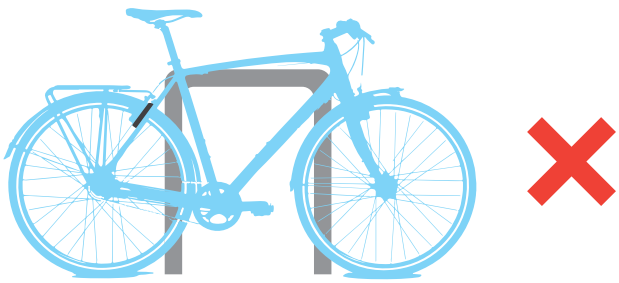
Therefore in order to heighten the user friendliness a secure solution which have a reusable weight would be to prefer.

> Higher security level locks result in worse user friendliness as a result of weight.

Ill. 26: Weight diagram



Ill. 27: Securing the bicycle the right way



Ill. 28: Securing the bicycle the wrong way

LOCKING RECOMMENDATION

There have previously been written a little about the proper way of locking the bicycles correctly, but a more thorough investigation was done to find out, what the actual recommended method for locking a bicycle securely is.

On the Danish criminal prevention council's website they write that as a minimum the bicycle frame should be locked on to another object, while the recommended advice is also to lock the wheels, either on to something else or on to the frame of the bicycle (Det Kriminalpræventive Råd, 2016).

Other sources also recommend the approach of locking the frame of the bicycle along with the wheels and then securing them by locking them on to another stationary object, with two high security locks of a U-lock or folding lock design (City of London Police, 2015), (Petersen, 2012), (TopDanmark.dk, 2016) [See ill. 27].

This means that simply locking the bicycle with a mounted lock will not be enough to secure a bicycle, because the bicycle can still be lifted off the ground and carried away and then forced open elsewhere [See ill. 28].
The only thing that the mounted lock might help secure against is situational theft, as these kinds of thefts mostly happen when the bicycle is unlocked.

When locking the bicycle on to another stationary object it also needs to be considered, what that object is and how tough it is, because thieves can decide to target the bicycle rack instead of the lock if the lock can be too time consuming to cut over.

HOW FAST CAN THEY BE LOCKED

Now that the proper way of securing a bicycle have been clarified, a test was carried out in order to gain knowledge on, how much time it takes to lock a bicycle using the correct way as well as improper ways. Therefore it was tested using three different ways of locking a bicycle, by using a bicycle with a mounted lock and two flexible lock. These three locks was used in different combinations in order to simulate a real situation.

The bicycle was parked at different types of bicycle racks. It was locked in three different ways, one only with the mounted lock, another with the mounted lock as well as a flexible lock through the wheel locked and the bicycle rack. The last test was only locking the wheel onto the bicycle rack. it was made sure when locking the wheel that

the bicycle frame was also locked.

The results was that the mounted lock was the quickest and also the easiest one, by always being at the same spot and that the spokes was the only problem when locking it. It took roughly 10-16 seconds to lock this kind of lock.

The slowest times was from 29-42 seconds and that was by using two locks, which was expected considerate that it would take longer time using the mounted and front wheel lock. By having tested this, knowledge were gained, which will be used further in the process, in order to help evaluate future concepts. [see appendix 6]

Locking solution should not take longer than the highest measured time.

HOW FAST CAN THEY BE BROKEN

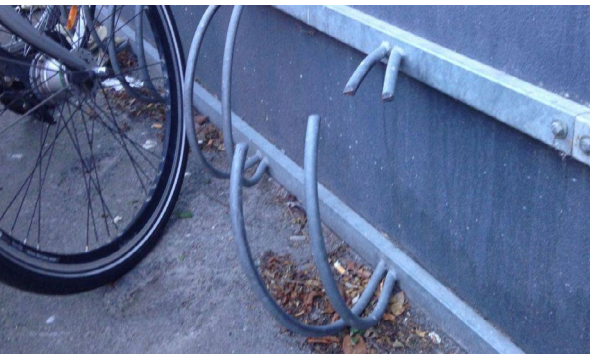
Now that it has been tested how fast a bicycle can be locked using different types of locking methods, a search into how fast the various locks then can be broken was conducted. It was needed to investigate how quickly real bicycle thieves can break open different types of bicycle lock, which kind of tools they use and which counter measurements can be used to design a bicycle lock that would be more or less impossible to break open.
Research showed that bicycle thieves uses many different tools, as they can vary from a simple rock to an angle grinder.
It was also found that there are many ways to break a bicycle lock. The type of approach depends on what type of bicycle lock there is on the bicycle (DeeRidekick, 2013).

If the bicycle is locked only with the mounted lock, then the thief might simply lift the back wheel of the bicycle and roll away with the bicycle. He or she can then later cut the lock up in a more secure location (TV 2 PLAY, 2010).

If the bicycle is locked around another object, then the thief might cut or break the bicycle free. If a cable lock is used, a typical tool to use will be a cable cutting plier. For the more heavy locks such as a chain lock then a bolt cutter or an angle grinder will typically be used.
A thief demonstrated that it only took him under 3 seconds to cut 5 cable locks, using a cable cutting plier, and when cutting a chain lock it took him 11 seconds.

Ill. 29: Example of a rack for leaning.


Ill. 30: Example of an existing security rack.



Ill. 31: Bicycle rack cut by a bolt cutter.

Ill. 32: Example of rack lock cut by a blowtorch.

Other types of locks that are quite popular are the U-locks. These locks are often made of stronger combination of materials than the chain locks. But when using an angle grinder it does not matter, how tough the material or combination thereof are. The demonstration showed that it only took from 36 seconds to 1 minute to cut various models of such design (City of London Police, 2015).

In an TV interview with a former bicycle thief, called Kai Køhler, different bicycle lock were rated and discussed what pros and cons some of the existing solutions have. He also confirms that if the bicycle is not locked onto another object, he would simply lift it away and deal with the lock at another location. He also mentions and confirms previously mentioned tools which are used to steal bicycles. Later in the interview he claims that if he did not have time to break or cut the bicycle lock, he would simply cut the object the bicycle is locked onto, which typically would be a bicycle rack. He claims that bicycle racks are *"soft as butter"* (Petersen, 2012).

He is not the only bicycle thief, who have damaged the bicycle rack in order to steal a bicycle. An article in Politiken explains, how someone got their cargo bicycle stolen at their apartment, because the thief cut the bicycle rack with a bolt cutter [See ill. 31] (Dilling, 2013).
In another article on Metroxpress a bicycle thief had cut the bicycle rack open by using a blowtorch [See ill. 32] (Briks, 2014).

This proves that the bicycle racks are the least secure element when dealing with the high security level locks for bicycles, as this method makes them obsolete when the bicycle is parked at the common front wheel bicycle racks. This changes the whole aspect on bicycle locks, because now it does not matter, how secure the bicycle lock is, as it would always need to be locked on to another object in order to secure the bicycle and when the object is not secure, then the lock does not matter.

There is no solution completely secure against all tools. Only the cumbersomeness of the theft has any effect.

Bicycle racks are more likely to be cut over than high security locks if the bicycle is locked on to such.

THIEVES' TOOL

It was previously mentioned that thieves uses a wide variety of tools in order to steal a bicycle, therefore a more detailed investigation was done in order to fully understand some of the most common tools a bicycle thief uses.

CABLE CUTTING PLIER

As indicated by the name these pliers are specifically designed to be able to cut a wire or cable in two in a matter of seconds (City of London Police, 2015) [See ill. 33].

Ill. 33: Cable cutting plier.

SCREWDRIVER

It is possible to hammer a screwdriver into the key whole for some bicycle locks and by doing so the lock will either break or the thief will be able to turn the lock open (Brown, 2012) [See ill. 34].

Ill. 34: Screwdriver.

HAMMER

Hammers are usually used to either hammer for example a screwdriver into a lock or to simply smash the bicycle lock up through force of impacts [See ill. 35].

Ill. 35: Hammer.

CROWBAR

Twisting and rotating a crowbar around in the same direction while it is pushed through the loop of a cable lock or a chain lock can result in the locks breaking [See ill. 36].

Ill. 36: Crowbar

BOLT CUTTER

A bolt cutter is one of the more usual tools the bicycle thieves will use, as it can essentially be used to cut both; cable, chain, U-locks and folding locks depending on their size. Bolt cutters can also be used on the bicycle racks themselves depending on the width or diameter [See ill 37]. The bad thing about bolt cutters from the thief's perspective is that the bolt cutter can usually only handle around 0 to 30 millimeter think objects.

Ill. 37: Bolt cutter

ANGLE GRINDER

One of the more extreme measures that the thieves can take is to use an angle grinder but these kinds of tools will also make a lot of noise which may alarm people or the police. Angle grinders can be dangerous though, which can result in people refraining from making a confrontation with the thief (City of London Police, 2015), (Petersen, 2012) [See ill. 38].

Ill. 38: Angle grinder.

1050 mm long bolt cutter

Ill. 39: Large size bolt cutter.

600 mm long blot cutter

Ill. 40: Medium size bolt cutter.

450 mm long bolt cutter

Ill. 41: Small size bolt cutter.

BOLT CUTTER MEASUREMENTS

As it was discovered that a bolt cutter is one of the preferred tools among bicycle thieves, a test was conducted. By measuring three different blot cutter sizes, one 1050mm long, one 600mm long and one 450mm long, it was possible to get a view into, which thickness the three bolt cutters can, from tip to tip, reach around. It should however be noted that bolt cutters are not constructed to cut metal tubes/pipes/etc. at the very tip of the blades. This means that the thickness of the material that can be cut is essentially smaller than the measured opening width, therefore while maintaining the ability to cut a tube or pipe of an acceptable thickness, a generally rule is that the object that needs to be cut, should be cut around the middle of the blades so that the bolt cutters head will not break.

The test result concluded that in order to make it impossible to cut a lock with a bolt cutter the material needs to be bigger than 17mm, however if the material is too soft, the bolt cutter may be able to cut it using the tip, but it will take a longer time and be very difficult.

Angle grinders are impossible to make a secure solution against, but such is possible for bolt cutters.

SOCIAL REACTION TO THEFT

Bicycle thieves does not only need to think about, which tool they want to use for their thefts, they all need to consider, where and when the theft takes place. A search into how people react when thieves are spotted stealing a bicycle in public day light was investigated to see if it had any effect on the theft. This search is based on different sources, from TV shows to written articles.

In multiple social experiments people have tested if they get a reaction from someone else when stealing a bicycle in public.
The first example is from a guy called Casey Neistat, who did a social experiment, about bicycle theft in the streets of New York City in the United States. Even though he stole a bicycle right in front of the police station in one of the experiments there were no reaction from anyone.
It was only after nine minutes during his experiment with the angle grinder that he was finally confronted by a couple of police officers (CaseyNeistat, 2012).

A similar social experiment was conducted by the Avon and Somerset Police in England. Here a police officer dressed as a bicycle thief went out in public areas and stole bicycles. He even attempted to give bystanders the tools he had used to break the lock, no one called the police (Marthy, 2012).

In the Danish TV show Hælerjagt, which was broadcast on Kanel 5, they too did a social experiment, where they stole bicycles in public areas. In the test three people confronted the bicycle thief and one of them commented that she would call the police if he had continued the theft. The only reason she confronted the thief was, because she have had her bicycle stolen before (Kanal 5, 2016).

NOISE, DOES IT WORK?

In Germany a small social experiment was conducted, which involved bicycle theft where the lock activates an alarm. They placed the bicycle in an open area and observed whether or not people would react when the thief activate a loud alarm by cutting the lock. The experiment showed that no one reacted to the noise, not even the police when they drove straight past the bicycle while the alarm was active (Marktcheck, 2014).

The majority of people have confrontational anxiety and will not confront an obvious bicycle thief.

TRACKING DEVICES, DO THEY WORK?

What are the solution when tracking down a stolen bicycle, other than register the VIN number? One solution is to install a tracking device in the bicycle.

As mentioned in the previous interviews with the bicycle stores, there exists tracking devices that bicycle users can attach to their bicycle and then through for example their cellphone see the location of the bicycle.
There exists various tracking devices on the market, of which many work differently from each other.

One of which was the Diims tracking device, which was designed and produced by the Danish company called Commotive A/S. Like noted before the device uses the Danish postal trucks to track the bicycle's location (Ernst, 2013).

Other tracking options are mentioned in the TV show Hælerjagt, where it is mentioned that some tracking devices uses GPS signals to track the location of the device and if the GPS signal is not available then it can switch over to cellphone towers and track through cellphone signals. There even exist proximity trackers, which can track the signal of a device if it is relatively close by (Kanal 5, 2016).

There is one downside to using trackers, which is when the bicycle is located, then the police will, if they are called, tell the owner to either wait many hours or even days before they have time to go with the robbed out to confront the person having stolen the bicycle. If they decide to wait then the bicycle can have been sold before they arrive. This is also the case if a robbed person discovers their bicycle on sales sites such as Den Blå Avis (Dilling, 2013), (Guldagger, 2013), (Sparre, 2013).

It is however also recommended by certain police personnel that civilian people should not take up the confrontation with the thief by themselves (Jeppesen, 2015).

The police does not have time to get bicycles back from thieves.

Ill. 42: Female city bicycle with diagonal upper bar.

Ill. 43: Female city bicycle with low rounded frame.

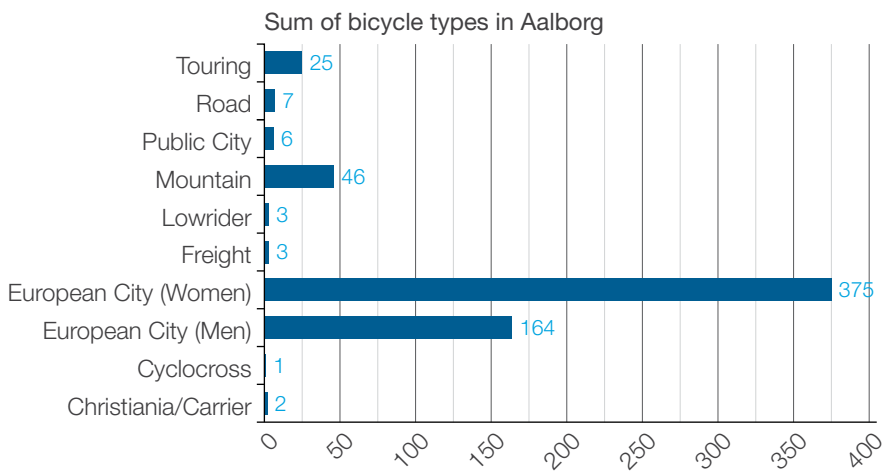
COMMON BICYCLES

It have been impossible to find any information regarding, which types of bicycles are the most stolen one, therefore an investigation into the most common bicycle type used in Aalborg have been conducted in order to identify the type of bicycle any possible product solution should fit.

FIELD INVESTIGATION

Sessions of field observations was conducted at busy bicycle parking areas, where a lot of people daily comes through. During the observations all of the bicycle racks were video taped in order to be able to categorize the various types of bicycles that were found parked in the urban environment [See appendix 7]. Through finding the types of bicycles, the most common ones could be determined. In the investigation 632 bicycles were noted down and put into a group for that specific bicycle type.

As can be seen from the graph below [See ill. 44], the majority of the bicycles were women's city bicycles of the two types seen to the left [See ill. 42 & 43]. The second most common bicycle type were men's city bicycle, where the top bar of the frame is more or less horizontal.



Ill. 44: Field investigation regarding bicycle types.

BICYCLE TYPES

The various types of bicycles on the market was also researched and these bicycles were categorized into types as a result of this research. This field investigation ran parallel with the previous investigation and was done in order to gain more knowledge regarding different shapes of bicycle frames. Four of the more common bicycle types in the urban environment, which we observed, can be seen here from illustration 42 to 47, while the rest can be seen in the appendix [See appendix 8].

Illustrations 42/43 and 45 are known as European city bicycles, but were divided into two types, because the form of the frame are so very different from one another. City bicycles are a very common type of bicycle, especially in Denmark.

Mountain bicycles are the third type and are designed to be ridden off road with their large wide tires, suspension and strong but light frames. These bicycles are both used by professional people and by amateur joy riders where they can serve as a fitness instrument. Mountain bicycles are also often used as a means of transportation, which can be seen from the field observations where they were ranked as the third most observed type.

The fourth type is a touring bicycle type, which can be seen from their wider tires than those on the city bicycles. Their tires can often remind of those seen on mountain bicycles.
Their frames also are sturdier and can support more weight, than many other types of bicycles and are often built for comfort.

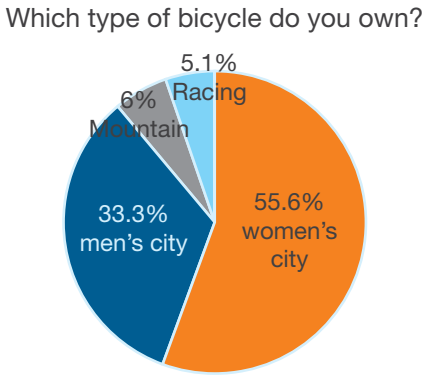
It was found from this field investigation that bicycles such as mountain bicycles can vary a lot in sizes, therefore it is wished that the final design solution will be able to fit these different sizes of bicycle. However the City bicycle type far surpasses the other types in popularity and will be the main focus area.

The majority of bicycles are city bicycles types, therefore they are the main focus point

Ill. 45: Men's European City Bicycle.

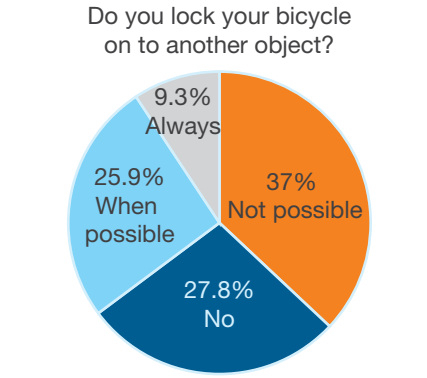
Ill.46: Mountain Bicycle.

Ill. 47: Touring Bicycle.



Ill. 48: Questionnaire - Type of bicycle.

Ill. 49: Questionnaire - Experienced theft.



Ill. 50: Questionnaire - Locking method.

QUESTIONNAIRE

To gain additional insight into all of the various areas regarding bicycles and bicycle security, a questionnaire was created. The questionnaire received 54 responds all in all.

As can be seen from the illustration to the right [See ill. 48], the majority by 55.6% of the people that have answered marked that they own a women's city bicycle, while 33.3% marked that they have a men's city bicycle. These numbers appear to fit quite well with the field observations carried out earlier.
Through the questionnaire it was found that the majority of people uses one lock to lock their bicycle, while a few answered that they use two locks to lock their bicycle, and it was concluded that a majority used mounted locks. The second most used lock was cable locks and only 5 out of the respondents used chain locks.
9 out of the 54 people used two locks; a mounted lock combined with one of the other two types.

The questionnaire also touched upon the experiences regarding bicycle safety for the respondents, namely how many have experienced getting their bicycle stolen.
The question showed that 55.6% of all the respondents said that they have at some point in their life, experienced getting their bicycle stolen [See ill. 49]. This number adds up quite well with the previously mentioned 52-54% from other sources.

With elaborative questions regarding, how many of the respondents lock their bicycle on to another object found, that 37% does not have the possibility of locking their bicycle on to another object, while 27.8% answered no, which is either because they do not have the possibility or because they only uses their flexible locks on the bicycle. 25.9% answered that they lock their bicycle on to another object when it is possible and the rest of 9.3% said that they always lock their bicycle on to another object [See ill. 50].

Mounted locks are the most common locks used by the respondents.

About every second person in Denmark have experienced getting their bicycle stolen.

INVESTIGATE BICYCLE RACKS

So far many point indicate that the main problem lies with the bicycle racks, especially the common bicycle racks, which only support the front wheel. Therefore an investigation into the marked of bicycle racks was done, with a more precise investigation on which options there are when having to secure your bicycle safely. This was done in order to gain inspiration and knowledge regarding the current market.

BICYCLE RACK SOLUTION GENERAL

The investigation includes existing solution as well as proposals for competitions, with no limitations other than the rack or similar should keep the bicycle secure under parking. Not all of the findings have an incorporated lock, but instead have an interesting feature, which could be used as inspiration.

An interesting parking option in Japan, operates by an automatic system. It requires that you pay to use it, in return you get a card and a chip, which is placed on the front of the bicycle. The storage of the bicycle is underground in a cylinder shape parking garage, which shelters the bicycles from the environment. It is only possible to access your own bicycle. The negative with this parking is, that it is an expensive solution and it would also take more time to build compared to place a normal bicycle rack (GIKEN LTD., 2013) [See ill. 51].

In the Netherlands they have underground bicycle parking areas with room for 5,000 bicycles. The rack helps lift the bicycle up with hydraulics. There is no incorporated lock in this and the user needs to lock the bicycle before lifting it up. In order to use this, the user need to be strong enough, to push their bicycle up the ramp in order to place it correctly on rack (BicycleDutch, 2015) [See ill. 52].

There are many different solution on how racks for public bicycles are designed. What is common for them all is that the bicycles and rack have a locking system, which only they fit together. In the illustration 53, the front fork have an added metal component, which fit into the rack. These solution are difficult to match, because all the public bicycles are designed so that only they fit into their racks (Cibi - AFA JCDecaux, 2016) [See ill. 53].

BikeVault is an idea, where the bicycle is placed between two pillars and the with the swipe of a card a metal pipe slides through the bicycle frame and locks or unlock from the other pillar on the other side of the bicycle. The con-

Ill. 51: Bicycle parking, Japan.

Ill. 52: Bicycle parking, Netherlands.

Ill. 53: Public bicycles, Randers, Denmark.

Ill. 54: BikeVault locking system.

cept is that the rack should be placed out in the open and that it should be free to use, this will be done by having companies advertise on the pillars. The idea behind this concept is good, but the aesthetic is boring and bulky (Peters, 2015) [See ill. 54] [See appendix 9]

Existing secure parking solutions are big and very expensive and none were found on the Danish market.

DANISH SAFETY RACKS

There are not any companies in Denmark, which sells bicycle racks with some sort of incorporated lock. Therefore instead the focus changed to searching for security bicycle racks, which is bicycle racks where it is possible to lock the bicycle frame onto.

Out-side is a company, who design and sell street furnitures. This company's designs have a more playful look to their products. They proclaim that they sell experience furnitures. Investigation into the company revealed they only have three different bicycle racks, two of which are where it is possible to lock the bicycle frame, Stoppenålen and Navigation. These two are made in steel where the third is made in fiber concrete. Their price range is DKK 1600-8000 (Outsider, 2016).

outsider

Ill. 55: Out-sider - Navigation

Veksø also sells street furnitures and city products and have designed bicycle racks for 66 years. Their products divide equally between the traditional bicycle racks and leaning hoop bicycle stands. Their bicycle racks are normally made in some form of steel. Their price range is between DKK 1200-8000 (Veksø, 2016) [See appendix 10].

VEKSØ NRGi

Ill. 56: Veksø - Largo

By investigation these Danish companies, knowledge in what product are on the market was obtained.
The conclusion were that there are not much focus on selling bicycle racks where the bicycles safety is thought into the design. And many of the companies focus more on the traditional approach with different designs in various styles.

None of the Danish companies have bicycle rack with a incorporated lock.

2.2 DESIGN BRIEF

PROJECT OVERVIEW

The project centers around bicycle security in regards to the many people that daily experience getting their bicycle stolen. As a result of interviews, field observations and analysis of the gathered data, the focus of the project has changed and will going forward therefore focus on creating a bicycle rack, with an integrated locking system that should allow the bicycle user to lock their bicycle securely in place in the urban environment without having to carry around heavy locks.

The finished product is intended to be sold directly to organizations such as the various municipalities in Denmark as they have a lot of influence in regards to which bicycles racks are installed in the cities. It has additionally been considered selling the product to larger companies, shopping malls, restaurants, housing associations and for areas such as train stations og hospitals.

VISION

Giving bicycle users peace of mind when leaving their bicycle behind.

MISSION

We strive to create a bicycle locking system that will be primarily implemented in towns and cities in northern Europe. It should provide the user with the feeling of security, be non disruptive to the urban environment, be user friendly and ease the locking of the bicycle.

PROBLEM STATEMENT

How can we create a bicycle rack with an integrated locking system, which is both user friendly and gives added value to the urban environment?

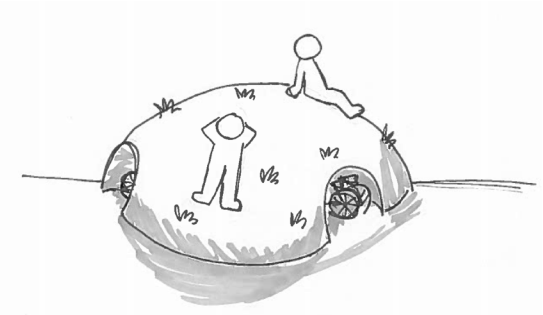
DEMANDS

- The design proposal should have an incorporated locking system.
- The lock needs to be bigger than the measured 27mm of the biggest bolt cutter.
- The design proposal needs to be able to lock around most city bicycles.
- The locking interaction should at maximum take 42 seconds.
- The lock needs to lock around the frame of the bicycle.

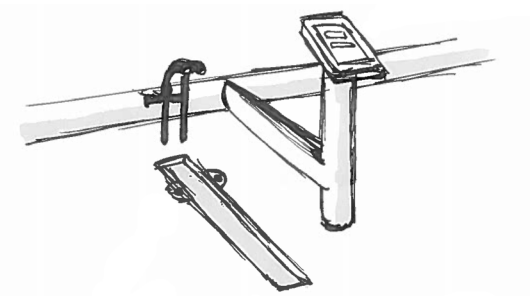
WISHES

- Approval by the Danish Institute of Informative Labeling will be needed for insurance claims.
- The solution should be cumbersome for thieves to break, which could be done through the form and construction or thickness of components.
- The user should be able to operate the lock while carrying objects.
- The product should through extra features add value to the urban environment.

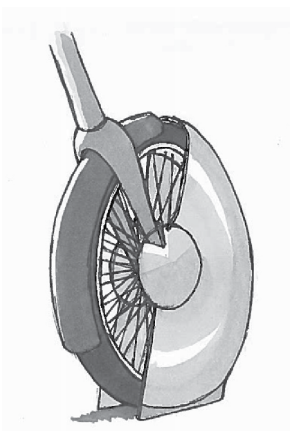
2.3 CONCEPT DEVELOPMENT



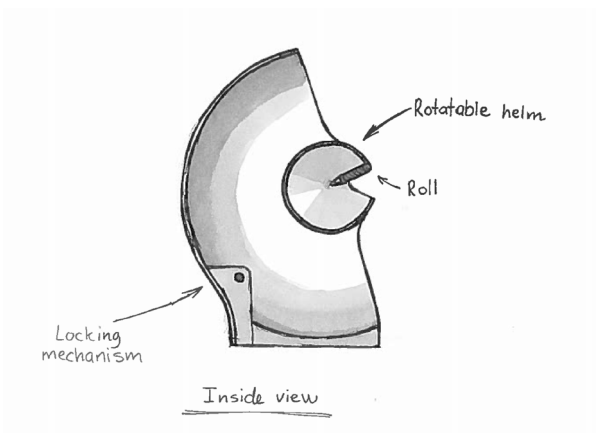
Ill. 57: Initinal sketching - Bicycle covering hill.



Ill. 58: Initinal sketching - Rack with touchscreen and wheel lock.



Ill. 59: Concept 2: Clam



Ill. 60: Concept 2: Clam detailing.

SKETCH ROUND 2

This sketching round was done after knowledge had been obtained during the research phase and was evaluated based on the demands and wishes from the design brief. Even though the urban environment was only a wish it was still chosen as one of the focus points in this concept development. It was chosen, because it was observed that many bicycle stands in Aalborg, are of the traditional types and they are not designed with the urban environments in mind. Many of the sketches during this round therefore focused on making concepts that interacted with the urban environment.

In order to generate as many ideas in as short a period of time as possible, the sketching round was done with an alarm turned on. This is a method in which sketches are forced to be quick and generally very over all and is very useful in the beginning of concept phases, because it forces more ideas because of time pressure.

After the first sketching round, three sketches was chosen to continue working on. These three concepts was then presentation at the first status evaluation [See ill. 59 - 62].

The first concept, was heavily influenced by trying to add something to the urban environment. The idea behind the concept was that the bicycles should become an art object, while they are parked. They would be hung up on a big metal canvas, where there on one side would be some sort of street art, while on the other side, your bicycle would hang and there would be spotlights on. By bringing so much attention to the bicycles, it would be obvious if a thieves were to try and steal a bicycle. These big metal canvas' were also meant to help divide parks or public areas. In order to install these a lot of preparatory work would have to be done, and the amount of bicycles placed on this would not be enough compared to how big it is [See ill. 61].

The second concept, was the most detailed one, this one took inspiration from a car lock, which closes around one of the wheels. Here the idea is that you place your bicycle's front wheel into it. It then close around the front wheel and the front fork, making it impossible to reach the front attachment on the bicycle's wheel. It also have a locking mechanism, which places an object in between the spokes. This should prevent any thieves to steal the bicycle, because it would be impossible to pull the bicycle out and also impossible to detach the front wheel from the frame. The undecided factor with this concept is whether or not the sides should be rotatable so it would clamp up

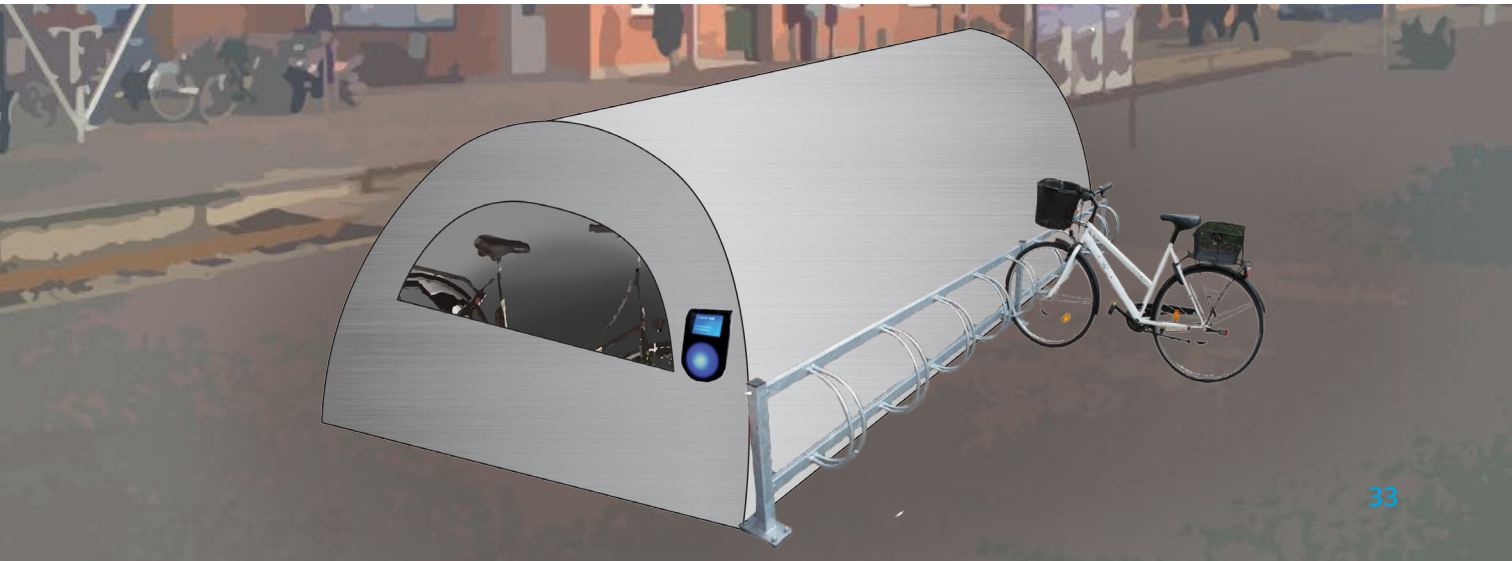
around the front wheel or if it should be still and the bicycle is just placed into it [See ill. 59 and 60].

The third concept, is more traditional. It is a type of shed, with a construction inside that should hold each individual bicycle. The construction's pipes would be made in a star shape so it would be difficult for a bolt cutter to cut. The thought was that it would be placed at train stations or bus stations and in order to have access to the shed a travel card or something alike should be used. This concept had a lot of problem parameters in regards to designing the inner space as well as developing a system so the right bicycle is accessed [See ill. 62].

Concept 2 was for further work, because of its mechanical detailing, its installation possibilities and its simple locking solution.

Ill. 61: Concept 1: Urban Art.

Ill. 62: Concept 3: Bicycle shed.



PROJECT PHASE**3.0**

Phase 3 was a quite short phase compared to the previous. The phase includes a bit more research and investigations, as well as some more concept development.

3.1 RESEARCH

ALTERNATIVE LOCKS

With concept 2 having taken inspiration from car wheel locks a session of research into locking systems for other things such as cars was conducted. This was done in order to gain more knowledge, which could be used for future concepts. The first dive looked into car locking systems, where a broad range of systems was discovered [See appendix 11].

STEERING WHEEL LOCK:

One of the more common ways of making it harder for car thieves to steal a car is to lock the steering wheel with a so called Steering Wheel Lock. Most steering wheel locks has a long arm protruding from one side of the steering wheel, which means that when the thief begins turning the wheel the arm will hit another part of the interior in the car and will not able to be turned any further [See ill. 63 - 66].

PEDAL LOCK:

Another locking system is the pedal lock, which is meant to be mounted underneath one or more pedals so that they will not be able to be pressed down. Depending on the price range of them they will either have an integrated lock or will have the possibility of using a padlock. By locking the pedals in place the thief either will not be able to change gear, brake or speed up the car [See ill. 67 - 70].

WHEEL LOCK:

The wheel lock is similar to how many bicycles are locked, which is by putting something through the wheels so that if they driev then the spooks of the wheel will be destroyed or will stop the wheel from turning any further. The car version of this type of systems does however not have the possibility to mount the lock on the frame of the car like with most bicycles. Therefore the wheel locks for cars have been designed to make it nearly impossible for the car to drive with them because of their solid design [See ill. 71]. The more expensive versions of the wheel lock also comes with a metal plate that covers the bolts to the car wheel, which disallows the wheel from being dismounted [See ill. 72].

KEY SYSTEMS

There exists a variety of different key systems for cars. The most common car keys in modern times are a type of system known as a Remote Keyless System (RKS) or Remote Central locking. With a RKS key the users are able to remotely unlock their cars by pressing a button in the key handle. The key transmits an encrypted code with a short range radio transmitter in the form of radio waves, which the car then picks up though the radio reciever and

Ill. 63: Steering wheel lock.

Ill. 64: Traditional steering wheel lock

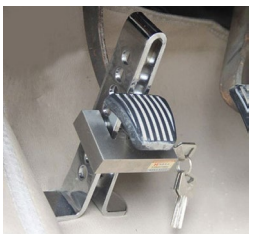
Ill. 65: Full cover steering wheel lock.

Ill. 66: Steering wheel lock.

Ill. 67: Pedal lock.

Ill. 68: Pedal lock, both pedals.

Ill. 69: Floating pedal lock



Ill. 70: Small pedal lock

Ill. 71: Wheel lock.

Ill. 72: Wheel locking shield.

either unlocks or locks the car. The locking or the unlocking of the car is usually signaled through blinking lights and/or sounds.

TRANSPONDER KEY

Keys that require the user to manualy put the key into the ignition are most often equipped with a transponder. When the key is insereted into the keyhole in the car and then turned, then the car sends an electronic message to the key and if it recieves the correct respond from the key only then can the car be turned on.

SMART KEY SYSTEMS

Some newer cars have installed a hands-free technology which makes use of proximity sensors to unlock or lock the car. This kind of key does therefore not require the user to pull out their key in order to press an unlock button. The key is identified via one of several antennas under the car's cover and through the keys radio pulse generator. Some versions unlock the car simply when you enter the proximity of it, others require the user to take a hold of one of the cars door handles before it will unlock the car.

Nothing interesting besides using wireless signals to lock or unlock the product had any interest, of which could be implemented later on.

PLACEMENTS OF BICYCLES

The following investigation was done in order to narrow down the field of operations for the project to a specific area. This investigation is primarily based on a report done by COWI for Aalborg municipality in 2014.

The COWI report on bicycle parking in Aalborg, have located where the existing bicycle racks are, how many of them are occupied and if there are any bicycles clustered around, as well as clusters not near any bicycle racks. It was found that the biggest clusters of bicycles were at the Utzon center, Sallingen and at Aalborg train station. [See appendix 12].
It should be noted that many of the bicycle racks in Aalborg are suffering from being overfilled with too many bicycles and it was reported that some of the racks have reached more than 200% of what they are meant to have parked. Information regarding how the bicycles are parked in Aalborg have been conducted both in the afternoon and in the evening. Depending in the time of day the bicycle racks have either more or less bicycles, but common for most of them is that there are parked more bicycles then what they are meant to hold, even in the evening. As can be seen on the illustrations, there especially appear to be filled with bicycles af Nytorv if compared to the actual available bicycle rack parking spot (COWI, 2014) [See ill. 73 & 74].

NYTORV BICYCLE RACK

After the COWI report was handed over to Aalborg municipality they placed three new bicycle racks at Nytorv, the traditional double-sided design, these were installed in 2015.
A quick observation was conducted at Aalborg Nytorv to see how the situation there might have changed after the new installations. There are room for 60 bicycles, which can be parked in the racks, but even with these placed there are still more bicycle placed at the racks then what they are designed for. It was observed that most of the bicycles did not use the rack, but were just placed close to it, it is not known if this is because there previously was no room or if people do not want to use the racks [See ill. Even though these bicycle racks are fairly new, they are already starting to tear and some of the stands is already unusable [See ill. 75].

It can be concluded based on the report done by COWI and the investigation done by the group that Nytorv still is a highly used area, which do not have capacity for all the bicycles that are parked there daily.

OBSERVATIONS

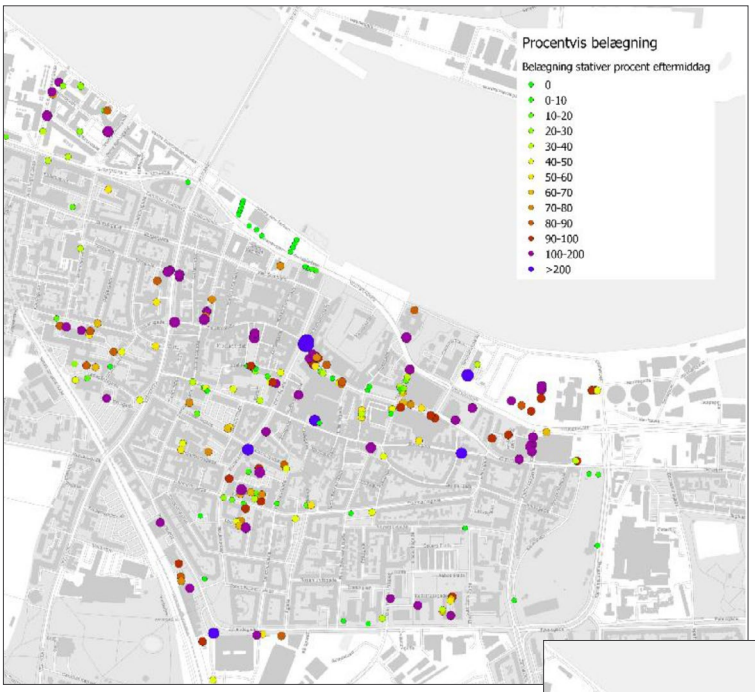
In combination with the observation a survey was conducted, this was done a Friday afternoon during rush hour. The survey was also conducted at Aalborg train- and bus station, because these areas also have high activity of bicycle parking. There were only asked two question to the people parking there:

1. How long do you intend to park your bicycle here/ how long has it been placed here?

2. Have you experienced any problems with the bicycle racks in Aalborg?

These were asked in order to gain knowledge on what kind of uses the bicycle racks are exposed to, if it is short time use or long time use and to locate any problem involving the bicycle racks.

The results from the observations and survey have been illustrated in the pie carts on the following pages and grouped according to the place of the investigation.

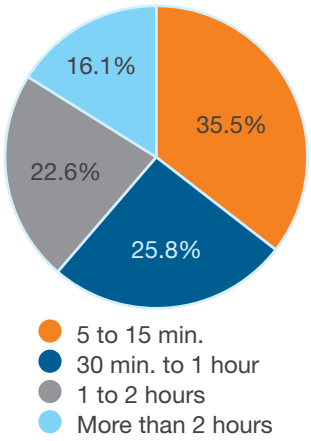


Ill. 73: Occupation percentage - afternoon.

Ill. 74: Occupation percentage - evening.

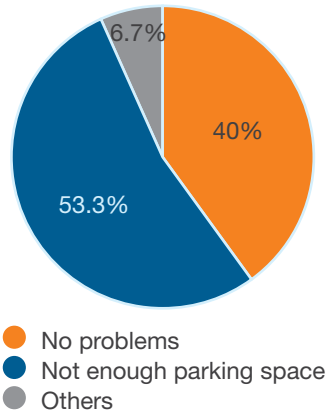
Ill.75: Nytorv bicycle rack.

Nytorvet - Parking times



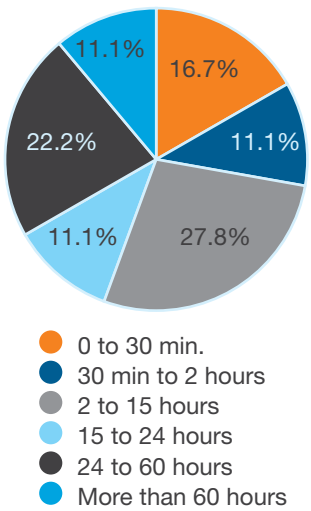
Ill. 76: Parking times - Nytorv.

Nytorvet - Parking problems



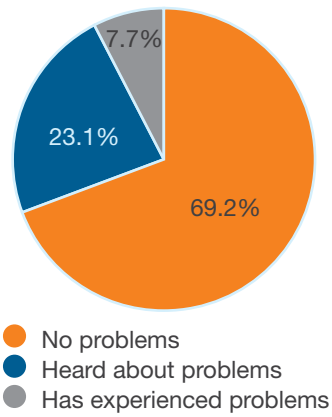
Ill. 77: Parking problems - Nytorv.

Trainstation - Parking times



Ill. 78: Parking times - Trainstation.

Trainstation - Parking problems



Ill. 79: Parking problems - Trainstation.

Bicycle racks are placed along the road of Nytorv and in front of Burger king and Spar Nord, which is the new bicycle racks.
The majority used the bicycle rack from 5 to 15 min at a time, while few used the bicycle racks more than 2 hours [See ill. 76]. This could be because the bicycle racks are placed close to shopping opportunities or that it was combined with the survey was done a Friday afternoon and people were eager to get home.
But it can be concluded from it the bicycle racks at Nytorv are primarily used in short period of time, meaning that it should be made easier and quicker to park and retrieve the bicycles.
Some of the big issues at Nytorv was that there were not enough parking spaces, meaning that it was very difficult to find free parking spots, which can conclude that the newly placed bicycle racks are not effective enough [See ill. 77].

At Aalborg train- and busstation there are bicycle racks placed almost all the way around the buildings. Here the time people parked in the bicycle racks was higher than at Nytorv, but there were also a higher variety in time. People parked from 2 to 60 hours, which is considerable more than 15 minutes at Nytorv [See ill. 78].
At the train- and bus station people typically use the bicycle racks for long time parking. Surprisingly enough there were no problems regarding the bicycle racks. Only 7.7% have experienced problems themselves with the bicycle racks [See ill. 79]. This goes against the previous investigation, which found that train stations are a common place for bicycle theft. This outcome could have something to do with the possibility to lock the bicycle in sheds provided by DSB.

The results from this field investigation shows that there are a use for a bicycle rack which are easy to use for short time uses and long time use. Meaning that it should be quick and easy to park the bicycles. Results from previous survey confirm that there is a problem with too few parking spaces as well as a problem with the small space between each bicycle, in the racks. There being a too small space between each bicycle result in a more difficult and time consuming bicycle parking [See also Appendix 13].

Quick and easy parking and retrieval of bicycle are essential to short term parking, while security is important for long term parking.

DISTANCE BETWEEN BICYCLES

One of the problems observed during the survey was that there were not enough room between each bicycle in the rack, therefore it was investigated what the normal distance between parking in the traditional bicycle racks is. The result here will be incorporated in future concepts.

BICYCLE RACKS

A search into the competitors' bicycle racks were made in order to see how much distance they had decided on. The most common distance between each bicycle rack is 400-500mm. The problem with this distance is that it does not consider that people can have baskets, different handlebars and children seat installed on their bicycles. When there are not enough room between each bicycle, people move the bicycles around in order to make room for themselves and their bicycle. This can sometimes create an avalanche effect [See ill. 82].

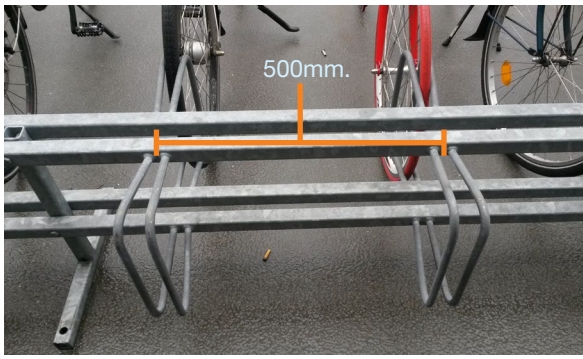
MEASUREMENT

In order to evaluate how big the distance should be between each bicycle, different bicycles were measured in width. This was done outside of the university, where a lot of different bicycles are parked. The bicycles' handlebars, pedals and accessories were measured [See also appendix 14];

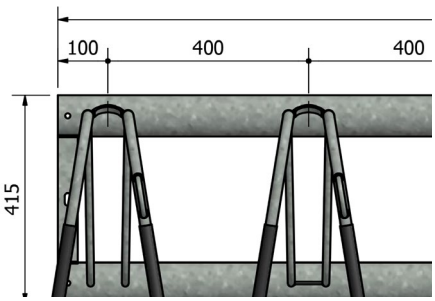
- The handlebars were from 480mm to 680mm.
- The pedals were from 350mm to 390mm.
- The baskets were 310mm to 420mm.

It was decided to illustrate an average bicycle with the measurements in width [See ill. 83].
These measurements consist with the Cykelparkeringhåndbog done by Dansk Cyklist Forbund and they have also put the criteria that the length of the parking should be 2000mm (Dansk Cyklist Forbund, 2007). Through bodystorming it was decided that the distance from the center of a bicycle to another should be around 750mm and the length should be 2000mm. With these measurements it is possible to comfortably park the bicycle without interfering with the other bicycles. This is slightly more than what is recommended in Cykelparkeringshåndbog, which recommends 600mm between each bicycle, but user comfort was decided to be more important (Dansk Cyklist Forbund, 2007).

Parking space:
Length: 2000mm x Width: 750mm

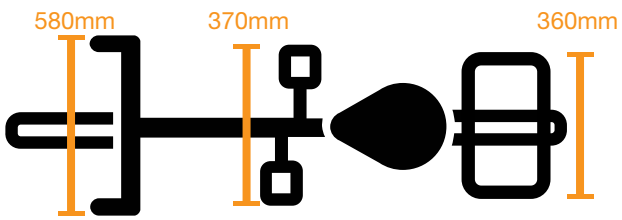


Ill. 80: Distance between bicycle rack stands.



Ill. 81: Bicycle rack illustration.

Ill. 82: Bicycles in a bicycle rack.



Ill. 83: Bicycle meassurements.

3.2 CONCEPT DEVELOPMENT

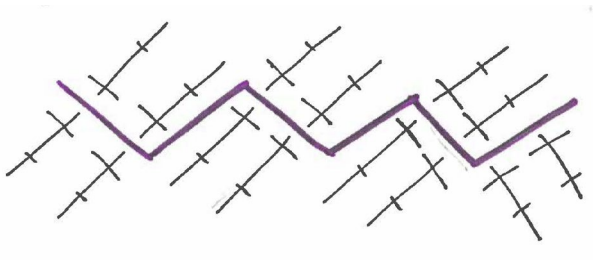
There were confusion on how to correctly create functional concepts, that could be used on basis of the gathered findings, as well as how to evaluate the concepts.
To force start conceptualization process a session of Forced Relation was used to create new concepts. By using this method certain ideas are forced together in order to create a new concept [See ill. 84 & 85].
Many of these concepts attempted to bring an added value to the solution by eg. combining them with outdoor furnitures.

The structure of the bicycle rack was also conceptualized, which resulted in a zigzag shape in order to both have room for more bicycles and to gain easy access [See ill. 86].

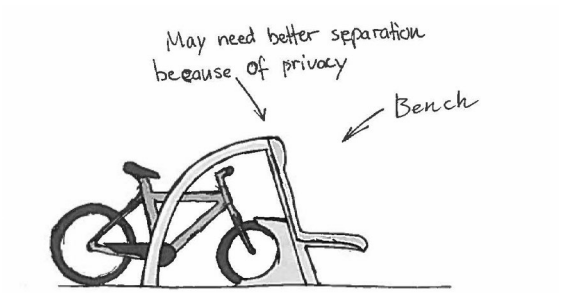
During this concept phase, a previous concept, from phase 2, was worked further with. The clam have been made smaller and angled in order to have room for more bicycles [See ill. 87].

By evaluating these concept based on the demands, it was chosen to continue working with the Clam concept as well as the zigzag concept. Both ofm these concept do not add something to the urban environments, but do solve the problem with easy access and parking space.

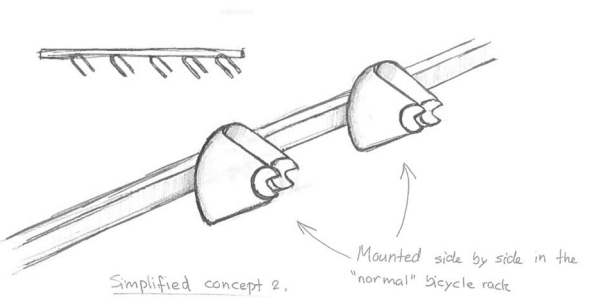
Ill. 84: Leaning bar concept.



Ill. 86: Bicycle parking pattern seen from above.



Ill. 85: Bench and bicycle parking concept.



Ill. 87: Simplified concept 2.

PROJECT PHASE**4.0**

In this project phase a lot of real world tests were conducted and it was also the phase where the final concept was decided after the requirements had been updated.

4.1 RESEARCH

USER FRIENDLINESS TEST

In order to properly evaluate difficulties of using different bicycle racks, a test was carried out. A bicycle was locked onto seven different bicycle racks located in the center of Aalborg. With every bicycle rack it was attempted to lock the bicycle frame to the rack, as recommended. If that was not possible then one of the wheels were used instead.
This test was carried out in order to get an understanding of how difficult parking a bicycle correctly is and in order to demonstrate the problems that could occur.

Ill. 88: Traditional bicycle rack.

Ill. 89: Hoop stand.

Ill. 90: Bicycle tree.

Ill. 91: Safety rack.

TEST RESULTS

TRADITIONAL BICYCLE RACK

When locking the bicycle to a traditional bicycle rack, found at Rendsburggade 14, it was found that it can not be done without getting into uncomfortable positions, where the user need to stretch or bend their body in order to reach the rack [See ill 88].

HOOP STAND

At Musikkens Hus in Aalborg the hoop bicycle stands that are formed as bicycles were tested out.
The hoop stand has plenty of space for locking the bicycle with the access to the bicycle from the side. This makes it easier to lock the bicycle frame to the hoop stand without having to stand in uncomfortable positions. It can however be discussed how good this hoop stand is when supporting the bicycle [See ill. 89].

BICYCLE TREE

At Nordkraft and at Vesterå, there have been placed these bicycle trees, which can support four bicycle at a time.
These bicycle racks are designed to carry two bicycles in the upper arms and can therefore force the user into uncomfortable body position, mainly when lifting the bicycle up over the head. In some rare cases it could end in injury, because of the weight of the bicycle and the cumbersomeness of the placement [See ill. 90].

SAFETY RACK

At the back entrance for one of the departments of Aalborg municipality, there are installed safety bicycle racks. These bicycle racks are placed with large space between them, which makes it easy to get to the bicycle and lock it correctly. Furthermore by using these bicycle racks the user did not need to place their body in any uncomfortable position [See ill. 91].

HOOP STAND 2

These hoop bicycle racks are placed at Friis. They are placed with a broad even space between them, which makes it easy to place the bicycles up against them.
By using these hoop bicycle racks it is easy for the user to interact with the bicycle and the rack. No uncomfortable position was found for the user. But by using the hoop stand the bicycle was not supported in any way and it was therefore easy for the bicycle to fall over [See ill. 92].

Ill. 92: Hoop rack 2.

TRADITIONAL ANGLED RACK

Placed on the other side of the department of Aalborg municipality, there were installed a type of traditional bicycle racks with angled design. When parking the bicycle in an angled position there should, in theory, be room for more bicycles and they should not take up as much space of the sidewalk as straight traditional bicycle racks. The problem with access to the bicycle rack, was however still a problem when the user needed to lock the bicycle with a flexible lock [See ill. 93].

Ill. 93: Traditional angled rack.

TEST CONCLUSION

It was only possible to lock the bicycle's frame to the rack in four out of the six cases.
It was only possible to keep the body in a comfortable position when locking the bicycle to these racks.

At the traditional racks, angled and not, it was only possible to lock the front wheel, by standing in uncomfortable positions.

In order to design a user friendly bicycle rack, the user should not bend down under knee height and should not have to place their bicycle up over their heads. These are the two positions that needs to be avoided [See ill 94] [see also appendix 15].

The user should not bend down under knee height and should not place their bicycle over their heads.

Ill. 94: Positions to avoid.

4.2 UPDATED REQUIREMENTS

In addition to the already existing demands new demands were found through the additional investigations. On top of those newfound demands, additional more specific requirements were added to help make more detailed concepts in the concept development phase.
All of the demands and the wishes have been given values to symbolize their importance during future concept developments. The higher their given value the more important the requirement is. One being the lowest and 5 being the highest.
By prioritizing the demands it will become easier to evaluate concepts by giving the concepts points according to the requirements and then comparing them to the requirements expressed here.

The section of wishes can be important parameters for the concept development, like the demands are, however wishes are considered to the things that could be nice to have, but are not a demand and are therefore not equally as important as the demands.

DEMANDS

5	The design proposal should have an incorporated locking system.
5	The design proposal needs to be able to lock around most city bicycles.
5	The lock needs to lock around the frame of the bicycle.
4	The lock needs to be bigger than the measured 27mm of the biggest bolt cutter.
4	The locking interaction should at maximum take 42 seconds.
4	Maximum space used to the parking of one bicycle needs to be 2000mm x 750mm.
3	Enable use with a wheel thickness from between 30mm to 40mm.
3	Enable use with a wheel size from between 26inch - 28inch.

WISHES

5	Should not bring the user into uncomfortable usage positions during the interaction.
4	Should be durable and able to withstand attacks.
3	The user should be able to operate the lock while carrying objects.
3	The product should through extra features add value to the urban environment.
2	The solution should be cumbersome for thieves to break, which could be done through the form and construction or thickness of components.
-	Approval by the Danish Institute of Informative Labeling will be needed for insurance claims.

4.3 CONCEPT DEVELOPMENT

During the fourth round of concept development, the zig-zag concept was scrapped, because it did not match many of the demands. The fourth concept development round instead was initiated as a result of the updated requirements. Seven new concepts was introduced and evaluated based on these demands.
All seven concepts was evaluated by comparing the values given to the demands and the values that was given to the concepts based on the evaluation of them.
In the end an overall score was calculated and the three concepts with the highest score was chosen for further concept development.
Evaluation of the concepts were based on the demands and gave a clearer understanding of what direction the product was going, as well as what was important for the group to accomplish [See also appendix 16].

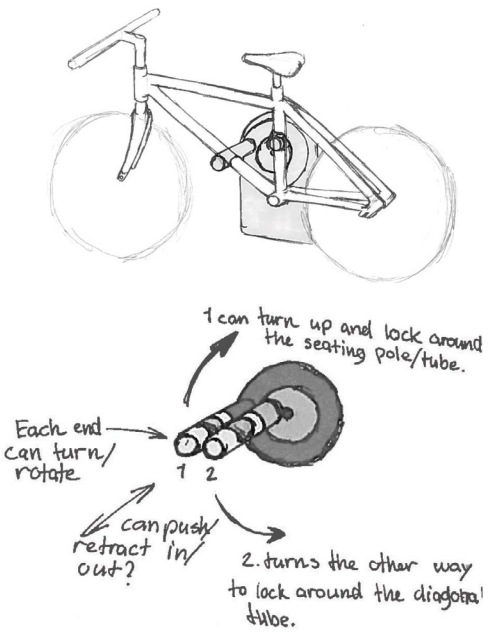
CONCEPT 1

The first concept was a rack, that locks around the middle of the bicycle's frame [See ill. 95].
Here two arms are placed in an outer and an inner circle, making it possible to rotate both individually. Additionally the arms' tips can rotate matching any angle of the bicycle frame. The user should themselves rotate the arms so they matches their bicycle's frame.

PROS:
- Any type of city bicycle can use the system.
- Easy to understand.

CONS:
- No consideration to the urban environment.
- Uses too much space.

RESULT:
The concept scored 44 points.



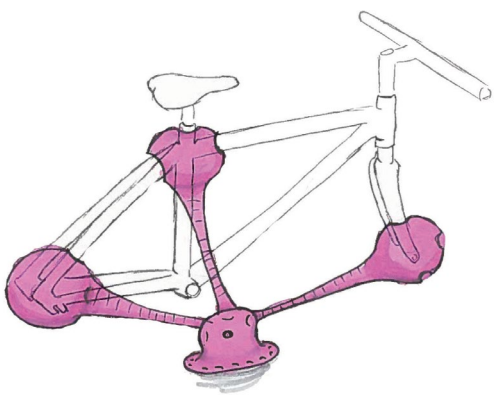
Ill. 95: Concept development 4 - Concept 1.

CONCEPT 2

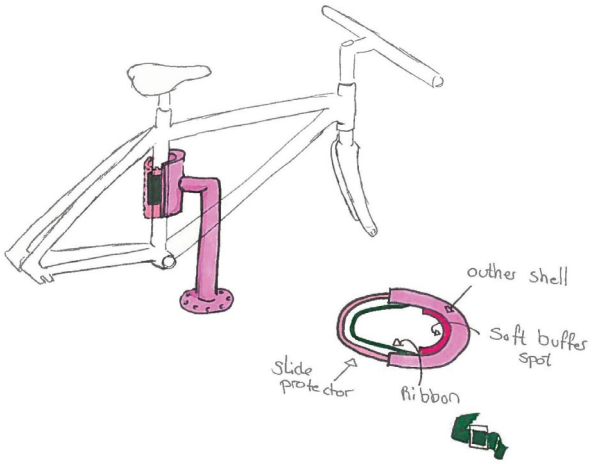
The idea with this concept is that there are three arms, which lock all the critical areas, frame, front wheel and fork and back wheel and frame [See ill. 96].
This should make it very difficult for thieves to steal the bicycle. The arms can stretch or retract, so they can fit different heights of bicycles. The arms are meant to be attached to an anchor at the ground. The user should manually place the three arms himself.

PROS:
- Does not use more than the maximum space allowed.

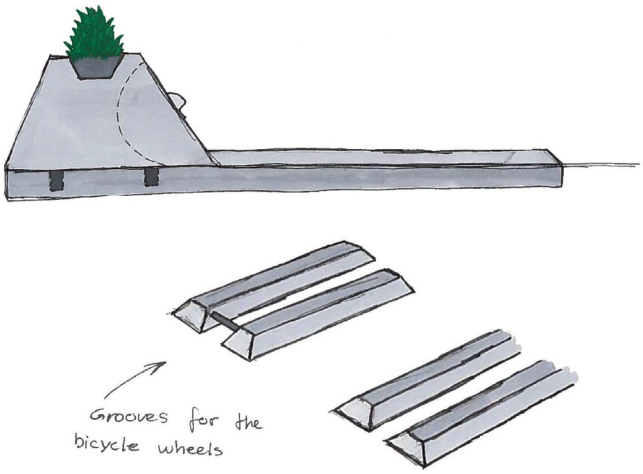
CONS:
- Does not fit into the urban environment.
- Easy to vandalize.



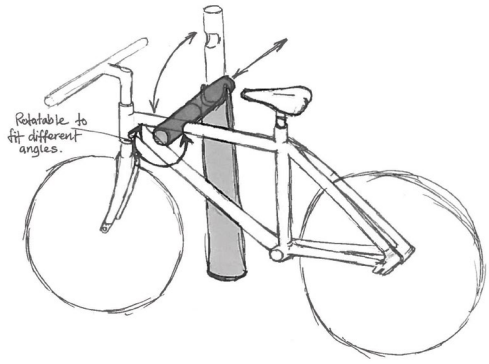
Ill. 96: Concept development 4 - Concept 2.



Ill. 97: Concept development - Concept 3.



Ill. 98: Concept development - Concept 4.



Ill. 99: Concept development - Concept 5.

RESULT:
The concept scored 42 points.

CONCEPT 3

Concept three is a pole which an arm, on which a belt is placed underneath a protective screen [See ill. 97].
This belt should make it possible to lock different types of bicycle frames, because it can be adjusted to different sizes. The screen is in order to protect the belt from being cut. Inside the arm is also placed a cushion in order to avoid damage to the bicycle frame.

PROS:
- Uses very little space.

CONS:
- Easy to cut with metal tools.

RESULT:
The concept scored 38 points.

CONCEPT 4

Concept four is a development of the Clam-concept [See ill. 59, 60 & 87]. In this concept here, the clam is placed in a concrete block, where the front wheel are to be placed inside. There are two concrete groves, which should make sure that the bicycles are placed correctly. It could be possible to place a lock for the back wheel, thereby securing both wheels and the frame [See ill. 98].
On top of the rack there are placed vegetation, to create a contrast between hard concrete and green living plants. The clam itself works as previously, by shielding the front fork and wheel from any tools, which could detach the front wheel.

PROS:
- Effective parking solution for multiple bicycles.
- Locks both wheels and the frame.

CONS:
- Many mechanical parts.

RESULT:
The concept scored 51 points.

CONCEPT 5

Concept five is a pole where an arm can bend down over the bicycle frame [See ill. 99]. On this arm is a rotatable joint, which makes it possible to fit various angles of the upper bar of the bicycle's frame. The user should manually place the arm.

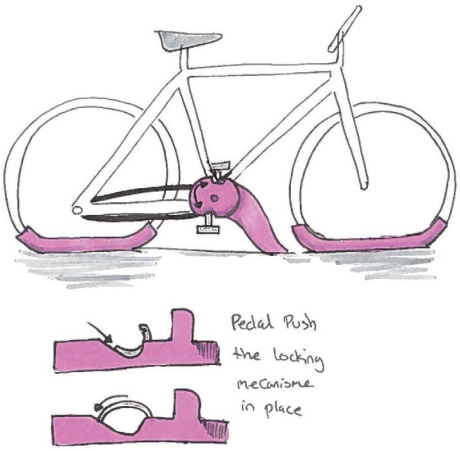
PROS:
- User friendly with its comfortable height.
- Easy to understand.

CONS:
- Might be vulnerable to kicking.

RESULT:
The concept scored 47 points.

CONCEPT 6

Concept six is a ground based concept. This is conceptualized to lock the pedals, as well as both wheels [See ill. 100]. The idea behind this concept is that the user can slide their bicycle into the rack and a mechanism, when feeling the pedals, will lock the bicycle, so the user does not have to bend down.

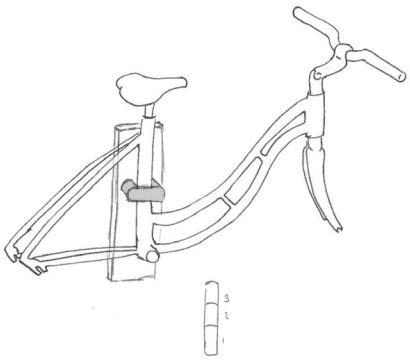


Ill. 100: Concept development - Concept 6.

PROS:
- Can lock both wheels as well as the frame.
- Does not use a lot of space in the environment.

CONS:
- Safety concern, because of visibility when it is so low.
- Dirt and other ground based things might affect the mechanisms.

RESULT:
The concept scored 50 points.



Ill. 101: Concept development - Concept 7.

CONCEPT 7

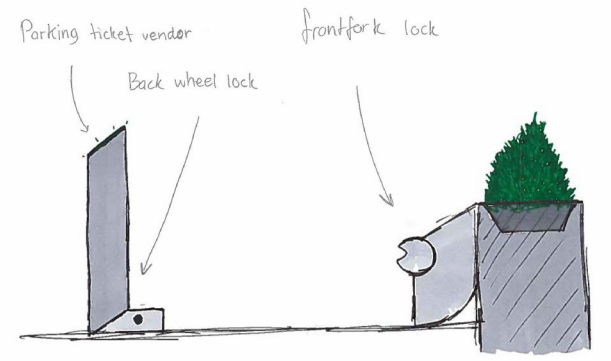
Concept seven is a pole with three joints, these joints that can rotate in any direction and grab around the bicycle's frame [See ill. 101]. When locked, the pole is fixated and can not be moved.

PROS:
- Minimal usage of space.

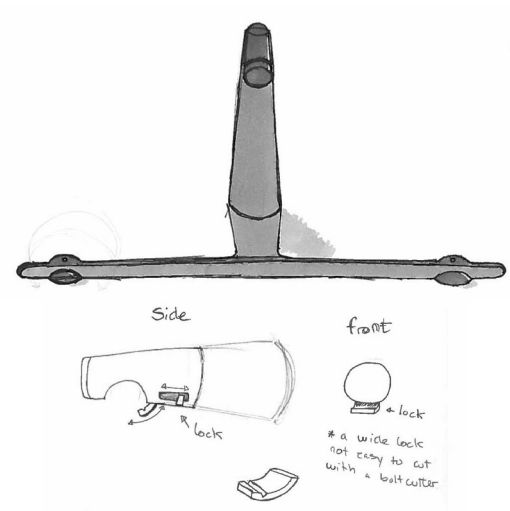
CONS:
- Only locks the frame.
- No addition besides locking to the urban environment.

RESULT:
The concept scored 40 points.

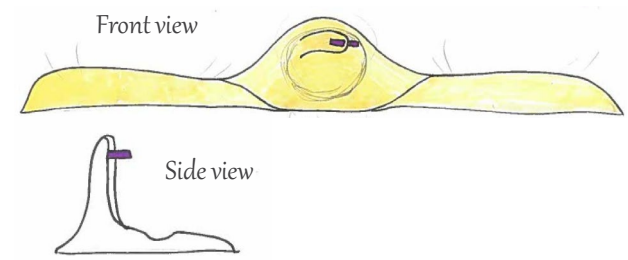
Concept 4, 5 and 6 were chosen for the further concept development, because of their potential and higher scores.



Ill. 102: Concept development - Concept 4.1.



Ill. 103: Concept development - Concept 5.1



Ill. 104: Concept development - Concept 6.1

The concepts needed physical models to get a better understanding on their shape and size, as well as the interaction.

DETAILING OF CONCEPTS

The concepts chosen from the previous concept development were worked further on by developing new ideas, through drawings and models, on the basis of those concepts.

The requirement specifications were used again, but was instead this time used as a means of evaluating the concepts' weak points and then focus on improving those faults.

CONCEPT 4.1

Concept four were not worked with as much as the two others, which were because the concept had been in the project from the start in the form of the Clam concept.

Evaluation from the requirements meant that the design needed some development and new sketches were drawn. The concept needed to be more user friendly [See ill. 102]. The clam can be seen moved outside of the concrete block in order for the user to see more clearly what to do. This was later canceled, as it also made it more vulnerable to thieves and for people to vandalize.

CONCEPT 5.1

During the detailing of concept five the were a focus on helping people understand how to place the bicycle correctly. A dive into how to lock the wheels were generated through a new idea and a grove and bump was added to the concept. In the end it was chosen to go forward with the grove, because this fit the concept visually.

Another aspect that was worked with, was what kind material it should be produced in. The thought initially were in some sort of concrete or maybe fiber concrete. It was also considered to add some form of lighting into the design, which could add an interesting aspect to the product.

For easy locking of the bicycle's a simple sliding lock was added to the concept [See ill. 103].

CONCEPT 6.1

Concept six evolved into a more smooth appearance to minimize any potential damage to each individual part of the concept [See ill. 104]. The material for this concept was thought to be in concrete or hard plastic in order to protect all the mechanical and fragile parts. The locking mechanism was also looked at in order to see how the lock should interact with the pedal, but was unfortunately not very detailed.

MODEL WORKSHOP

A model workshop was conducted as a result of the previous detailing session. The models were made in a scale of 1:10. Models of the bicycles were also made to have a comparison of the concepts [See ill. 105] [See also appendix 17].

CONCEPT 6.1

Concept six was thought to be placed at Nytorv. The model was shaped organic, in order to symbolize a wave to associate it to the fjord. The idea was that this concept should be produced in concrete or plastic, which also enables the possibility of this shape [See ill. 106 & 107]
This concept is very large and would demand much attention in the urban environment, which is not necessarily a bad thing, but not many of them could be placed in the same area, because of their size. This could result in less parking places compared to the traditional bicycle rack. Furthermore by being in such an organic shape and close to the ground, it could potential become a safety hazard, if people were to trip over it.

CONCEPT 6.2

From concept six another concept was developed. This concept only locks around the pedals, but lock the pedals from both sides instead of one side as with concept 6.1. Locking from both sides makes the solution more secure. It is shaped in a way to resemble a clam, again to associate to the sea and the Limfjord. It is possible to slide the bicycle in between the to shells [See ill. 108 & 109].
This concept does not require as much space as concept 6.1. The concept could also be a potential safety hazard by being so close to the ground, although more visible.

CONCEPT 6.3

Another variety of 6.2 were made and while this also locks the pedals, it requries the user to lift the front wheel over and into the shells [See ill. 110 & 111]. The lifting could help indicate the direction from which to approach this locking system, as only one of the ends enables the lifting. It could be difficult to lift the bicycle and therefore it can be argued that it is not very user friendly. This concept is still close to the ground and smaller than concept 6.2, making it easier to fall over, which means it could cause a safety hazard.

Ill. 105: Bicycle models.

Ill. 106: Concept development - Concept 6.1.

Ill. 107: Concept development - Concept 6.1.

Ill. 108: Concept development - Concept 6.2.

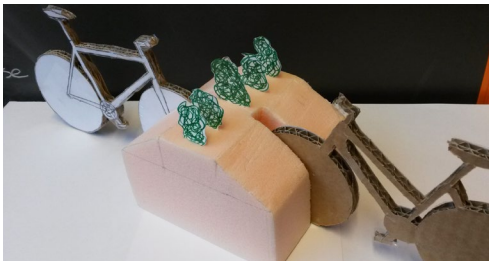
Ill. 109: Concept development - Concept 6.2.

Ill. 110: Concept development - Concept 6.3.

Ill. 111: Concept development - Concept 6.3.

Ill. 112: Concept development - Concept 5.1.

Ill. 113: Concept development - Concept 5.1.



Ill. 114: Concept development - Concept 4.1.

CONCEPT 5.1

Concept 5.1 is essentially a high bollard, with a rotatable arm. The bollard design can remind of the maritime atmosphere of the harbor in Aalborg where a large amount of bollards have already been installed [See ill 112 & 113]. This concept could be produced in fiber concrete, as mentioned earlier, or potentially be produced in steel.
This concept does not take up much ground space, and therefore it is possible to place several of them on a small area. When not in use this concept is a very slim and has a symmetric design, which was found pleasing for the eye. When in use the design take on a more playfulness expression.

CONCEPT 4.1

Concept 4.1 is more solid and robust than the other concepts. The thieves would think twice before vandalizing and try to steal a bicycle from this construction. Furthermore it should be produced in concrete adding to the robust lock. In order to soften the aesthetic, vegetation was added. The model helped understand the size of this concept even though the scale was only in 1:10. It was found that the solution were going to take up a lot of space, but it would be easier to control the position of the bicycles with this concept [See ill. 114].

Concept 4 and 5 were chosen for further development on the basis of the realizability, potential and because the physical dimensions.

KEY-SYSTEM FOR THE RACK

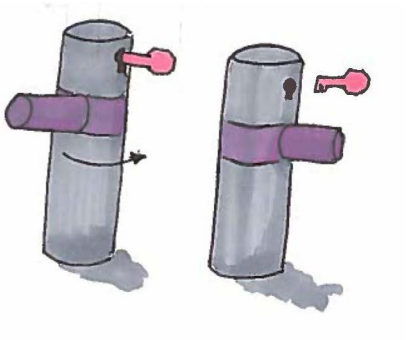
The focus of the concept development took a bit of another direction after the model workshop, because it was needed to figure out how the actual locking mechanism should work from the users' perspective.
Up until this point the focus had been on obtaining an overall design of the product as it was thought easier to figure out how the locking should work afterwards.

With a clean slate, a brainstorm and sketch session was conducted to generate as many solutions as possible.
In the beginning all of the ideas incorporated normal keys, like those used currently for locking or unlocking a bicycle lock [See ill. 115]. However based on a discussion in the group it was decided that such a solution would not make any sense with the current product direction.
Not only would the key only fit one lock on one rack but people would also need to carry around an additional key and thieves would also be able to pick the lock if they had the proficient lockpicking still.
It was decided that more modern and integrated solutions should be the focus of these ideas.

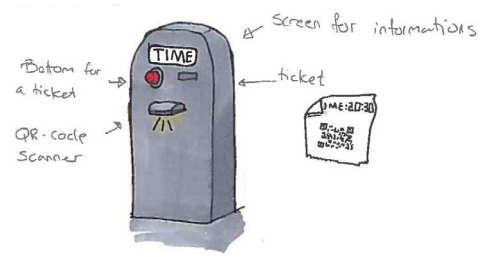
One of the new ideas took inspiration from car parks ticket machines, where the user would receive a ticket with a QR code on, this QR code would be needed to be scanned in order for the user to unlock their bicycle [See ill. 116]. This idea was not chosen because the user could easily lose the ticket and they are generally annoying to carry around.

A short evaluation of the things people carry around with them in their bags, wallets and pockets was discussed and through this it was found that many people, especially around Aalborg bus and train station, would have their travel card on them (Rejsekort). A short search showed that in total around 1.7 million people in Denmark owns a travel card (Wahlsten, 2016).
As a result it was chosen to make a key-system where the users could lock and unlock their bicycles to the rack using their travel cards [See ill. 117].

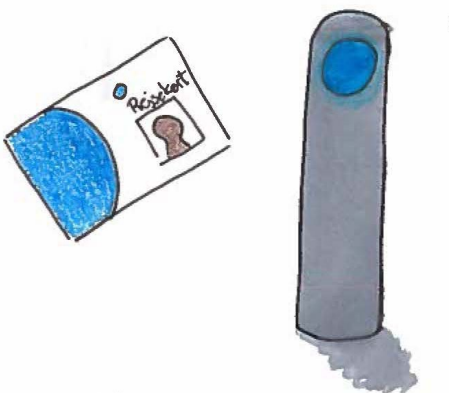
Based on the potential it was chosen to develop the future concepts with the travel card as the lock access in mind.



Ill. 115: Key lock concept.



Ill. 116: Parking house ticket concept.



Ill. 117: Travel card lock concept.

BICYCLE FOCUS AREA

The outcome for this task was to eliminate focus areas on the bicycle, by focusing on mechanical aspects, eg. if a mechanical lock were to be placed near the ground and then figure out what implications such a choice could involve.
Three areas on the bicycle were chosen for evaluation. These areas were; close to ground on the bicycle, in the middle of the bicycle or at the top of the bicycle [See ill. 118 - 210].

The results are divided up in pros, cons and neutrals. This result in a quick overview.

CLOSE TO THE GROUND

[See ill. 118].

PROS

+ Not noticeable in the cityscape.
+ Difficult for thieves.
+ Could only consider wheels and spokes.
+ Would be possible to lock pedals and frame at the same time.

CONS

- Dirt in the mechanisms.
- Difficult to interact with.
- Pedals are in the way.
- Security hazard, people could fall over it.
- Difficult area to lock onto.
- The bicycles are often dirty in that area.
- Needs to consider spokes.
- Could get dirty by interaction in this area.
- If only locking the wheels, it would be possible to steal the rest
- Locking of the pedals would be difficult.
- Many mechanical parts to take into account.

NEUTRAL

o Can be both stable and unstable support of the bicycle.

MIDDLE OF THE BICYCLE

[See ill. 119].

PROS

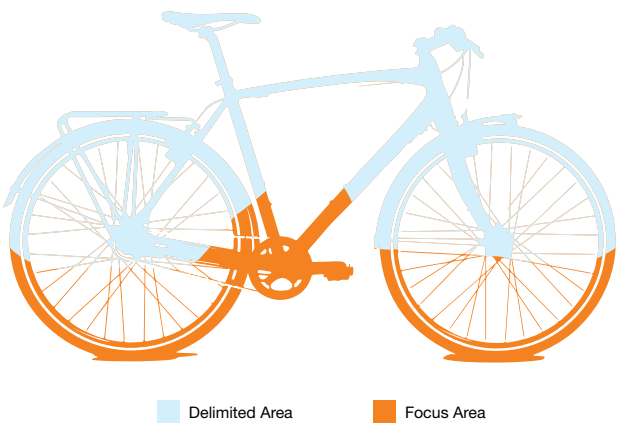
+ Possible to lock both womens and mens bicycle.
+ Many places to lock onto.
+ The lock is lifted from the ground.
+ Stable support of the bicycle.
+ Possible to lock both frame and wheel.

CONS

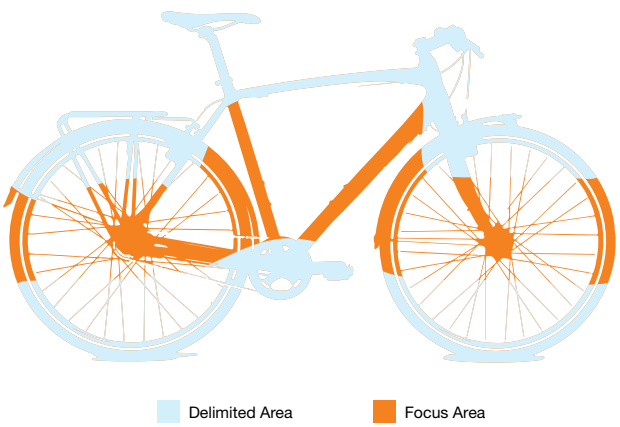
- Many parts to take into consideration.
- There are many joints to take into account.
- Different types of front forks.
- Bicycle lights will get in the way.
- Need to consider spokes.
- Gear is often bulky and could get in the way.

NEUTRAL

o Both a dirty and clean area to interact with.
o Interaction could be both easy and difficult.



Ill. 118: Proposal one.



Ill. 119: Proposal two.

TOP OF BICYCLE
[See ill. 120].

PROS

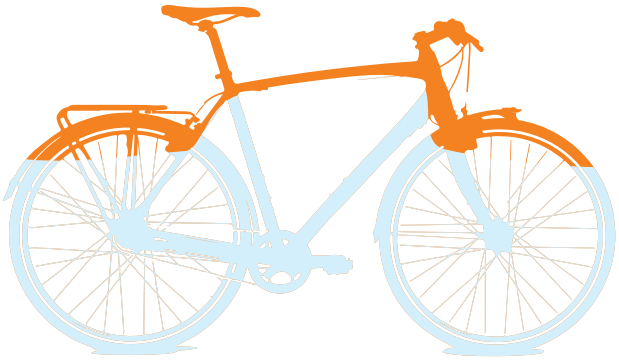
+ Most clean area.
+ Easy to interact with.

CONS

- Handlebars and seat can be removed
- Difficult area for woman bicycles
- Limited space at the wheel due to basket, lights, brakes and luggage carrier
- Need to consider spokes

Neutral

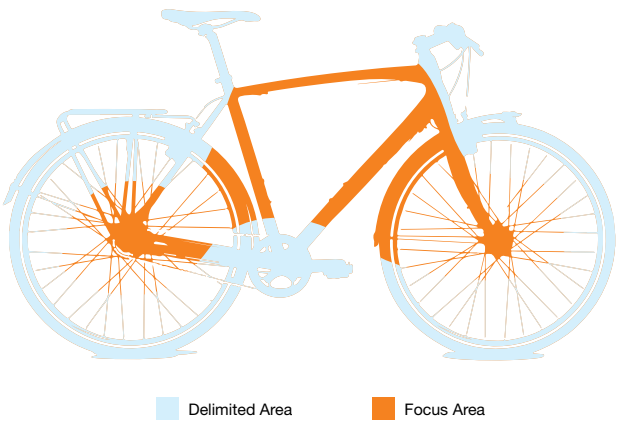
o There are nothing to add.



Ill. 120: Proposal three.

BICYCLE FOCUS AREA

It can be concluded that the area that were chosen were a combination of the middle of the bicycle and the top of the bicycle.
The top frame of the bicycle were selected, because this were one of the easiest parts to interact with.
The handlebars and seat were deselected, because these can be detached from the bicycles. The deselection also included the top of the wheels, because here a variety of objects can have been installed and would only add a unnecessary challenge.
Furthermore the wheels will not be the main focus area as locking the frame would be much more effective and time consuming for the thief.



Ill. 121: Final focus result.

Ground based concepts have been eliminated as a result of this investigation. Concept 4.1 and 5.1 will be further developed.

Ill. 122: Clam - test model.

Ill. 123: Turning Tower - test model.

Ill. 124: Turning Tower - test 1.

Ill. 125: Turning Tower - test 2.

BODYSTORM WITH MODELS

When the concept 4.1 and 5.1 were chosen to keep developing on, it was decided to model them in a 1:1 scale in cardboard. Even though a previous model workshop had been carried out, this bodystorm was important in order to gain an understanding of the right dimension and how it would be for the user to interact with the concepts. [see also appendix 18]

CLAM TEST

Concept 4.1, also called Clam were made in a cardboard model. Clam is a big and chunky construction, therefore only a section of this was built. The end result when using Clam, was the same when using any traditional bicycle rack, but during the bodystorm there were some concerns about whether or not it would damage the front wheel or the front fork of the bicycles and if the users were concerned that the lock being very hidden [See ill. 122].

TURNING TOWER TEST

When evaluating concept 5.1, also called Turning Tower, the main focus was to come to a conclusion regarding its height. Therefore the arm and the body were made in different heights and placed together after turn. Furthermore the models were tested on three different types of city bicycles, male, female and lady bicycle [See ill. 123].

TEST 1

The first model to be tested was bottom part of the model 800 mm and top part of the model 200 mm. This set up experienced problems reaching the bicycles' frames for all of them, because the bottom was either too high or the arm too short [See ill. 124]. It did however have comfortable 800mm height of interaction.

TEST 2

The second mode consisted of the 600 mm bottom and the 400 mm top part. The top part was found too short to reach the male bicycle, while the model was still too high to reach the lady bicycle, although it could reach the saddle frame [See ill. 125]. The model is however still in a comfortable height.

TEST 3

The third model was the 400 mm bottom part and 600mm top part. This combination was used in order to see if it would be easier to operate. This was not the chase, by placing the rotational joint so low, as it was very unhandy.

This was however the only model, that could reach the male city bicycles frame, while also being able to lock around the female and the lady bicycle, although the female and the lady bicycles needs to be parked further away or have additional locking holes, because of the angles and height difference [See ill. 126].

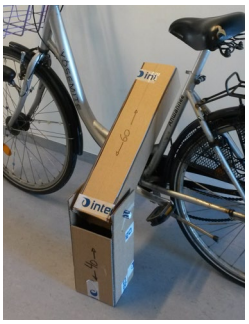
TEST 4

The fourth model was bottom part 800 mm and top part 600 mm. This model was too big and could not reach neither the frame of the lady bicycle or the female city bicycle. It would only have been possible if the top could turn further down. In addition to not being able to reach the bicycles, the size of the solution also made it difficult to use and gave it an imbalanced look [See ill. 127].

TEST 5

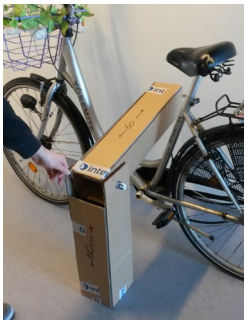
The the fifth and last model, was a combination of a bottom part 600 mm and top part 600 mm. This combination could easily fit onto the male city bicycle frame and it was also possible to reach the female bicycle's top bar. It was not possible to lock the lady bicycle the intended way because of height issues, however because the concept was designed to be able to rotate out in the end of the arm it could still lock on to the seat pole of the bicycle's frame. The only other problem would be the need to lock the bicycles in different distances [See ill. 128].

None of the tests proved to be a success in regards to finding a concept solutions.



Ill. 126: Turning Tower - test 3.

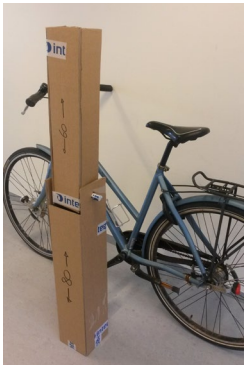
Ill. 127: Turning Tower - test 4.



Ill. 128: Turning Tower - test 5.

Ill. 129: Concept 5.1 - Turning Tower - height test low.

Ill. 130: Concept 5.1 - Turning Tower - height test medium.



Ill. 131: Concept 5.1 - Turning Tower - height test high.

Ill. 132: Concept Tolok.

HEIGHT TEST

A height scale was also done in order to get an impression of how tall the concept would be.

- The smallest consisted of the bottom part 600 mm and top part 400 mm, which made it 1000 mm in total [See ill. 129].
- The medium size test consisted of bottom part 600 mm and top part 600 mm. In total it was 1200 mm [See ill. 130].
- The tallest of the height tests was made of bottom part 800 mm and top part 600 mm, which made it 1400 mm in total [See ill. 131].

The medium height test was decided as the winner, because of its adaptability, visible height and comfortable interactive height.

SOLIDWORKS MODELING

Simultaneously with the bodystorming, models in the 3D program SolidWorks was made in order to gain a more technical understanding of the concepts.

By working with the models in 3D, a problem occurred with the Turning Tower concept as the top bar of the bicycle's frame all have various sizes in diameter. It was therefore investigated if there were a similarity anywhere else on the different city bicycles' frames. It was discovered that the frame around the seat pole, more or less always have the same size in diameter.
Unfortunately the Turning Tower had difficulties reaching the frame around the seat pole properly, therefore different proposals were constructed and eventually a new concept was developed. This new concept was given the name Tolok.
Tolok took inspiration from a sketch done under the chapter regarding Key-System for the Rack [See ill. 115].
The arm is instead of being rotated downwards, rotated along the horizontal axis to easier reach the frame around the seat pole.
The tip of the arm could still rotate in order to securely lock onto the various angles of seat poles.

In order to properly test the interaction with Tolok, a simple cardboard model was constructed [See ill. 132]. During the testing it became clear that what heights the body should have and how long the arm should be in order to

lock properly around the frame and not hit the frame.
By working in 3D programs it forced more detailed decisions to be made and the 3D models were presented at the final status seminar.

The first concept to be 3D modeled was Clam, here concerns such as height and lengths was discussed as well as the distance between the opening in the Clam. Clam is supposed to be divided up in three parts, the “floor”, which is where the grooves will be made and two halves of the main part where the locking is installed. By dividing the construction into parts it would make installation of the solution easier [See ill. 133 & 134].

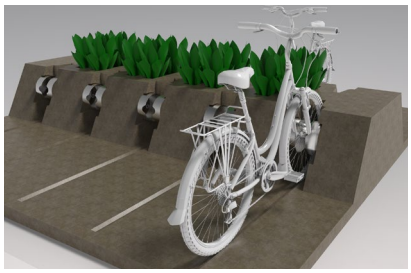
As mentioned in the previously, the Turning Tower concept evolved into Tolok, but not before it had been through multiple other Turning Tower concepts such as version 1 and 2.
The first Turning Tower version was a cone formed tube and was the closed 3D model to the original drawn Turning Tower concept. The concept did however have some problems regarding space for the frame around the seat pole [See ill. 135].
By further development version 2 of the Turning Tower was conceptualized. It had an elliptical shape in order to have a larger locking system. But the aesthetics of it seemed broken when the end of the arm was turned, which also made it vulnerable to thieves with hammers. Because of these findings the second version was scrapped [See ill. 136].

Tolok was chosen as the only pole concept to be brought to the final status seminar.

FINAL STATUS SEMINAR

During the project’s final phase a status seminar were held for all of the semester groups. This seminar was the second on the semester, as the first had already been held much earlier in the project while still in the start up phases. The final status seminar was in the group’s case used to receive feedback on the Clam and the Tolok concept with the intend on deciding which concept should be the one going into the detailing phase.

The Clam was the first concept to be evaluated. There were a lot of doubt regarding if the different types of bicycle would be able to fit into the Clam, especially if the bi-



Ill. 133: Concept Clam.

Ill. 134: Concept Clam.

Ill. 135: Concept Turning Tower 1.

Ill. 136: Concept Turning Tower 2.

Ill. 137: Concept Tolok - Open.

Ill. 138: Concept Tolok - Locked.

cycle had Quick-release on their front wheel. Furthermore it was stated that it was very sensitive to different heights of bicycles and would therefore make it difficult to park both small wheel and big wheels in the Clam. In addition it was stated that Clam would end up taking too much space, both ground area and visibility.

Tolok was also presented at the final status seminar. Here it was stated that it would be important not to take up too much space, by placing them incorrectly as well as only have room for one bicycle per rack. Another concern was that if it would be tough enough to handle getting hit by a car and still function?

After the final status seminar Tolok was evaluated based on the demands and wishes. It scored overall high points;

PROS:
- Locks the frame in a cumbersome theft area.
- User friendly interaction.
- Can support the bicycle.

CONS:
- Concerns about durability of the arm.

RESULT:
The concept scored 54 points.

Based on the feedback from the final status seminar and the evaluation based on the requirements it was chosen not to continue developing the Clam concept and instead focus entirely on the Tolok concept.

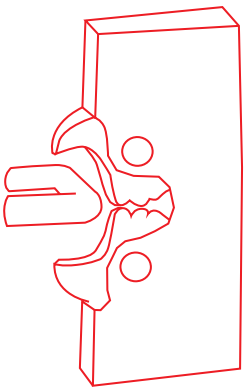
Tolok to chosen as the final concept and the concept to be further developed in the detailing phase.

PROJECT PHASE**5.0**

This phase was the last phase and here the product was detailed and production methods and price were investigated.

5.1 CONCEPT DETAILING

The detailing phase begun after having chosen the final concept to continue development on. The chosen concept were Tolok and the overall design of the concept only changed very little during the detailing phase.



Ill. 139: Car door lock mechanism.

Ill. 140: Car door lock mechanism concept.

LOCKING MECHANISM

As the most important part of the product a locking solution was needed for the locking mechanism. Therefore an investigation into existing mechanisms on the market was done, as well as considered through generated concepts. Initially it was decided that the mechanism should be something mechanical so that the user would be in control of the locking speed and movement.

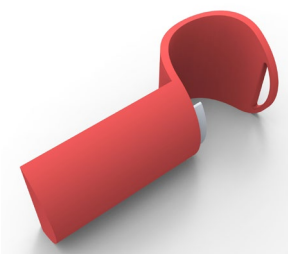
MECHANICAL LOCK

One of the found mechanisms on the market was found on the doors of cars. This locking mechanism functions by having two claws, which get activated by pushing a metal bar in between the claws. By hitting the middle the claws will snap around the metal bar [See ill. 139].

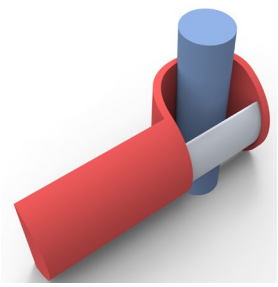
Models of the different principles were done in SolidWorks in order to gain an understanding about, how they would work and function. There were evaluated three different concepts, all of them worked mechanically. Unfortunately the mechanical concepts took up to much space in the arm of Tolok.

ELECTRIC POWERED LOCK

To gain more space around the lock, another suggestion was made, on a much simpler principle. Here a straight locking bar was placed in the arm [See ill. 141 & 142].
By using a straight bar the lock takes up less space than the other suggestions, and it does not break the overall aesthetic form of the concept.
The downside with this suggestion is that the user can however not control the speed of the locking and where the other suggestions adds more space for the bicycle frame, this cuts the hole partly, which means the room for the bicycle frame become smaller.
Evaluation of the concept made it clear that its simplicity alongside with the aesthetics of this suggestion made it a better suggestion and the previous ones and that meant that a straight locking solution was chosen for Tolok [See also appendix 19].



Ill. 141: Straight locking mechanism.



Ill.142: Straight locking mechanism test.

A lock with a straight bar design was chosen as the locking solution.

MOTOR

In order to operate the locking bar in the arm, a motor is needed. The motor requires a small size and enough torque to be able to move the locking bar, which weighs around 283g.

MOTOR CONCEPT 1

The first idea was to place two motors in the arm, one to push the locking bar forward and one to control a split, that would prevent the locking bar from getting pushes back. This solution required either two motors or a complex gearing system to work to make the motor switch between the movable parts.

MOTOR CONCEPT 2

Another suggestion was to place a spindle, which is connected to the locking bar. The tread of the spindle is of a trapezoidal design, which prevents the locking bar getting pushed back. This solution only requires one motor, therefore it can be bigger and more powerful than with the first solution, which required two motors.

Motor concept 2 was chosen as the motor setup, because of the available torque with the larger available motor space and automatic locking.

MOTOR TYPE

In order to operate the spindle two similar motor types were researched. The first was a stepper and the second being a servo;

STEPPER MOTOR

A stepper motor have four electromagnets or more, which control the rotation by getting activated in pairs, this makes the rotor turn, because the electromagnet pairs shift between being north and south poles.
A stepper motor can be very jerky, because it starts and stops on pulses, but they are very cheap.

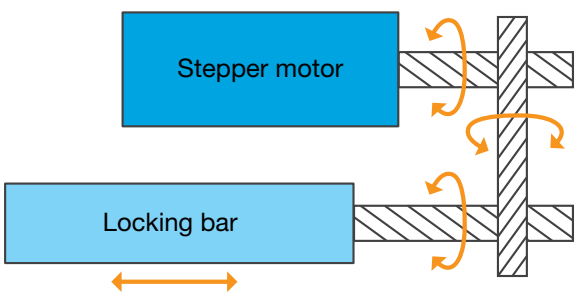
SERVO MOTOR

The alternative is to use a servo motor, which functions the same way, but have an optical encoder attached to its rotor, that enables the servo to know how many rotations it has taken. This means that the servo can be controlled more smooth and precisely than the stepper motor (Woodford, 2012).

It was chosen to use a stepper motor to operate the locking bar, as it is cheaper than the servo motor and it is not important to have feedback in the motor, because the locking bar can not move further than the end of the arm, where it will hit the inside of the lid and then stop.

There is not enough room in the arm to have the motor placed in extension of the locking bar, therefore by using a gearing system the motor were placed above of the locking bar, where it was mounted to a 10mm thick stainless steel bar that is used to give the lock additional strength because of the hole in the arm itself [See ill. 143].
In order to make sure the motor could push the locking bar out, a motor which have a torque of 3 kg/cm were chosen. This is a precaution to make sure it can operate the locking bar smoothly [See also appendix 20].

The stepper motor was chosen, because of its cheaper price.



Ill. 143: Spindle and stepper motor setup.

KEY TECHNOLOGY

In order to access Tolok with the travel card, an NFC reader needed to be installed inside the concept.

The NFC reader is needed, because like many other things today the travel card houses an NFC chip. This NFC technology is based on RFID (Radio Frequency Identification), where a chip is connected to an antenna.
When the travel card gets near an NFC reader, the NFC chip is activated through radio signals by the reader. The reader receives the information and then then sends that information to a data processing device [See ill. 144] [See also appendix 21].

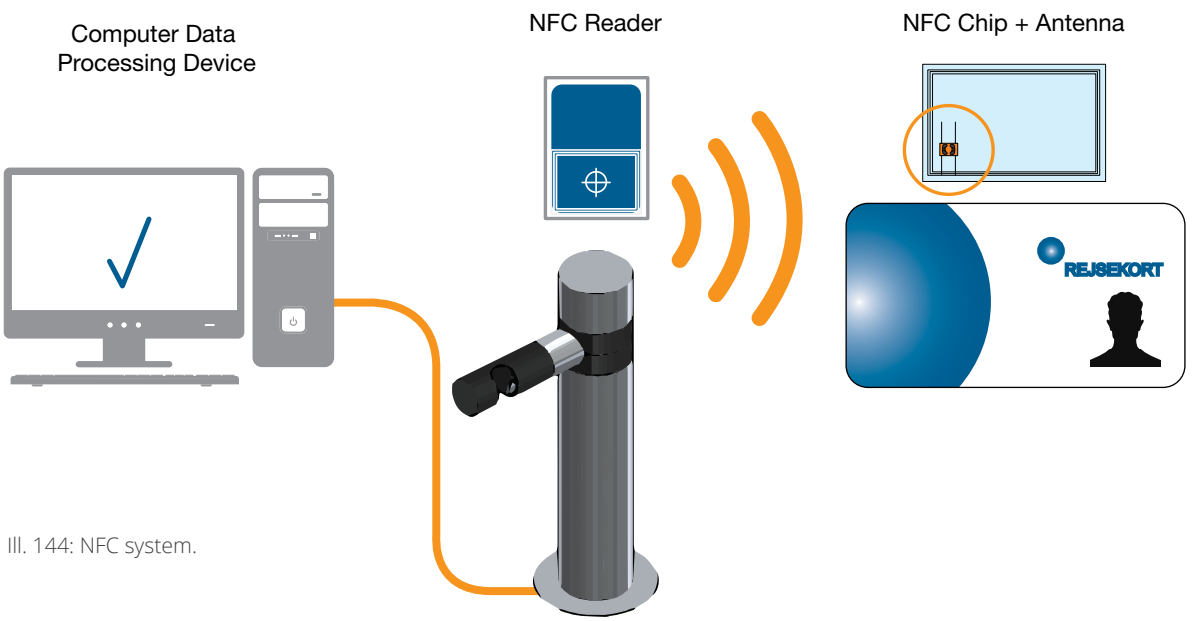
Other than an NFC reader, light and sound was also added to the Turning tower. The intention was to provide the user with useful feedback when interacting with the product.
All this was connected to a circuit board, which was placed at the top of Tolok. This circuit board needed to be made in a rounded shape with a hole in the middle in order to fit into Tolok, therefore the components connected to the circuit board needs to be small, but effective.

NFC readers can typically reach within a proximity of 4 cm, therefore in order for it to reach the chip in the travel card the reader needed to be placed close to the top of the product as the interaction between the user and the product had been decided to happen there. With those reasons the circuit board needed be raised as high as possible (Thrasher, 2013).
Tolok's circuit board also had a speaker installed in order to provide the user with an additional feedback through sound. A small flash drive was also added to the circuit board in order to store information from the travel card as well as sounds for the speaker.

To gain an overview of how the electrical components in Tolok were connected, a flow chart was made. The flow chart shows how the different components are related to each other [See also appendix 22].

While NFC readers have become more common, they have also started getting added to cellphones, which could add another access solution to Tolok. The use of cellphones as access cards could also enable the implementation of a mobile app. This app could be accessed by holding the cellphone up to the top of Tolok, where the NFC Chip/reader in the cellphone would connected with the NFC reader in Tolok and this would in turn activate the app, which would allow the user to lock or unlock their bicycle. NFC readers in cellphones are however relatively new implementations, but could be added to the product in the future.

Another suggestion was to place QR codes on Tolok, making it possible for the user to scan it and by doing so allow access to the app and the lock.
QR codes are an older technology that uses cameras to scan for certain patterns and then activate the application



Ill. 144: NFC system.

added to that pattern.
But it was decided that having to place a QR sticker on Tolok would disturb the overall aesthetic design of the product and might also, like most stickers, eventually fall off, as a result of weather and usage.

The travel card, because of its potential with using NFC technology, was chosen as the access solution for the product.

ELECTRICAL CIRCUIT

It was found necessary to calculate how much Watt was needed to power Tolok, because of the wiring that needed to be connected to the various electrical components in the product. A short calculation was therefore done to determine which kinds of size the cables needed to provide the needed Watt;

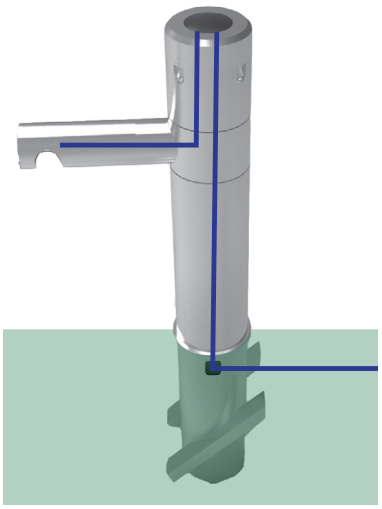
- The stepper motor needs 3,45 Watt.
- The power needed for the circuit board have been estimated to 0.587 Watt [See also appendix 23].

In total the system needs 4.04 Watt to run, which means that the cables does not need to be any bigger than the current 3.0 USB cables (Bilton, 2012). The diameter of the cables have therefore been estimated to be around 3.5 mm. With cables in such a relatively small size they will easily be able to run through the tubings of the product, as these inner diameter was made 40mm. Additionally electrical fuses also needs to be installed on the circuit board in case of power surge.

To get the power into Tolok, thicker and more protected ground cables needs to be installed underneath the surface of the ground. These cables will be protected by a tubing system of plastic and will enter through the hole in Tolok's main body underneath the ground.
Here cables are connected to a branching box and the thicker power cables supplies the smaller internal cables with the power needed.

By having the cables running through the inner tubes of Tolok the twisting of the cables are minimized and will therefore make them last longer. The cables are first led up to the circuit board which is then connected to the stepper motor in the arm. Electrical signals will then, when activated, either tell the motor to push the lock closed or to open the lock.

When the lock have moved its desired position then signals are sent back to the circuit board and the interaction is complete [See ill. 145].
To allow maintenance of the product, the cables inside needs to be longer than what is actually required to connect the different components, because the arm is designed to allow it being dismounted.



Ill. 145: Wiring inside Tolok.

Thin cables with a diameter of around 3.5 mm were chosen. The cables needed to be longer than required because of maintenance.

FRAME MEASUREMENTS

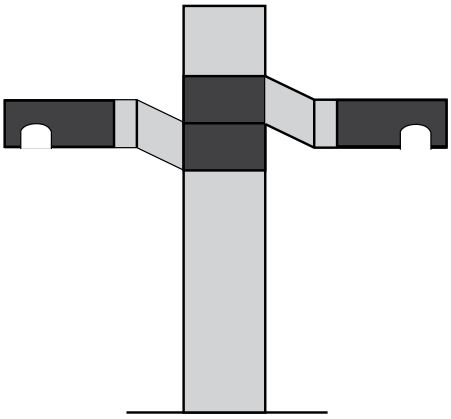
To determine if Tolok had been designed in the right height and there were enough space in the locking area for the bicycles' frames, a quick field investigation was conducted.
The result of the investigation confirmed the initial theory about nearly every bicycle having the same frame size around the seat pole.
The investigation revealed that the average height to lock around the frame in that given area was 625 mm and the average diameter of the frames were 35 mm [See also appendix 24].

The center of Tolok's arm was corrected to a height of 625 mm, while its locking areas was found big enough with its ~50 mm hole.

ONE VS. TWO ARMS

During the detailing phase of Tolok there arose concerns about how much space it would require, as well as the production price of the product, so a short concept generation session was done. This session had already beforehand decided that it should be about a solution where two arms were implemented in the design.

The positive thing about adding an extra arm to Tolok was that it could hold two bicycles instead of only one, which would mean customers would only need to buy half the amount of units and the overall production price was also guesstimated to be lower than the one arm solution.
The negative thing about this was that in order for both arms to be in the correct measured heights a bend on the arm was needed, because the arms needed to be able to rotate individually from each other [See ill. 146].
This would result in the arms to become longer, because of space requirements for the locking system and in turn that would result in too much space being used per bicycle and lock. In other words the requirement to keep the locking solution for each bicycle with the 750 mm x 2000 mm would not be upheld. Furthermore the rotational joint on the arm would require a more complex solution, which equals a higher production price.



Ill. 146: Tolok concept with two arms.

It was decided to continue with the initial Tolok concept with only one arm, because of complexity space consumption.

MOUNTING

Tolok's design means that certain sections of the product needs to be assembled before they can be put together into one product. Because of Tolok's focus on bicycle security the entire arm was decided to be assembled before being mounted on to the rest of the construction. The lower part of the main body would also need to be assembled before the arm can be mounted.
When the arm have been mounted then the assembly can be finished off by installing the top of the main body.

Tolok will be embedded into concrete in the ground, because of its size and needed security. The hole will approximately need a size of 500 mm deep and 200x200 mm in length and width.
Furthermore a groove for the ground cables should be dug between each Tolok to connect the cables to each of them installed.
When Tolok have been placed down into the hole the ground then concrete will be poured around it up till about the hole where the cables enters the side of Tolok. The concrete will then have to harden before the cables positioned on top of the concrete and installed. The cables and the rest of the hole is then covered by sand, pavement, etc..

MATERIALS & PRODUCTION

The choice of material is in Tolok's case quite important, as Denmark is one of the main target customers, where the weather can be very harsh and salty. With such weather conditions and because Tolok is to be installed outside it needs to be able to withstand the various parameters in the given environment. Various materials and finishes were considered but ultimately it was decided to produce the main parts in stainless steel. Galvanized steel was not chosen, because the thin layer of galvanization could be ruined by the movable parts and thereby initiate the corrosion process.
The type of stainless steel chosen was initially a type of Austenitic stainless steel that 18% chromium and 8% nickel, which is also called an 18-8 type of stainless steel. This choice was later revised to a type 316 stainless steel as that type of steel has an even better resistance to corrosion. This type of stainless steel is one of the types which are very easy to work with (ACO Nordic A/S, 2016), (Bosun Supplies, 1998).

There were some components in the Tolok which will not be made of stainless steel, these are;
- The circuit board holder.
- The blue semi transparent top plastic cover.
- The nylon rings between the turning outer shells.
- The rubber placed around the locking bar.
- The spindle gearing house.

CIRCUIT BOARD

The circuit board holder and the top plastic will be made in ABS (Acrylonitrile Butadiene Styrene). This plastic have a low cost and is normally used when molding computer housings and small appliances (Plastindustrien, 2016).

NYLON RINGS

The nylon rings between the outer shell parts will be made in polyamide which is added to make them glide easier against each other as well to prevent wear.
Polyamide have a high toughness and is wear resistance, but it is moisture absorbing and is expensive, which could be a problem, because the polyamide ring is directly exposed to the outside (Plastindustrien, 2016).

PROTECTIVE RUBBER

The rubber objects are to be made in TPE (thermoplastic elastomer) in order to protect the bicycle frame from being damaged and to avoid dirt getting into the gears.

GEARING HOUSE

The gearing housing is to be made in cast iron. Cast iron is a cheap metal and is also cheap to work with. It has medium tolerences towards corrosion. The gearing housing is mounted in the base of the arm and are therefore shielded from the outside environment (Vadstrup, 2006).

BALL BEARINGS

The Ball bearings used are standard components and are made in steel and because of Tolok's construction four ball bearings are needed. The ball bearings have been calculated to being able to withstand 1700N which is roughly the same as 175 kg of pressure. If the ball bearings are exposed to more than that they can get permanent deformations [See also appendix 25]. The weight of the arm have been calculated to around 7 kg, so it is estimated that 175 kg of deformation resistance is more than enough.

OUTER SHELLS AND TUBES

The outer shells and tubes for Tolok are to be produced by rolling, there are two types of rolling: hot rolling and cold rolling. Hot is when a steel plate is heated, typically to above 900C degrees. Immediately after it is rolled into the required shape and cooled. The good thing about hot rolling is that it is easy to form, it is easy to processes and it is cheaper and faster in production than cold rolling. But

with hot rolling the surface is very rough and when the steel gets cooled down it will shrink slightly, therefore the precession of the finished product is not very good.

Cold rolling undergoes several processes in order to get shaped into the correct shape, therefore it is a slower process than hot rolling. But by using cold rolling it is easier to control the end product's diameter, while also obtaining a better surface finish than with hot rolling.
It can be difficult to do major post processes on cold rolled part, because the material have an inner tension. (Metal Supermarkets IP Inc, 2014). But because the Turning tower is to have very precise measurements and limited after processes on the shells and tubes, cold rolling is chosen.

Cold rolling was chosen because of the needed precision of the parts.

PRODUCTION METHODS

MILLING

There are certain parts in the Tolok, which needs post processing, one of such processes is milling. When milling stainless steel, the milling tool need to be tougher, therefore abrasive wear could appear on the tools, making tooling costs high. Milling can be a slow process depending on the size and precision of the part and can in rare cases result in cracks, edge chipping and bad surface finishes. Because of the precision of milling it will be needed in some of the inner parts of the Tolok (Sandvik Coromant, 2016).

WELDING

The lid on the arm is going to be welded on. While welding it is important that the welding is done properly, as to avoid creating weak areas.
There are many different types of welding, some are faster than others and leave a better surface finished. There are many different methods to chose from, laser welding and MIG welding is two of the methods that were evaluated, both are commonly used for welding steel.
The process of welding with MIG is quicker, because the filler material is fed though the electrode, MIG have a high deposition rate and less post welding cleaning, but setting up MIG welding have a high initial setup cost (EngineerStudent, 2009).
Laser cutting works similar as MIG, but typically do not have a filler material. Laser welding is more precise welding and it is possible to weld complicated objects, but is more expensive than MIG welding (Quada Art of laser, 2010).
Therefore it was chosen to use MIG welding, because the object being welding is not very complicated and laser welding is quite expensive. After the welding an after process such as polishing is needed in order to make an even surface.

CASTING

In order to cast stainless steel there are two different methods, sand casting and lost wax casting / investment casting.
Sand casting have a low upstart cost, which for example means it is often used to mold pilot products, it is possible to cast both small and large object with sand casting and it is a quick production method compared to lost wax casting. The units price is however high and it does not leave a nice surface finish, so post processes are needed if using sand casting (Thomas Publishing Company, 2016).
With lost wax casting/investment casting it is possible to cast many varieties of forms, it is possible to have a very smooth surface with no parting line and the accuracy is very good. It is a very slow production process, because of the many steps in order to produce the molds and it can be expensive unless it is mass production (SIMIS Precision Casting Co., Ltd, 2015).

It was chosen to use Lost Wax Casting to produce the inner parts, because of complexity, limited post processes and because Tolok is intended to be mass produced, which means the production price will be lower with lost wax casting.

INJECTION MOLDING

All the different plastic parts are going to be produced using injection molding, which is a quick and easy way to form almost every kind of plastic. Injection molding has a low production cost, but tool making is expensive therefore it is often used when a product is going to be mass produced (AV plastics, 2013).

5.2 BUSINESS

Now that the details around Tolok have been chosen, the overall business plan for the product need to be discussed. In this section the overall cost for the product, the overall business details as well as potential costumers are investigated.

ESTIMATED SALES

In order to eventually calculate the break even, there is a need to evaluate how many product there is going be sold. Therefore there have been investigated where it would be ideal to install Tolok.

Tolok would be ideal to place at bus stations, train stations, schools, apartment buildings, parks and other public places where bicycle are constantly parking and where thieves are always on the hunt.
In fact there is a potential customer in Aarhus municipality, that are working on building their light city rail. Here it would be ideal to place Tolok in order to secure commuters bicycle while they are commuting or the likes.
Aarhus light rail will have 18 new stations and at every station it was estimated that around 30 Toloks would in average be needed at each station, depending on the size of the stations. Aarhus municipality would potentially buy around 540 Toloks (Aarhus kommune, 2016).

Ill. 147: Aarhus light rail.

Another potential costumer could be Copenhagen municipality who are building a new metro ring, which will be done by Juli 2019. This new metro will add 10 new stations around Copenhagen (Metroselskabet, 2016).
Copenhagen is a popular bicycle city, therefore it would be ideal to place Toloks at these new stations, in order to secure the bicycles. Tolok have a friendly urban design, that fit into the architecture suggested of the stations.
It is estimated that there could be placed 20 - 30 Toloks at each station, which would mean that Copenhagen would buy 200 - 300 Toloks. By buying Toloks, the municipalities shows that they will go the extra length in order to guarantee their citizens' satisfaction.

Ill. 148: Metro ring Copenhage.

Tolok can also be installed at how many new apartments that are being built in the near future.
In Aalborg there have been an increase in apartment buildings over the past years and there are demands for more. At Eternitten they are planing to have 300 new apartments done by 2017 (Anderson, 2016). It could be ideal to place a Tolok outside such apartment, for users who do not have much time to safely secure their bicycles or have friends visiting. Therefore it is estimated that this building complex would buy around 50 products.

Aalborg is also building a super hospital, which are planed to be done in 2020. At the current time Aalborg hospital have around 7,000 employees, where some of these would use their bicycle as transportation, it is estimated that around 8% of the employees would be using Tolok to lock their bicycle, which means 540 are estimated to be bought (Linkedin, 2016).

There are many more new construction projects going on in Aalborg and many of these could be potential places to install Toloks. On Aalborg municipality local plans, there can be seen ongoing and future project (Aalborg kommune, 2016).

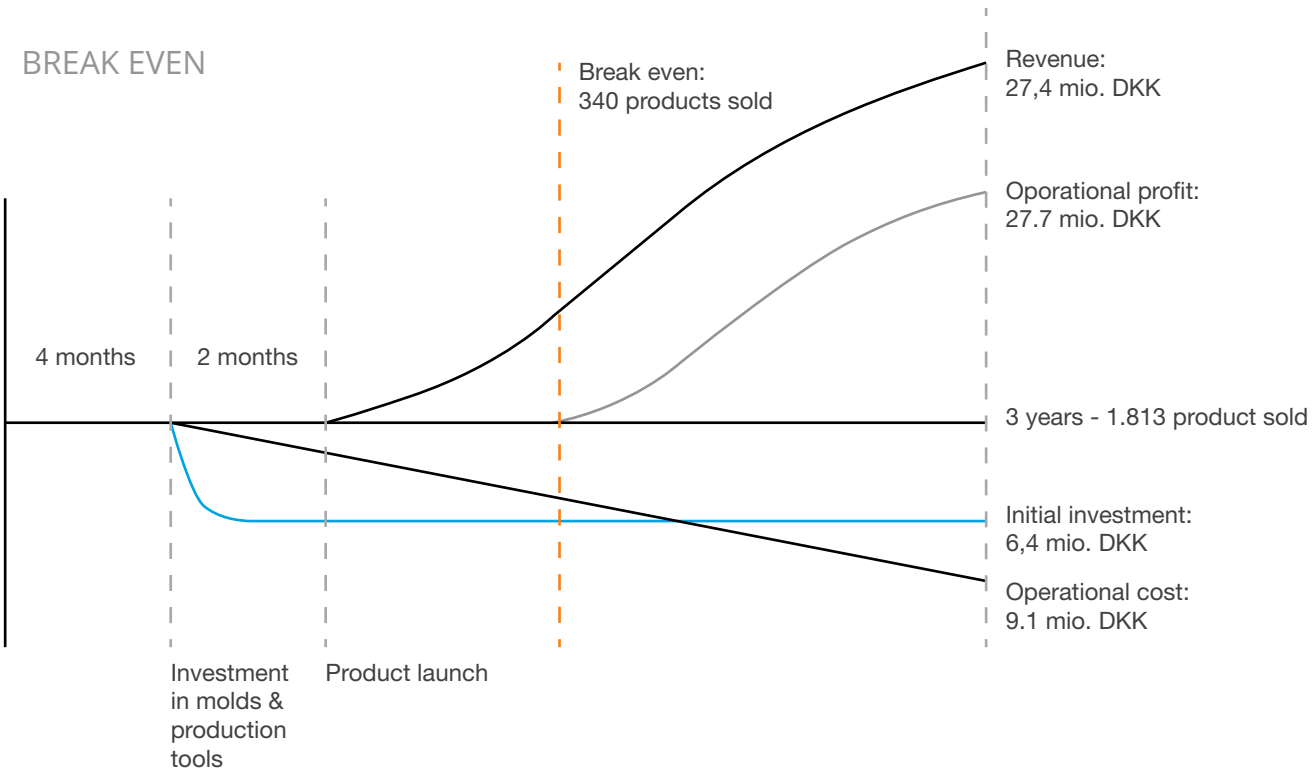
PRODUCTION COST

It was guesstimated, based on modified plastic molding production processes that one product would cost DKK 9,411 to produce. This price is a total of material cost, production, assembly hours and employee payment.

Based on these calculation a retail price is calculated:

Retail price	17.645 DKK
Tax (25%)	3.529 DKK
Retail price without tax	14.116 DKK
Sales price (Company)	14.116 DKK
Coverage (Company 50%)	14.116 DKK
Cost price	9.410,71 DKK

The retail price is cheap, because the producted is intended to be sold directly by Senni and not through another store. In other words the producted will be sold directly from the producer to the costumer, which is why the overall retail price is only DKK 17,645. On the basis of the low sales price and to make sure there is still a possibility to sell the solution for the various municipalities, it was decided only to double the sales price and not seven times as it normal for many other products. This means that the sales price after taxes are added will be DKK 35,290. This would enable Senni to reach the break even point after 340 sold products which is estimated to happen in a little over a year after production have begun [See ill. 149] [See also appendix 26].



Ill. 149: Break even.

STRATEGY CANVAS

A strategy canvas was done to help evaluate Tolok's chances on the Danish market.
The two closest competitive companies have been evaluated using the strategy canvas [See ill. 150].
Out-sider and Veksø were also the companies, that were evaluated in the marked analysis on page 30.
Veksø is one of the larger companies on the marked and have been on the marked for 66 years. They have a more traditional approach to their design and their business model.
Out-sider is a small company with 7 employees. Out-sider have a more playfulness approach to their designs and is transparent in their business compared to their rivals from Veksø.
Both companies unfortunately still have a traditional approach to bicycle racks, as the majority of their racks only support the front wheel. Both companies are well known and their products can be seen in a variety of Danish cities [See also appendix 10].

One of the downsides with Tolok is that the price will be higher then compared to the competitors, but only when considering the store capacity and not extra feature from the locking system. Tolok is a new product that and will be a few mover in rethinking how bicycle racks should be designed.

POSSIBLE TO LOCK FRAME

How many racks does the company have where it is possible to lock the bicycle frame to the rack?

VERSATILE IN SUPPORT

Is the rack supporting the bicycle in more than one place?

AMOUNT OF PRODUCTS

How many different types of bicycle racks does the companies sell? Here all bicycle racks are counted.

THINKING OUTSIDE BOX

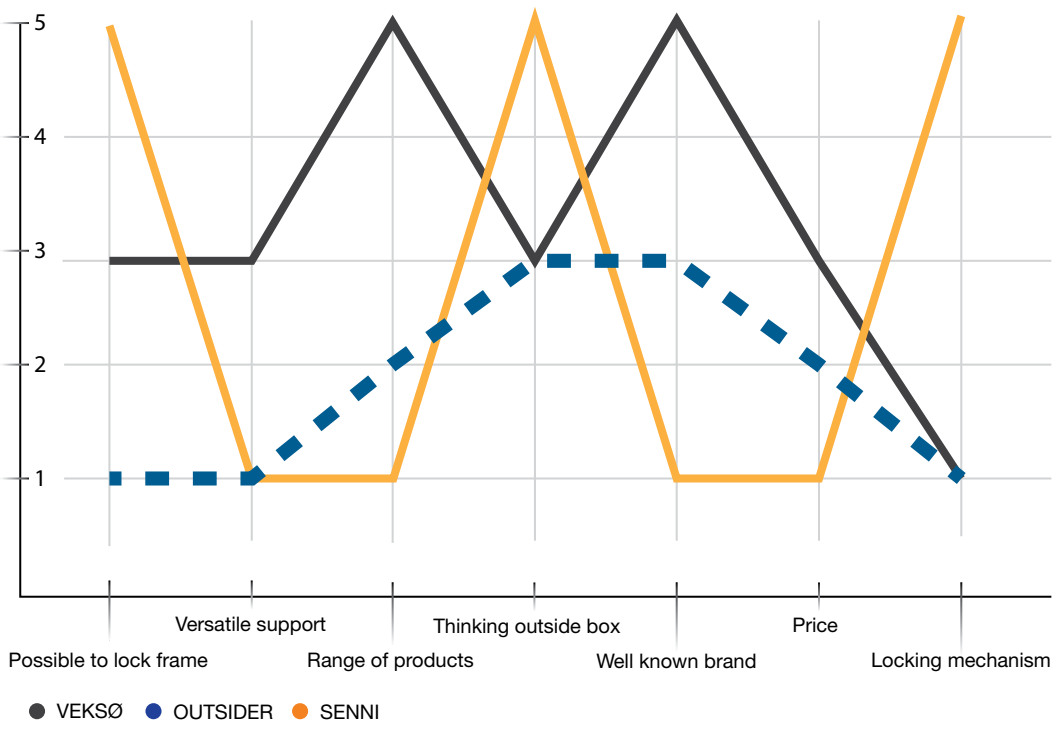
Do they have something else than the competitors? Do they take chances?

WELL KNOWN NAME

How popular are they and how known are they?

PRICE

1 is expensive and 5 is cheap. What do the companies take for there bicycle racks?



Ill. 150: Strategy canvas

BUSINESS MODEL CANVAS

To gain a clearer overview on, how the business plan will be structured and to find the weakness and strengths, the business model canvas were used. The canvas is divided up into nine parts which will all be presented underneath.

COSTUMER SEGMENTS

Mass marked:
- The municipality.
- Schools.
- DSB.
- Constructional project managers.

VALUE PROPOSITION

Risk reduction:
- Lower the risk of getting bicycle stolen.

Performance:
- Redesigning the traditional bicycle rack.

CHANNEL PHASES

1. Awareness:
- Participate in fairs.
- Direct contact of potential costumers.
- Collaboration with insures companies.

2. Evaluation:
- If chosen to incorporate the use of cellphones into the product then by using an app, there could be received feedback directly from the users.
- Surveys could be handed out where the product is installed.
- Feedback from the municipality via complaints or concerns from the users.

3. Purchase:
- Web page.
- Personal contact.

4. Delivery:
- Cargo services.

5. After sales:
- Direct contact.

REVENUE STREAMS

Asset sale
- Dynamic pricing/negotiation. It is most common to get a discount if buying in large numbers

KEY RESOURCES

Physical
- All production is out of house

KEY ACTIVITIES

Production
- Design and prototype

Problem solving
- New solutions in order to secure everyday objects

KEY PARTNERSHIP

Strategic alliances between non-competitors
- Professionals with expertise in stainless steel production

COST STRUCTURE

Value driven
- Sell safety and reassuring of users bicycles

Cost driven
- Aim to lower prices, in order to appeal to potential costumers

From the business model canvas it can be concluded that the weakness with this business plan lies with obtaining feedback from the users, where it in some cases needs to be delivered through the customers. Furthermore a lot of energy and time needs to be used on promoting the product, because it is such a new initiative, that the majority of people most likely would not know how to operate it.
The positive with this business plan is that there will be direct contact to the costumers, which can create reliable trust between customer and company.

5.3 CONCLUSION

Knowing that there were a problem with today's bicycle locks, research into that market was done, which lead to the discovery of an even greater problem.

It was discovered that many people today will in order to properly secure their bicycle, lock their bicycle on to existing bicycle racks.
However most of today's bicycle racks are not designed to function as security objects for the bicycle. The majority are only designed as a way to organize parking.
Furthermore it was discovered that today's top safety bicycle locks are heavy and difficult to carry around. Based on this there were found a requirement for a way to store bicycles in a safe and secure way, without having to carry around heavy locks. Through extended research, testing, demands and conceptualizing, there were found a solution.

The solution is Tolok, which is a reinterpretation of the old traditional bicycle rack and bicycle locks.
The solution has an incorporated locking system, which fits around the majority of today's popular city bicycle frames, and with easy understandable interaction ensures quick, easy and secure parking for bicycles. Toloks aesthetics are designed so that it fit into any urban environment.

5.4 REFLECTION

FINDING FOCUS AREA

There have been a clear focus from the start regarding the overall subject. There were an agreement of finding a solution of problems regarding the locking of bicycles. It was fairly easy to narrow down the focus to redesign the concept bicycle rack.

DEMANDS

It have been difficult to evaluate the concept during the beginning of the project, because the demands were vague and it was not until relatively late in the process that clear demands were made. Specific product requirements were not made before the revise Project Phase 4. The lack of specific requirements resulted in a lot of concept development phases that did not lead to anything useful, so if these requirements had been made sooner in the project then the decisions and speed regarding the product had been faster.

TIME AND TASK MANAGEMENTS

Another thing that have proved a challenge for the group have been the time management.
Both members of the group have been used to working in larger groups, therefore it should have been taken into consideration that certain tasks would take more time.
As a result of the poor planning both the start up and late phases were affected and pushed unnecessarily.
Especially testing of concepts and theories took a lot of time, both to conduct and to document, but were needed to gain a better understanding and knowledge of the various problems and solutions.

The SCRUM board proved to a useful tool, in the beginning of the project to keep overview of the various tasks, that needed to be done.
Some of the post-its that were used for the SCRUM board had time limits written on to them as well, as to indicate how much time consumption was allowed for that given task, but this was discontinued after a week.

While the SCRUM board is good at managing tasks, it was not so good at managing time and deadlines, so another calendar was used to keep the group notified about important dates, like the status seminars.
If the group had been better at managing the time of the various tasks there might have been more time available to detail the product.

PRODUCTION

Some of the production methods, for components such as the inner parts that holds the ball bearings, are based on assumptions and none in the group have had any previous experience working with stainless steel.
In retrospect there might have been used too much time on detailing the locking mechanism itself, instead of actually focusing on how to produce the parts needed. If the various parts had been given more time then there might have also been more time to consult an expert within production of stainless steel parts.
An expert might have also been able to give feedback on certain parts which could be optimized and in turn lower the concept's production price.
If the cost could be lowered it would be easier to gain investors and potential buyers.

AESTHETICS

The aesthetics have not been worked further on since the concept was chosen, but it was chosen to produce the product in brushed stainless steel, because its aesthetics matches the modern Scandinavian architectural style and if the surface gets scratched by the bicycles then they would not be as noticeable as those seen on polished stainless steel. It could be an idea to work further with the aesthetics and take inspiration from cities further south in Europe, to open up for the possibility to sell the product abroad in countries like the Netherlands.

KEY-SYSTEM

For the final concept it was chosen to provide access to the locking system with the use of the travel card, but this could limit the user group significantly and in the end hurt the business.
It was however not chosen to incorporate the mobile phone, because the NFC chips in the cellphones are a relatively new feature, which limits how many cellphones that would have the feature available.
It could however be a option to incorporate it in the near future. By incorporating the cellphone to access the product opens up for many new possibilities, such as location of the production when looking for a free parking spot, as well when finding the parked bicycle again.
By using an app on the cellphone the users could easily give feedback about the use of the product as well.

REFERENCES

ELECTRONIC

Aalborg kommune (2016) *Lokalplanportal.* Available at: http://aalborgkommune.viewer.dkplan.niras.dk/plan/5#/ (Accessed: 17 May 2016).

Aarhus kommune (2016) L*etbanens etape 2: Aarhus Kommune.* Available at: http://www.aarhus.dk/letbane (Accessed: 15 May 2016).

ABUS Security Tech Germany (2016) *ABUS security levels and threat areas.* Available at: http://mobilesecurity.abus.com/eng/bike/contents/security-levels-threat-areas (Accessed: 28 April 2016).

ACO Nordic A/S (2016) *Rustfrit stål - Generel information.* Available at: http://www.aco.dk/media/1428668/Rustfri%20st%C3%A5l%20-%20Generel%20information.pdf (Accessed: 5 May 2016).

Andersen, T.N. (2014) *Danskerne ruster sig mod rekordstort cykeltyveri, www.b.dk*. Available at: http://www.b.dk/nationalt/danskerne-ruster-sig-mod-rekordstort-cykeltyveri (Accessed: 4 February 2016).

Anderson, M.K. (2016) *300 nye boliger bygges på Eternitgrunden i Aalborg.* Available at: http://www.tv2nord.dk/artikel/300-nye-boliger-bygges-paa-eternitgrunden-i-aalborg (Accessed: 16 May 2016).

AV plastics (2013) *Advantages and disadvantages of injection moulding.* Available at: http://www.avplastics.co.uk/advantages-and-disadvantages-of-injection-moulding (Accessed: 10 May 2016).

Axa Security (2016) *Safety levels.* Available at: http://www.axasecurity.com/bike-security/en-gb/information-locks/safety-levels/ (Accessed: 28 April 2016).

Basta Cycling (2013) *Safety level - axabasta*. Available at: http://www.bastacycling.com/important-information/safety-level/ (Accessed: 28 April 2016).

BicycleDutch (2015) *Delft bicycle parking facility.* Available at: https://www.youtube.com/watch?v=UuhLv1AN0bE (Accessed: 1 May 2016).

Bilton, R. (2012) *With new 100-watt standard, your USB cable could soon charge your laptop.* Available at: http://venturebeat.com/2012/07/24/with-new-100-watt-standard-your-usb-cable-could-soon-charge-your-laptop/ (Accessed: 21 May 2016).

Bosun Supplies (1998) *Stainless steel information knowledge.* Available at: http://www.bosunsupplies.com/StainlessInfo2/ (Accessed: 21 May 2016).

Briks, J. (2014) *Flere får stjålet ladcyklen: "De skar cykelstativet over", MX.dk*. Available at: http://www.mx.dk/nyheder/kobenhavn/story/28108486 (Accessed: 4 March 2016).

Brown, J. (2012) *We've got a bike thief here to answer your questions, Gizmodo.com*. Available at: http://gizmodo.com/5922324/weve-got-a-bike-thief-here-to-answer-your-questions (Accessed: 4 May 2016).

Danmarks Statistik (2016) *STRAF10: Anmeldte forbrydelser efter overtrædelsesart, Statistikbanken.dk*. Available at: http://www.statistikbanken.dk/statbank5a/default.asp?w=1920 (Accessed: 8 February 2016).

Carstensen, N.H. (1996) *Cykeltyverier har toppet, Jyllands-posten.dk*. Available at: http://www.jyllands-posten.dk/protected/premium/indland/ECE3463266/Cykeltyverier-har-toppet/ (Accessed: 2 February 2016).

CaseyNeistat (2012) *Bike thief 2012, Youtube.com*. Available at: https://www.youtube.com/watch?v=UGttmR2DTY8 (Accessed: 2 March 2016).

Cibi - AFA JCDecaux (2016) *Cibi i detaljer*. Available at: http://cibi.dk/cibi-i-detaljer/ (Accessed: 23 April 2016).

City of London Police (2015) *How secure is your bicycle lock?, Youtube.com*. Available at: https://www.youtube.com/watch?v=pywN558dJaU (Accessed:17 February 2016).

Cykelpartner.dk (2016) *DIIMS tracker - cykel tracker til sporing af din cykel, Cykelpartner.dk*. Available at: http://www.cykelpartner.dk/index.php?manufacturers_id=174 (Accessed: 2 May 2016).

DeeRidekick (2013) *Preventing bike theft, Ridekick.com*. Available at: http://ridekick.com/preventing-bike-theft/ (Accessed: 16 February 2016).

Det Kriminalpræventive Råd (2016) *Cykeltyveri, Dkr.dk*. Available at: http://www.dkr.dk/cykeltyveri-0

(Accessed: 2 March 2016).

Det Kriminalpræventive Råd (2016) *Cykeltyveri, Dkr.dk*. Available at: http://www.dkr.dk/cykeltyveri-1 (Accessed: 2 March 2016).

Diims.dk (2012) *Diims datablad, DatabladDiimsG104.pdf*. Available at: http://www.diims.dk/Images/DatabladDiimsG104.pdf (Accessed: 2 May 2016).

Dilling, S. (2013) *Cykellåsen var for kraftig: Tyven klippede cykelstativet over, Politiken.dk*. Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2084211/cykellaasen-var-for-kraftig-tyven-klippede-cykelstativet-over/ (Accessed: 11 February 2016).

Dilling, S. (2013) *Politiet indrømmer: Vi efterforsker ikke cykeltyverier, Politiken.dk*. Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2099859/politiet-indroemmer-vi-efterforsker-ikke-cykeltyverier/ (Accessed: 15 February 2016).

Dilling, S. (2013) *Straffen er hård: Cykeltyve kommer også i fængsel, Politiken.dk*. Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2101334/straffen-er-haard-cykeltyve-kommer-ogsaa-i-faengsel/ (Accessed: 14 March 2016).

EngineerStudent (2009) *Mig welding - advantages and disadvantages.* Available at: http://www.engineerstudent.co.uk/mig_welding_advantages.html (Accessed: 10 May 2016).

Ernst, N. (2013) *Sådan fandt Post Danmark og dansk dims min stjålne cykel, www.b.dk*. Available at: http://www.b.dk/viden/saadan-fandt-post-danmark-og-dansk-dims-min-stjaalne-cykel (Accessed: 15 February 2016).

GIKEN LTD. (2013) *ECO bicycle parking EN.* Available at: https://www.youtube.com/watch?v=EY2AYA0O-VY (Accessed: 1 May 2016).

Gjertsen, M.N. (2010) *Det er jo 'bare' en cykel, Information.dk*. Available at: https://www.information.dk/indland/2010/07/bare-cykel (Accessed: 22 March 2016).

GPS-tracker.dk (2016) *GPS-tracker til cykel, gps-tracker.dk*. Available at: http://gps-tracker.dk/gps-tracker-til-cykel/ (Accessed: 2 May 2016).

Guldagger, M. (2013) *Claus fik stjålet sin ladcykel og stjal den tilbage to timer senere, Politiken.dk*. Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2081726/claus-fik-stjaalet-sin-ladcykel-og-stjal-den-tilbage-to-timer-senere/ (Accessed: 2 May 2016).

Jeppesen, K. (2015) *Kristoffer skaffede selv stjålet cykel tilbage: - Politiet havde ikke mandskab nok, Ekstrabladet.dk*. Available at: http://ekstrabladet.dk/112/kristoffer-skaffede-selv-stjaalet-cykel-tilbage-politiet-havde-ikke-mandskab-nok/5570381 (Accessed: 2 May 2016).

Kanal 5 (2016) *Hælerjagt - Episode 1, Kanal 5*. Available at: http://www.dplay.dk/haelerjagt/season-1-episode-1/ (Accessed: 2 March 2016).

Linkedin (2016) *Aalborg Universitetshospital.* Available at: https://www.linkedin.com/company/aalborg-universitetshospital (Accessed: 17 May 2016).

Marktcheck (2014) *Hightech-Fahrradschlösser im test: Stopp dem Diebstahl, Youtube.com*. Available at: https://www.youtube.com/watch?v=l8Vfdob74Tk (Accessed: 8 March 2016).

Marthy (2012) *Police investigate how easy it is to steal a bike, Youtube.com*. Available at: https://www.youtube.com/watch?v=8A4GexkTp-4 (Accessed: 25 February 2016).

Metal Supermarkets IP Inc (2014) *Difference between hot and cold rolled steel.* Available at: http://metalsupermarkets.com/blog/difference-between-hot-rolled-steel-and-cold-rolled-steel/ (Accessed: 10 May 2016).

Metroselskabet (2016) *Københavns metro.* Available at: http://www.m.dk/#!/om+metroen/metrobyggeriet/om+cityringen (Accessed: 16 May 2016).

Nielsen, T.S., Christensen, L., Haustein, S. and Koglin, T. (2015) *Danmark er cykelland nummer 2 i Europa, Cyklistforbundet.dk*. Available at: https://www.cyklistforbundet.dk/cykelviden/Artikler-og-videnblade/Danmark-er-cykelland-nummer-2-i-Europa (Accessed: 4 February 2016).

Outsider (2016) *The cityscape is our home*. Available at: http://out-sider.dk/ (Accessed: 23 March 2016).

Peters, A. (2015) *What if you didn't need A bike lock, because the bike rack locked your bike for you?* Available at: http://www.fastcoexist.com/3045931/what-if-you-didnt-need-a-bike-lock-because-the-bike-rack-locked-your-bike-for-you#4 (Accessed: 1 May 2016).

Petersen, L.R. (2012) *Cykeltyven guider dig til den bedste cykellås, Politiken.dk*. Available at: http://politiken.dk/tv/tjek_dk/ECE1773036/cykeltyven-guider-dig-til-den-bedste-cykellaas/ (Accessed: 24 February 2016).

Plastindustrien (2016) *Det store Plastleksikon: Alt hvad du skal vide om plast.* Available at: http://plast.dk/det-store-plastleksikon/ (Accessed: 10 May 2016).

Quada Art of laser (2010) *Advantages and disadvantages of laser welding.* Available at: http://www.quada-office.com/advantages-and-disadvantages-of-laser-welding.html (Accessed: 10 May 2016).

Sandvik Coromant (2016) *Stainless steel milling.* Available at: http://www.sandvik.coromant.com/en-gb/knowledge/milling/getting_started/milling_different_materials/stainless_steel_milling/?Country=dk#4 (Accessed: 19 May 2016).

SIMIS Precision Casting Co., Ltd (2015) *Advantages & disadvantages of investment casting.* Available at: http://www.simiscasting.com/advantages---disadvantages-of-investment-casting-153.html (Accessed: 10 May 2016).

Sparre, S. (2013) *Politi: Tag selv ud og hent din stjålne cykel, Nyheder.tv2.dk*. Available at: http://nyheder.tv2.dk/article.php/id-70885009%3Apoliti-tag-selv-ud-og-hent-din-stj.html (Accessed: 2 May 2016).

Stephansen, C.G. (2016) *Tyveriforsikring - Erstatninger, Forsikringogpension.dk*. Available at: http://www.forsikringogpension.dk/presse/Statistik_og_Analyse/statistik/forsikring/erstatninger/Sider/Tyveriforsikringerstatninger.aspx (Accessed: 9 February 2016).

Sørensen, M.S. (2013) *Din dyre cykel er guf for cykeltyve, Politiken.dk*. Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2052756/din-dyre-cykel-er-guf-for-cykeltyve/ (Accessed: 8 February 2016).

The Best Bike Lock (2016) *Sold secure gold bike locks: The list*. Available at: http://thebestbikelock.com/best-bike-lock/sold-secure-gold-bike-locks/ (Accessed: 28 April 2016).

Thomas Publishing Company (2016) *Comparing casting processes.* Available at: http://www.thomasnet.com/articles/custom-manufacturing-fabricating/comparing-casting (Accessed: 10 May 2016).

Thrasher, J. (2013) *RFID versus NFC: What's the difference between NFC and RFID?* Available at: http://blog.atlasrfidstore.com/rfid-vs-nfc (Accessed: 10 May 2016).

TopDanmark.dk (2016) *Sådan sikrer du dig mod cykeltyveri, Topdanmark.dk*. Available at: http://tophistorier.topdanmark.dk/post/128327309329/saadansikrerdudigmodcykeltyveri (Accessed: 16 February 2016).

TV 2 PLAY (2010) *Krimimagasin: 26. april 2010 - Station 2 - Magasiner - Programmer - TV 2 PLAY*, *Play.tv2.dk*. Available at: http://play.tv2.dk/programmer/magasiner/serier/station-2/krimimagasin-26-april-2010-15155/ (Accessed: 10 March 2016).

TV 2 PLAY (2012) *Krimimagasin: 8. oktober 2012 - Station 2 - Magasiner - Programmer - TV 2 PLAY, Play.tv2.dk*. Available at: http://play.tv2.dk/programmer/magasiner/serier/station-2/krimimagasin-8-oktober-2012-58887/ (Accessed: 24 February 2016).

Vadstrup, S. (2006) *Www.Bygningsbevaring.Dk*. Available at: http://www.bygningsbevaring.dk/uploads/files/materialer/stoebejern.pdf (Accessed: 10 May 2016).

Woodford, C. (2012) *How do stepper motors work?* Available at: http://www.explainthatstuff.com/how-stepper-motors-work.html (Accessed: 19 May 2016). (Woodford, 2012)

INTERVIEWS

Bøgh, G. (2016) “Interview - Lost Property Office”. Jyllandsgade 27 9000 Aalborg.

Kalstrup, M. (2016) “Interview - Løbekompaniet BIKE”. Urbansgade 22, 9000 Aalborg.

Lavendt, A. (2016) “Interview - Aalborg Bicycle Store”. John F. Kennedys PL. 1F 9000 Aalborg.

BOOKS AND ARTICLES

Dansk Cyklist Forbund (2007*) Cykelparkerings-håndbogen.* Edited by Padlo Celis and Erik Belling-Ladegaard. 1 edn. Dansk Cyklist Forbund.

Gjensidige Forsikring (2013) *‘Hver anden dansker har fået stjålet sin cykel’*, https://www.gjensidige.dk/om-os/presse/pressearkiv/: Gjensidige Forsikring. pp. 1–2.

Nielsen, T.A.S., Christensen, L., Haustein, S., Koglin, T. and Technical University of Denmark (2015) *‘Danmark er cykelland nummer 2 i Europa’, Cykelviden*, 16 March, pp. 1–4.

TNS Opinion & Social (2013) ‘Attitudes of Europeans towards urban mobility’, http://ec.europa.eu/public_opinion/index_en.htm, European Commision.

ILLUSTRATION LIST

1.1 PROBLEM

Ill. 1: Autor/website(2001) Name of database [Online image]
Avalibla at: ... (accesed 5 feb 2016)
Ill. 2: Own illustration

1.2 INITIAL RESEARCH

Ill. 3 - 11: Own illustrations

1.3 CONCEPT DEVELOPMENT

Ill. 14-16: Own illustrations

2.1 RESEARCH

Ill. 17-19: Own illustration
Ill. 20: Helligsø, A. (2015) Lej en pendlercykel. Available at: http://www.tv2oj.dk/artikel/244570:Aarhus--Lej-en-pendlercykel (Accessed: 22 May 2016)
Ill. 21: s, C.M. (2011) Když sedlo slouží jako zámek na kolo. Available at: http://kolo.cz/clanek/kdyz-sedlo-slouzi-jako-zamek-na-kolo/kategorie/kolo-o-cem-se-mluvi (Accessed: 22 May 2016)
Ill. 22: Inventos creativos (no date) Available at: http://www.elafter.com/foro/f187/2137683-inventos-creativos/ (Accessed: 22 May 2016).
Ill. 23: b, B. nieuwe media (2013) Sikkerhedsniveau - axabasta. Available at: http://www.bastacycling.com/dk/vigtige-oplysninger/sikkerhedsniveau/ (Accessed: 22 May 2016).
Ill. 24: Kollios, af M. (2015) Abus Bordo x-plus - Kompakt, leicht, sicher. Available at: https://www.rosebikes.dk/article/abus-granit-citychain-x-plus-1060-chain-lock/aid:21832 (Accessed: 22 May 2016).
Ill. 25: AXA RLE 150/10 - AXA bike security (no date) Available at: http://www.axasecurity.com/bike-security/nl-nl/producten/sloten/plug-in-kabels/axa-rle-15010/ (Accessed: 22 May 2016).
Ill. 26-30: Own illustration
Ill. 31: Cykellåsen var for kraftig: Tyven klippede cykelstativet over (2013) Available at: http://politiken.dk/forbrugogliv/forbrug/dintransport/ECE2084211/cykellaasen-var-for-kraftig-tyven-klippede-cykelstativet-over/ (Accessed: 22 May 2016).
Ill. 32: Briks, J. (no date) Flere får stjålet ladcyklen: De skar cykelstativet over. Available at: http://www.mx.dk/nyheder/kobenhavn/story/28108486 (Accessed: 22 May 2016).
Ill. 33: Dewalt 18V Akku vinkelsliber DCG412 bar enhed SLIDE IN (no date) Available at: http://www.prishammeren.dk/shop/dewalt-18v-akku-2079p.html (Accessed: 22 May 2016).
Ill. 34: Alibaba (1999) Alibaba manufacturer directory - suppliers, manufacturers, exporters & importers. Available at: https://www.alibaba.com/product-detail/POWER-SLOTTED-SCREWDRIVER_111774207.html (Accessed: 22 May 2016).
Ill. 35: Black, S. and Decker (2002) Specialty Hammers. Available at: http://www.stanleytools.com/products/hand-tools/hammers/specialty (Accessed: 22 May 2016).
Ill. 36: Wilhelmsen ship service (no date) Available at: http://wssproducts.wilhelmsen.com/life-saving/life-saving-appliances/helideck-and-safety-equipment/crowbar-600-mm (Accessed: 22 May 2016).
Ill. 37: HDX 14 in. Bolt cutters-9001H - the home depot (2016) Available at: http://www.homedepot.com/p/HDX-14-in-Bolt-Cutters-9001H/100094248 (Accessed: 22 May 2016).
Ill. 38: Dewalt 18V Akku vinkelsliber DCG412 bar enhed SLIDE IN (no date) Available at: http://www.prishammeren.dk/shop/dewalt-18v-akku-2079p.html (Accessed: 22 May 2016).
Ill. 39-41: Dreamstime (2000) Matthew Valentine (Leschnyhan) - portfolio uytkownika. Available at: http://pl.dreamstime.com/leschnyhan_portfolio_pg1 (Accessed: 22 May 2016).
Ill. 42: Centurion damecykel på tilbud (no date) Available at:http://www.stcykler.dk/dk/centurion-cykler/damecykler.html (Accessed: 22 May 2016).
Ill. 43: Citybike (no date) Available at: http://www.munk-aalborg.dk/?page=bikes&type=3 (Accessed: 22 May 2016).
Ill. 44: Own illustration
Ill. 45: MERIDA and GmbH, C.G. (2016) City speed 8 EQ - Trekking & city - CENTURION bikes. Available at: http://www.centurion.de/de_de/bikes/2016/147/Trekking+%26+City/City+Speed+8+EQ (Accessed: 22 May 2016).
Ill. 46: Ragley Marley 650b MTB Alu. Trail Hardtail (no date) Available at: https://bikecycles.dk/produkt/ragley-marley-650b-mtb-alu-trail-hardtail/ (Accessed: 22 May 2016).
Ill. 47: https://www.bulls.de/produkt/bulls-crossbike2-563-03344
Ill. 48-50: Own illustration
Ill 51: Davidson, J. (2014) Check out Tokyo's amazing underground robotic bike parking system. Available at: http://newsfeed.time.com/2014/02/03/check-out-tokyos-amazing-underground-robotic-bike-parking-system/ (Accessed: 22 May 2016).
Ill. 52: Cycle parking (2009) Available at: https://bicycledutch.wordpress.com/tag/cycle-parking/ (Accessed: 22 May 2016).
Ill. 53: Own illustration
Ill. 54: BikeVault — the future of bike parking? (2015)

Available at: https://www.evanscycles.com/coffeestop/news/bikevault-the-future-of-bike-parking/ (Accessed: 22 May 2016).
Ill. 55: NAVIGATION (no date) Available at: http://outsider.dk/da/product/navigation (Accessed: 22 May 2016).
Ill. 56: Product - VEKSØ (no date) Available at: http://vekso.com/da/produkter/product/?id=16927 (Accessed: 22 May 2016).

2.3 CONCEPT DEVELOPMENT
Illu 57-62: own illustration

3.1 RESEARCH
Ill. 63: Steering wheel lock recommendations (no date) Available at: http://www.locksmith-apachejunction.net/steering-wheel-lock-recommendations/ (Accessed: 22 May 2016).
Ill. 64: Amazon (1996) Universal anti-theft car steering wheel lock. Available at: https://www.amazon.co.uk/Universal-Anti-Theft-Steering-Wheel-Lock/dp/B003R7W8TY (Accessed: 22 May 2016).
Ill. 65: PopScreen (2016) New DISKLOK SECURITY full STEERING WHEEL LOCK car Airbag auto S (34cm. Available at: https://www.popscreen.com/prod/MTU2ODM4MTUw/New-DISKLOK-SECURITY-Full-STEERING-WHEEL-LOCK-Car-Airbag-Auto-S-34cm- (Accessed: 22 May 2016).
Ill. 66: http://www.dailymail.co.uk/news/article-2699733/Unfashionable-effective-Police-tell-luxury-car-owners-traditional-steering-clamps-best-way-beat-modern-thieves.html
Ill. 67: Step, H.T. (2000) Pedal jack anti-theft device. Available at: https://www.autosportcatalog.com/products/pedal-jack-anti-theft-device.html (Accessed: 22 May 2016).
Ill. 68: Brake lock (no date) Available at: http://www.brakelock.com/ (Accessed: 22 May 2016).
Ill. 69: Builder depot (1999) Available at: http://www.builderdepot.com/browse.ihtml?step=5&prodstoreid=9181&pid=1144166 (Accessed: 22 May 2016).
Ill. 70: Bang good (2006) Available at: http://www.banggood.com/ru/Stainless-Steel-Anti-Theft-Security-Supplies-Device-Auto-Car-Clutch-Brake-Lock-p-1007893.html (Accessed: 22 May 2016).
Ill. 71: CO, A.T. (2015) Wireless portable security anti-theft wheel clamp. Available at: http://www.ansaikeji.net/sell-2787643-wireless-portable-security-anti-theft-wheel-clamp.html (Accessed: 22 May 2016).
Ill. 72: Amazon (1996) Dealkoo wheel lock clamp boot tire claw auto car anti theft lock. Available at: http://www.amazon.com/Dealkoo-Wheel-Lock-Clamp-Theft/dp/B013B1UB7G (Accessed: 22 May 2016).
Ill. 73-74: COWI (2014) 'CYKELPARKERINGSANALYSE 2014', , pp. 8–9. (Accessed: 22 May 2016).
Ill. 75-80: own illustration
Ill. 81: BV, F. (2012) Cykelstativ FalcoIdeal 2.0 | Falco A/S. Available at: http://www.falcoas.dk/produkter/cykelparkering/cykelstativer/cykelstativ-falcoideal-20/ (Accessed: 22 May 2016).
Ill. 82-87: own illustration

4.1 RESEARCH
Ill. 88-94: own illustration

4.3 CONCEPT DEVELOPMENT
Ill. 95-138: Own illustration

5.1 CONCEPT DETAILING
Ill. 139-146: Own illustration
Ill. 147: Bernth, M. (2014) Pas på letbanen – den er ny i trafikken - Ingeniøren. Available at: https://ing.dk/artikel/pas-paa-letbanen-den-er-ny-i-trafikken-172382 (Accessed: 22 May 2016).
Ill. 148: Metroselskabet (no date) Københavns metro. Available at: http://www.m.dk/#!/om+metroen/metrobyggeriet/status+paa+metrobyggeriet/arkitektur-nye-metrostationer (Accessed: 22 May 2016).
Ill. 149-150: Own illustration

APPENDIX

1.0 INTERVIEW ABS

Anders Duun Lavendt and Micheal, Anders' father.
Aalborg Bicycle Store ApS
J.F. Kennedys plads 1F
tlf: 26 43 40 83
info@aalborgbicyclestore.dk
Aalborgbicyclestore.dk

SP: Hvilken lås anbefaler i (1 vs 2 låse/bestemt type)?
SV: En lås der ikke er fast monteret, da disse kan låse cyklen fast til andre objekter. Ville anbefale at man køber tommestok type låsen, da den har et sikkerhedslevel på 10 og er svær at skære op. Som udgangspunkt skal låsen være forsikrings godkendt og for at den er det, skal den være varefakta godkendt, gennem Dansk Varefakta, for at vi kan give en kvittering med. Sikkerhedslevel går fra 1-15.
Abus har deres egen som går fra 1-6.

Varefakta godkendt = cykelsmede kvittering = forsikrings godkendt.

SP: Hvordan fungere GPS - kender i til Diims (holdbarhed/ hvem betaler)?
SV: Nye cykler kan få en monteret, det er en gps med et simkort, så den måler hver gang man bevæger cyklen. Et batteri til sådan en holder alt fra 4 måneder til 1 år, afhængig af hvor meget man bruger cyklen. Den bliver monteret i sadelstangen eller i styregaflen.
Der er i gang med at blive udviklet en ny gps som bliver ladet, hvis man har en cykel med elektronisk gear.
De har haft dårlig erfaring med Diims - købte et parti på 10 men solgte kun 7 på over 3 år. Da den kun registrerer hvis en postbil eller postkasse er i nærheden.

SP: Hvilken type cykel er mest populær?
SV: Mountainbike(bliver købt mest om vinteren) eller racercykler og City bike. Der er også nogle der selv vil samle deres egne cykler, men det er tit cykel nørder. Et stel starter fra 30,000 kr og når de er færdige med at samle kommer såden en cykel typisk op på 70,000 kr., men vi har oplevet en stigning igennem årene.

SP: Hvilken slags cykler har i?
SV: Vi har til alle alders grupper - børne cykler til ældre (en fast kunde på en gamle mand) sælger ingen elektriske cykler på grund af dyre dele.

SP: Hvad er cykeltyves fremgangsmåde?
SV: De bryder cyklen op på stedet hvis de kan. De vælger somregl neutrale cykler eller designercykler (dyrer cykler) der bliver skildt ad, hvor dele så bliver solgt for sig, da man på den måde ikke kan spore det som ikke stjålet (stelnummer er det eneste man kan spore) cyklerne bliver typisk kørt til grænsen mellem Tyskland og Polen

SP: Hvilken cykler bliver typisk stjålet?
SV: Alle standard farver, det er typisk dem der bare skal bruge en cykle fra A til B (brugstyveri) og så de dyre som bliver skildt af (tyveri) hvis en cykel har kostet mere en 20,000 kr vil politiet gerne eftersøge det.

SP: Hvordan tester Dansk Varefakta låsene?
SV: De tester brudstyrke, hvor lang tid det tager at save en lås over og med hvilken slags sav. De kulde tester også deres låse, da man i nogle tilfælde kan fryse en lås og så slå på den, hvorefter den går op. Abus låse er sikret mod dette.

SP: Hvad skulle den optimale cykellås kunne?
SV: Man skulle kunne låse cyklen fast til andre genstande og så skulle den være lavet af et let materiale så den ikke er så tung at bære rundt på. En af mine ingeniør venner prøver at lave en lås af titanium, men prisen kom over 70,000 kr.

Bonus:
Anders har selv 3 dyre cykler. Han har lavet en forsikring på dem, hvor at så længe de er låst inde i hans skur er de forsikret. Ydermere har han låst dem fast med kæder til gulvet fordi han har fået nogle cykler stjålet før.
Anders har forsikring igennem Max Levig, hvor de forsiker cykler fra 15.000 kr. og op.
(Tryg forsikring, 2016)

Tryg Forsikring (2016) Max Levig Specialforsikring - Tryg Forsikring. Available at: http://www.tryg.dk/forsikringer/max-levig-specialforsikringer.html (Accessed: 19 February 2016).

2.0 INTERVIEW LØBEKOMPANIET

Løbekompaniet BIKE
Mathias Kalstrup - butiksansvarlig
tlf: 21 73 02 56
bike@loebekompagniet.dk
www.loebekompagniet.dk

SP: hvilken type lås anbefale i?
SV: Abus låse med en varefakta godkendelse og et godt sikkerhedslevel. Sikkerhedslevel går fra 1-15, hvor 15 er det bedste. Hvis man har en dyr cykel kræver forsikringen en lås med et bestemt niveau på sikkerhedslevelet.

SP: hvilken kendskab har i til GPS?
SV: Vi sætter ikke GPS i, fordi det ikke er noget forsikringen giver tilskud til. Så skal privat personen selv betale for det.

SP: Hvilken type cykler er mest populære?
SV: Mountainbike; dette er en meget populær sport som selv har toppet golf. For noget tid siden var det landevejscykler der var populære. Det ændre sig med hvilken cykelsport der er populær. Hvis man skal have en god mountainbike ligger prisklassen fra 6.000 kr og op.

SP: Hvordan ville du låse en cykle?
SV: Den skulle låse fast til noget og begge hjul skulle helst være låst sammen med stellet, hvor alle 3 dele er låst fast. Damecykler er svære at låse fast på grund af det “runde” stel.

SP: hvordan ville den optimale lås være?
SV: Altså det skulle være en let lås men stadigvæk effektiv, den skulle være let at have med. Min egen lås vikler jeg omkring sadelpinden når jeg cykler, men den vejer meget.

Bonus:
Under en promille (1 ud af 1000) af cykler bliver fundet igen efter de er blevet stjålet.

3.0 INTERVIEW MAX LEVIG

Interview with Tutti Kaare.

Hvilken prisklasse er det somregel jeres cykler bliver forsikret inden for?
Det er somregel dyre cykler, men dyre cykler er jo et vidt begreb fordi for nogen kan en cykel på 15.000kr være meget mens ved andre skal den helt op på 75.000kr. Men det handler om at vores forsikring har en minimums præmie.

Hvad vil det sige?
En minimums præmie? Det er den mindste præmie vi overhovedet kan opkræve på den type forsikring her og den præmie udgøre 1.500kr. og der er en selvrisiko på 2.000kr. på vores forsikring så hvis man har en cykel til 10.000kr. så er det ikke målgruppen til denne her type forsikring. Det bliver simpelthen for dyrt for kunden.

Vi snakkede med en cykelhandler der ikke mente at han behøvede at låse sin cykel for at denne forsikring gjaldt, er det rigtigt?
Det er ikke rigtigt. Det er ikke rigtigt fordi med hensyn til tyveri dækker vi udelukkende tyveri fra aflåste bygninger eller aflåst bil, så selvfølgelig har han ret i at han ikke behøver låse den når den står inde i en aflåst bygning, det er jo ligegyldigt. Så det er ikke når den står ude på gaden, nej. Der dækker vi den slet ikke, hvis den bliver stjålet. Uanset om den er låst eller ej.
Vi dækker kun forsikringen på baggrund af, hvor cyklen befinder sig når den bliver stjålet.

Hvor mange cykler får i meldt stjålet?
Jeg ved det heller ikke, altså jeg aner det ikke.

Så kan du nok heller ikke svare på hvor mange der bliver fundet igen?
Nej det kan jeg ikke. Det kan jeg ikke.
Der er jo også det ved det at mange stjålne cykler er jo dækket på cykeldelen under indboforsikringen, altså familieforsikringen, så der ville det jo være både Max Levig og Tryg man skulle tænke på. Så jeg ved ikke om der er nogen der ved hvor mange cykler vi får stjålet eller hvor mange der bliver fundet. Jeg aner det ikke.

Har du nogen generel viden om hvilke typer af cykler der bliver forsikret på den her måde?
Det er både de dyre racer og de dyre mountainbikes. Det er begge dele vi forsikrer.

Findes der flere forsikringer af den her type? Jeg ved ikke om du kan nævne nogle andre?
Jeg tror også andre forsikringsselvskaber har den her type forsikring. Vores forsikring er jo en all-risk forsikring, dvs. en casko forsikring og det kan man også lave andre steder.

Har du nogen ide om hvor mange der har sådan en forsikringer ved jer?
Jeg kan ikke huske antallet af policer som vi har og det er jeg heller ikke sikker på at vi må oplyse.

4.0 BICYCLE LOCKS

AXA Rock	Basta Click 3 lock	Basta Click 3 lock Basta combination lock
		
- Open with keys - varefakta approved (AXA, 2015)	- Potented - Open with keys - Varefakta approved (Basta, 2013)	- combination lock - not Varafakta approved

CHAIN LOCKS

ABUS 1500/60 Web	RCP hign securer cable lock - RED	BBB MICROSAFE BBL-10
		
- chain lock -key or combination - Varefakta approved (Abus, 2016)	- key or combination lock - Varefakta approved (Bikester, 2016)	- combination lock - not varefakta approved (BBB Cycling, 2016)

BBB Cycling (2016) BBB MICROSAFE BBL-10. Available at: http://bbbcycling.com/accessories/locks/BBL-10 (Accessed: 19 February 2016).

Bikester (2016) RCP high secure cable lock Cykellås. Available at: http://www.bikester.dk/red-cycling-products-high-secure-cable-lock-cykellas-bla-sort-232721.html (Accessed: 19 February 2016).

Abus (2016) Lock-chain combination 1500/60 web black. Available at: http://www.abus.com/eng/Mobile-Security/Bike-Safety-and-Security/Locks/Lock-Chain-Combination/1500-Web (Accessed: 19 February 2016).

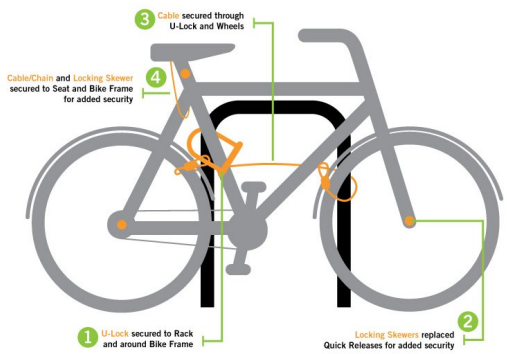
Basta (2013) ClickIII - axabasta. Available at: http://www.bastacycling.com/locks/frame-locks/clickiii/ (Accessed: 19 February 2016).

ABUS 6000 Bordo	HIPLOK POP	ABUS BØJLELÅS 40 U-MINI
		
- key - Varefakta approved (Cykelpartner, 2015)	- key - not incuerance approved in DK - when not in used, can be placed around the waist (Fahrrad.de, 2016)	- key - Varefakta approved (Netcyklen.dk, 2016)

Kryptonite Evolution Mini 7 Lock &
4 Foot KryptoFlex Cable

- key lock and cable
- ment to extra secure your bike
(Speedline.dk, 2016)

Using Multiple Locks

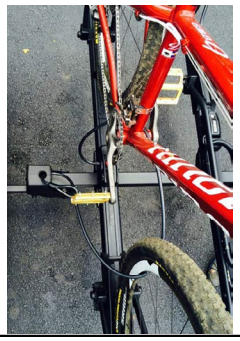


Speedline.dk (2016) Kryptonite evolution Mini 7 Bøjlelås m. Wire. Available at: http://speedline.dk/da/scooter/kryptonite-evolution-mini-7-boejlelaas-m-wire-c-kry-720018000990/ (Accessed: 19 February 2016).

Netcyklen.dk (2016) Abus U-Mini 40 godkendt bøjle lås - let at have med i tasken. Available at: https://www.netcyklen.dk/shop/abus-u-mini-40-1013p.html (Accessed: 19 February 2016).

Fahrrad.de (2016) Hiplok pop Kabelschloss schwarz günstig kaufen fahrrad.de. Available at: http://www.fahrrad.de/hiplok-pop-kabelschloss-schwarz-357774.html (Accessed: 19 February 2016).

Cykelpartner (2015) Foldelås Abus 6000 Bordo DK sort 90 cm. Available at: http://www.cykelpartner.dk/foldelaas-abus-6000-bordo-dk-sort-90-cm_03921.html (Accessed: 19 February 2016).

Inno Racks' versatile Tire Hold hitch mount bike rack	ClingCling,' a bicycle rack.	...
		
- car bike rack holder - keeps secure by a wire (Benedict, 2014)	- a prototype - two types: - SGW-H300, password - SGW-H315, bike card(on foto) (Aving Global Network, 2013)	- need a padlock to lock - located in Boston USA (Hack that whip!, 2015)

RACK LOCKS

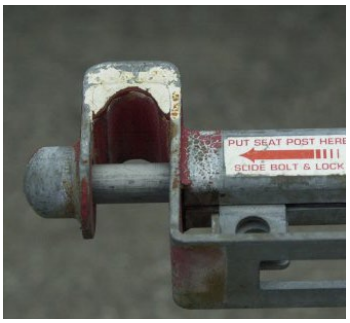
Randers Pendlercykler	Aalborg bycykler	Falco U-lok
		
-locked by the front wheel - public bikes	-locked at the handlebar - public bikes	- public bike rack - lock it with your own padlock (FalcoDanmark, 2013)

Benedict, T. (2014) Review: Inno racks' versatile tire hold hitch mount bike rack. Available at: http://www.bikerumor.com/2014/12/26/review-inno-racks-versatile-tire-hold-hitch-mount-bike-rack/ (Accessed: 19 February 2016).

Aving Global Network (2013) [ROTREX 2011] Hanlim GST to display 'ClingCling' for storing bikes safely AVING USA. Available at: http://us.aving.net/214266 (Accessed: 19 February 2016).

Hack that whip! (2015) 'BikeHacks', June. Available at: http://www.bikehacks.com/bikehacks/security/page/3/ (Accessed: 19 May 2016).

FalcoDanmark (2013) Cykelstativet U lok. Available at: https://www.youtube.com/watch?v=A5xBWVBSZwQ (Accessed: 19 February 2016).

unknown name	Armlock
	
- need a padlock - secure the seat post. - located in tokyo (Donk, 2005)	- Prototype - lock up at home - key to unlock - monted to the wall (Rodd design, 2013)

ALTERNATIVE LOCKS

Bitlock	Skylock	lock8
		
- not inscured approved in DK - key & comination less lock - use your phone as key (open without thouching the phone) (Bitlock, 2015)	- key less lock - uses phone as key (open without thouching the phone) - solarpowered (Skylock, 2016)	- GPS and alarm in one. - accessories to the bikelock. (LOCK8, 2015)

Donk (2005) Bike racks and locking devices. Available at: http://www.cyburbia.org/forums/showthread.php?t=19183 (Accessed: 19 February 2016).

Rodd design (2013) Rodd design | Armlock. Available at: http://www.rodd.uk.com/no-more-bike-crime/ (Accessed: 19 February 2016).

Bitlock (2015) Bitlock: Next generation keyless bike lock. Available at: https://bitlock.co/ (Accessed: 19 May 2016).

Skylock (2016) Keyless, electronic, smart bike lock. Available at: http://www.skylock.cc/ (Accessed: 19 February 2016).

LOCK8 (2015) Bike sharing & fleet management. Available at: http://lock8.me/ (Accessed: 19 February 2016).

TiGr lock	TiGr lock	Litelock
		
- key - “strong (for your bike) and light-weight (for your legs)” - not inscured apporved in DK (TiGr Lock, 2016)	- key - “strong (for your bike) and light-weight (for your legs)” - not inscured apporved in DK (TiGr Lock, 2016)	- uses a material they call Boaflex-icore - weighs under a kilo - key lock (LITELOK, 2016)

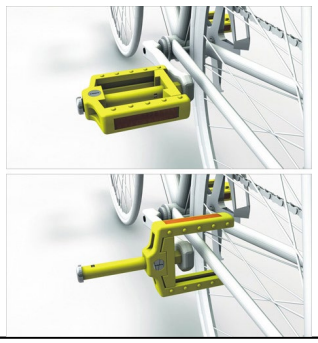
Seatylock	Sphyke lock
	
- when not in use it’s the bikeseat - key to unlock - one meter range (Seatylock, 2016)	- to lock induvidual parts of the bike - combination lock (Sphyke, 2011)

TiGr Lock (2016) About | bike locks | bike accessories. Available at: https://tigrlock.com/product/ (Accessed: 19 February 2016).

LITELOK (2016) Lightweight bike lock | light bike lock. Available at: http://www.litelok.com/ (Accessed: 19 February 2016).

Seatylock (2016) Seatylock. Available at: http://www.seatylock.com/ (Accessed: 19 February 2016).

Sphyke (2011) Security skewers. Available at: http://www.sphyke.com/ (Accessed: 19 February 2016).

Anti-Theft Pedal	DrinLock	Transit lock
		
- Bike competition suggesten - Not on marked (Metamason, 2013)	- Bike competition suggesten - Not on marked (Metamason, 2013)	- key to unlock - double as a wire rack (Behance, 2014)

Quick - stand&lock	B.Y. handle lock	Saddle lock
		
- not on marked - combination lock (wordlesstech team, 2013)	- a wire in the handlebar - combinatioin lock (Seth, 2011)	- not on marked - combination lock (Ziba Design, 2013)

Metamason (2013) International bicycle design competition 2013 winners, part 1. Available at: http://www.core77.com/posts/24668/international-bicycle-design-competition-2013-winners-part-1-24668 (Accessed: 19 February 2016).

Behance (2014) 'Transit lock', Behance, 25 May. Available at: https://www.behance.net/gallery/17054669/Transit-Lock (Accessed: 19 February 2016).

wordlesstech team (2013) Quick stand and lock. Available at: http://wordlesstech.com/quick-stand-and-lock/ (Accessed: 19 February 2016).

Seth, R. (2011) 'Num lock', 5 October. Available at: http://www.yankodesign.com/2011/10/05/num-lock/ (Accessed: 19 February 2016).

Ziba Design (2013) Red dot award-winning 'saddle lock': Yea or nay? Available at: http://www.core77.com/posts/24230/Red-Dot-Award-Winning-Saddle-Lock-Yea-or-Nay (Accessed: 19 February 2016).

5.0 INSURANCE RESPONSIBILITY

Question asked Dansk varefakta/Danish institute for informations labeling:
How do you test the bicycle locks? would it be able to get a approved bicycle rack? the conversation was with Jens Kristian Weidlich

They have different demands when testing their bicycle locks(Dansk varefakta nævn, 1991). But they only test out from user thievery, so they only use small tools when testing the locked, such as a hammer, junor saw or a screwdriver. One of the demands in order to get their locks approved is that it should be something that can be placed on the bicycle. Therefor they can not approve our bicycle racks.

If Dansk varefakta/ Danish institute for informations labeling can not approve our bicycle rack, that means that the insurings company will not pay the insurnings money, if a costumers bicycle gets stolen form our bicycle rack. The municipality do not what to have the responsibility so the conclusion is that it is the users own responsibility when using our bicycle racks.

One solution to this, is to continue so the responsibility stay with the user. Another solutions is to apply for insurance approval at Danish institute for informations labeling in order to create a new section where they take our bicycle rack into consideration.

Dansk varefakta nævn (1991) Cykellåse. Edited by Dansk varefakta nævn. Dansk varefakta nævn.

6.0 PARKING TIME TEST

In the tabel is listed the different types of bicycle racks, type of lock, how many wheels was locked and how much time it took.

Type bicycle rack	Type of test	Lockable wheels	Time
“normal” bicycle rack	Mounted	1	14 sek
“normal” bicycle rack	Front wheel + mounted	2	30 sek
“normal” bicycle rack	Front wheel	1	16 sek
Hoop rack Musikkens Hus	Mounted	1	14 sek
Hoop rack Musikkens Hus	Front wheel + mounted	2	24 sek
Hoop rack Musikkens Hus	Front wheel	1	13 sek
Hoop rack Musikkens Hus	Front wheel + back wheel	2	28 sek
Hoop rack Nordkraft	Mounted	1	18 sek*
Hoop rack Nordkraft	Front wheel + mounted	2	18 sek
Hoop rack Nordkraft	Front wheel	1	28 sek
Hoop rack Nordkraft up lock/lift	Mounted	2	20 sek
Hoop rack Nordkraft up lock/lift	Front wheel	1	27 sek
Hoop rack Nordkraft up lock/lift	Front wheel + mounted	2	29 sek
Hoop rack Nordkraft up lock/lift	Front wheel + back wheel	1	42 sek
Security rack Municipality	Mounted	1	13 sek
Security rack Municipality	Front wheel + mounted	2	27 sek
Security rack Municipality	Front wheel	1	19 sek
“normal” diagonally bicycle rack Municipality	Mounted	1	10 sek

Type bicycle rack	Type of test	Lockable wheels	Time
“normal” diagonally bi-cycle rack Municipality	Front wheel + mounted	2	22 sek
“normal” diagonally bi-cycle rack Municipality	Front wheel	1	16 sek
Hoop rack Friis	Mounted	1	12 sek
Hoop rack Friis	Front wheel + mounted	2	29 sek*
Hoop rack Friis	Front wheel	1	23 sek

**bicycle was about to tilt*

7.0 PARKING VIDEOS

These videos can be seen on the usb under the folder named Video 04.03.2016.

The videos show how the bicycles have been parked around Aalborg Nytorv and the Train station.

8.0 BICYCLE MAPPING

BMX Bicycle:

Most often used by professional people in competitive BMX settings and competitions. However there exists also a freestyle BMX culture where the bikes are used to do tricks on the streets.

BMX stands for Bicycle Motocross.

Christiania Bicycle:

Used by a large variety of people, from family transport (people/kids) to commercial goods.

European (Mens) City Bicycle:

A very common type of bike, especially in Denmark. Users of this type of bike go from late elementary school children to elderly people.

European city bikes are also known as utility bikes because they serve a variety of functions for the user.

European (Female) City Bicycle:

Serves the same function as the men's version of the european city bike but was originally designed to allow women to wear dresses and skirts while riding their bikes. There exists a variety of women's city bikes nowadays.

Cyclocross Bicycle:
An all around kind of bike, which have been designed to both be able to handle offroad and onroad drivin

Electric City Bicycle:
A European city bike equipped with an electric motor and a battery. This type of bike is often used by elderly people, who likes to take bicycle trips but have become too frail. This type of bicycle also comes in female versions.

Foldable Bicycle:
This small bike that can hold up in order to save storage space. The bike is not designed to be ridden for long distance drives but instead for short trips. For example if a family is on a trip somewhere and they had not planned on going bicycling but simply prepared themselves for the possibility.
The folding bike also fits under the utility bike because it can serve multiple functions.

Low Rider Bicycle:
These types of bicycles are not built with the user in focus. In fact often these bicycles are made purely as a styling exercise. The handbars are upward swept ape hangers and the seats most often used are called ‘banana seats’, which is basically long saddles that are supported in both ends, much like those seen on motorcycles.

Mountain Bicycle:
These bikes are designed to be ridden offroad with their large wide tires and, suspension and stronger frame.
These bikes are both used by professional people and by amateur joy riders where they can serve as a fitness instrument.

Racing Bicycle:
The racing bikes are designed to ridden on paved roads with their thin tires and light frame.
These bikes are used by professional people for competitive road cycling. They're equipped with many hi-tech racing features that gives them different benefits in the competitive scene.

Recumbent Bicycle:
A rare bike designed to be comfortable for the users with large laid back seats.
These bikes can also be used in a competitive setting.

Transport Bicycle:
Transport bikes are a category of the city bikes. However this type of bike is equipped with extra storage possibilities.

Public City Bicycle:
These european city bikes are possible to rent from public sites like in front of the train station in Aarhus. They're equipped with a locking mechanism at their front wheel axle.
These specific bicycles are meant to be used by people that do a lot of commuting between home and work.

Road Bicycle:
Road bikes are similar to racing bikes but there are differences still. The road bikes are not designed to be used for short bursts of speed but instead focuses on endurance.
The road bike is however still designed to be used for traveling at speed on paved roads.

Touring Bicycle:
The touring bikes are designed with stronger frame to make it more robust and make it able to carry a heavy loads. They are also significantly more comfortable than an ordinary road bike.

Cruiser Bicycle:
Cruiser bikes are equipped with wide balloon like tires and original cruiser bikes were only equipped with single-speed gearing, which meant that they had no other gear than the one the bicycle was in. A few cruisers bikes have nowadays been equipped with more gears.

Tandem Bicycle:
A tandem bike is a bike that is designed to be ridden by more than one person at the same time. These types of bikes are of the more social type

Penny-Farthing Bicycle:
Developed around 1870 and seen as the first real bicycle the Penny-Farthing was built with a large front wheel with direct drive pedals because it enabled higher speed on the bicycle with no gearing system.
The name Penny-Farthing comes from the english coins Penny and Farthing as the two coins had similar size differences.
Some people still ride these dangerous bicycles but they are very rare, even while there have been made updated versions of the bicycle.

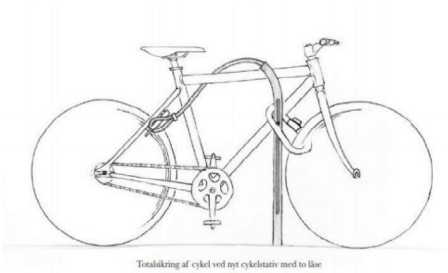
Handicap Bicycle:
The handicap bike was developed for people that has difficulty keeping their own balance as these types of bikes are equipped with three wheels.

Wikipedia (2016) ‘List of bicycle types’, in Wikipedia. Available at: https://en.wikipedia.org/wiki/List_of_bicycle_types (Accessed: 20 February 2016).

Century Cycles (2016) Bicycle types: How to pick the best bike for you - century cycles - Cleveland & Akron OH. Available at: http://centurycycles.com/buyers-guides/bicycle-types-how-to-pick-the-best-bike-for-you-pg9.htm (Accessed: 20 February 2016).

Bikesoup (2016) Guide to bike types. Available at: https://www.bikesoup.com/guides (Accessed: 20 February 2016).

9.0 BICYCLE RACK WITH LOCK



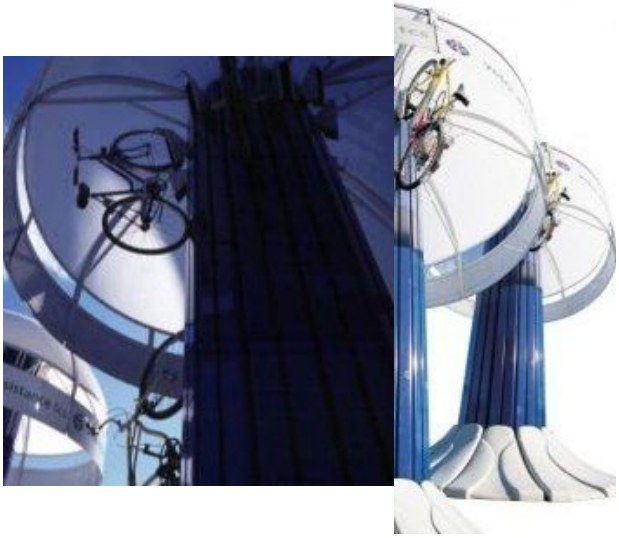
Totalsikring af cykel ved nyt cykelstativ med to låse

Idea competition against bicycle theft. Ended at September 15, 2014 which addresses the issues of how to reduce the impact of theft of bicycles at the train station in Copenhagen.

Trafik- og Byggestyrelsen (2010) Idékonkurrence mod cykeltyveri: Vinderne er fundet! Available at: http://www.trafikstyrelsen.dk/DA/Kollektiv-Trafik/Idekonkurrence-stop-cykeltyven.aspx (Accessed: 20 February 2016).

Bicycle parking in Japan, which operate by an automatic system. Requires that you pay to use it. Use a card to pick up the bike again.

Danny Choo (2013) Underground bicycle parking systems in Japan. Available at: https://www.youtube.com/watch?v=pcZSU40RBrg (Accessed: 20 February 2016).

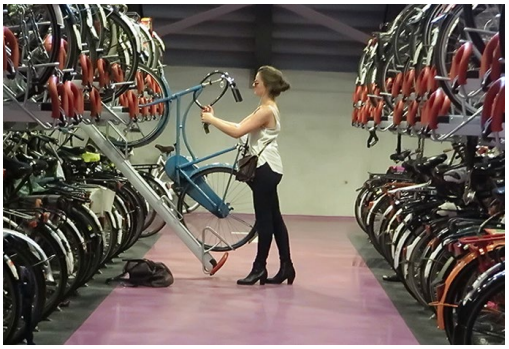


Bike tree parking. The parking of bicycles which are hung under an umbrella, here the user have a card in order to retrieve a “hook” which can clasps around the bicycle. then the bicycle is hung up under the umbrella. When you have to pick up the bike again, you have to scan the card and then it is then lowered to you.

upcycle (2006) A new way to park bicycles.. Hang them in a bike tree! Available at: https://www.youtube.com/watch?v=OcSD5MsQuVo (Accessed: 20 February 2016).

Bicycle park in the Netherlands. This is a huge bicycle parking with room for 5,000 bicycles. This video shows how the it function. At aound 2:40 min in the video it can be seen how difficult it is to put one's bicycle unto the upper parking.

BicycleDutch (2015) Delft bicycle parking facility. Available at: https://www.youtube.com/watch?v=UuhLv1AN-0bE (Accessed: 20 February 2016).



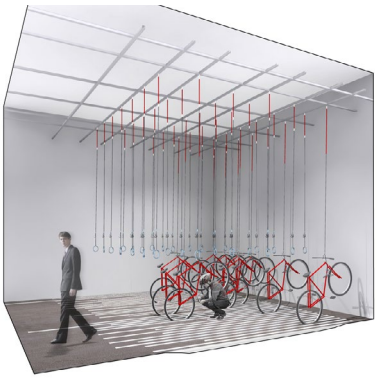
There are many different solution on how racks for public bicycles are designed. What is common for them all is that the bicycles and rack have a locking system, which only they fit together. In the illustration, the front fork have an added metal component, which fit into the rack. These solution are difficult to match, because all the public bicycles are designed so that only they fit into their racks.

pikeabike.com is an American s website which has created different solutions to store bikes safely. They have a locked bike shed where one can place one's bike.

Park A Bike (2016) Composite bike storage lockers – outdoor lockers - bicycle storage racks – park a bike. Available at: http://www.parkabike.com/composite-bicycle-vault-bike-lockers (Accessed: 20 May 2016).

Students suggestion. two students' suggestions for a bicycle rack with lock. A bit clumsy solution. The idea is that you have a card to lock, but you do not pay for it because there is advertise on the standers.

Peters, A. (2015) What if you didn't need A bike lock, because the bike rack locked your bike for you? Available at: http://www.fastcoexist.com/3045931/what-if-you-didnt-need-a-bike-lock-because-the-bike-rack-locked-your-bike-for-you#4 (Accessed: 20 February 2016).



Design competition that took place in New York (NYC CITYRACKS Design Competition - 2008) where there are two locked proposals where the bikes are locked in a shed. Some of the proposals regarding the storage of the bikes are pretty smar.

NYC Department of Transportation (2008) CityRacks design competition. Available at: https://nycityracks.wordpress.com/ (Accessed: 20 February 2016).

Cyclehoop has made a small bike shed which takes up just as much as a normal parking space. It is supposed to placed outside apartments in the city.

Cyclehoop Ltd (2014) Pioneering city of Grenoble welcomes first Cyclehoop Bikehangars in France. Available at: http://www.cyclehoop.com/news/january-2016/pioneering-city-of-grenoble-welcomes-first-cyclehoop-bikehangars-in-france/ (Accessed: 20 February 2016).

Six different ways to store one's bicycle, some of them are not with a built-in locks but some of the concept could be used.

Untapped Cities (2013) 6 innovative designs for bike parking and storage that could be used in NYC. Available at: http://untappedcities.com/2013/08/14/6-innovative-designs-for-bike-parking-and-storage-could-be-used-nyc/ (Accessed: 20 February 2016).

Biomega: who design bicycles have made a collaboration with Puma, where they have designed the bike: Disko, which are held together with a wire. when "locking the bike" you loosen the wire, fold the bike and wrap the wire around the bike.

Biomega (2016) Biomega. Available at: https://biomega.com/ (Accessed: 20 February 2016).

10 COMPETITORS

Byform: Sells bike racks and city equipments in Co_2 friendly designs.

All their bike racks are made in galvanized steel, EN DIN 1.4301 (AISI 304)/EN DIN 1.4404 (AISI 316 L). There are many different design options, Where it is made possible for some to lock your bicycle frame to the rack. Byform have most of the traditional bicycle racks which only support the front wheel, they have five racks who is atypical; Duero, Aehwa, Marapa, Kerjo and Velo up.
Overall price: The price range is between 700-2000 DKkr. The prices is calculated so it matches with one stands per bicycle rack. (Byform, 2016)

Duero: is a 8 mm hot galvanized steel hoop rack, with a hole in the top, where it is possible to lock the bicycle frame to. hight: 900 mm, width: 200 mm. It is possible to get it powder coated in custom colors.
Price: 1,989 kr ex taxes.

Aehwa: is made of 80 x 8 mm hot galvanized steel plate, with the finish as a foot plat or to embedment. It is possible to slide the wheel in between the Aehwa, and lock the bicycle frame to it. hight: 900 mm. can get it in different colors. Price: 1,386 kr ex taxes.

Marapa: hot galvanized steel in 80 x 80 mm. hight 1000 mm. Hoop rack where it is possible to lock the bicycle frame to the rack. Powder coated in different colors. Price: 1,098 ex taxes.

Kerjo: The basic structure is made of hot galvanized steel where the supporters is coated with plastic. Distance between bicycles is 500 mm. There are high and low support. Available for wall mounting, the foot plate and for embedment, single-sided or double-sided. Hight 1250 mm, depth 370 mm (one sided). Price: 2,240 kr ex taxes (for 3 parking support)

Velo up: this rack have been developed in collaboration with The Technical University of Eindhoven (NL). distance between bicycles is 500 mm. This is there most complicated bicycle rack.

Duero


Aehwa


Marapa


Kerjo

Byform (2016) Cykelstativer. Available at: http://www.byform.dk/pl/Cykelstativer (Accessed: 20 February 2016).


CS-3


CYL 1


Gard

G9 landskab:Park & Byrum
Sustainable landscape architecture with a focus on environmentally certified and sustainable recycling plast. Design and production of equipment for park and urban spaces, including security in the public and private spaces with auto height-adjustable bollards.
All their bike rack are made in the material steel with different kind of after process (galvanized/coated) they have five bicycle racks which are diffierent from “traditionel” racks; CS-3, CYL 1, Gard -3, -4 and -5
Overall price: There price is 2500 DKK and up
(G9, 2016)

CS-3: this rack is made so the bicycle frame can be locked unto it. the front wheel is not suported. It is made from hot galvanized steel. H: 1000 x B: 1600 x L: 4600 mm. Can be powder coated in RAL colors.

CYL 1: made from 8 mm flat steel, which have been galvanized or painted. H: 900 x B: 60 mm. Can be painted in any RAL color.

Gard -3, -4 & -5: these types are shead with a incorpirated rack. 3 and 5 have the same type of rack than CS-3, where 4 have the option to lift the bicycle. material is hot galvanized steel.

G9 (2016) Cykelbøjle, cykeloverdækning, automatisk cykelpumpe, vandstation, cykelstativer, cykelparkering, cykel service stationer. Available at: http://www.g9.dk/park-byrum/cyklisme.html (Accessed: 20 February 2016).

VEKSØ: Making city product - bicycle rack, furniture and more.
they have many different bicycle features beside racks; bicycle counters, bicycle pumps and bicycle counters. It is not all of their bicycle racks that they have designed themself, many are designed by other design companies. Of the 26 racks the have only seven are their own design. 13 of these rack are not the “traditonal” front wheel suport. So far Veksø is our main competitons, as they have a strong hold on the marked.
Overall Price: There price range is1200-8000 DK kr.
(VEKSSØ, 2016)

Aros hoop stan: is design by Byarkitekterne, Århus kommune and are part of a serie placed around Århus. the material is typicaly Hotdip galvanized steel, which can be powder coated.

Meno cardiobike rack: designed by Gottlieb Paludan Architects. This a rack made specifikally for cardiobikes . The material is fiberbeton and stainless steel.

Largo: designed by Veksø. This is what would be classified as a safty rack, where it is possible to lock the bicycle frame to the rack. The material is stainless steel, which can be powder coated.

Silhuet: designed by Creo Arkitkterne A/S. Is a frontwhell support rack, which it is also possible to lock the bicycle frame to the lock, if the bicycle is places beside it. Material is strain less steal.

Royal: designed by Schmidt Hammer Larsen Architects. A hoop stand with a hole in the top, where it would be possible to lock the bicyle too. Material is stainless steel.

Aros Hoop stand

Meno cardiobike rack

Largo

Silhuet

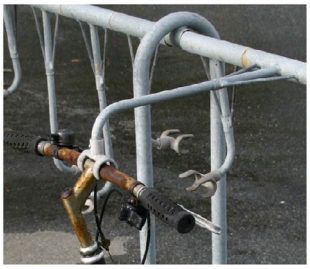
Royal

Outfit

Solid

Torino

Easylift



Outfit: designed by Anne Quist Design Office. A hoop stand, which is a bend pipe with a plastic coating. The main material is stainless steel.

Solid: designed by Lars Vejen. A hoop stand made in fiberbeton with a hotdip galvanized top, which can be powder coated. it is possible to lock you bicycle fram to the hoop stand.

Torino: designed by Byarkitekterne, Århus kommune. A hoop stand, which is a bend stainless steel plate, which can de powder coated or glass blown. it is possible to lock the bicycle frame to the hoop stand.
Opus: Designed by Veksø, a bent hotdip galvanized steel pipe which is a hoop stand, where it is possible to lock the bicycle frame to it.

Easylift: designed by VelopA. Velop design street furnitures and bicycle accessories, the companie is from the Netherlands. This rack is a two level bicycle rack, which main material is hotdip galvanized steel.

Klo: Original Veksø design. This rack grap around the handling of the bicycle. it is from 1950 so not many bicycle handle fit the bicycle rack. it is made in hotdip galvanized steel.

VEKSØ (2016) Cyklisme - VEKSØ. Available at: http://vekso.com/da/produkter/cyklisme/ (Accessed: 20 May 2016).

Outsider: an outside furniture companie, which clames that they make experience furniture. In their selection they have three different bicycle racks. They dont design thenself, but have a collaboration with many different designers and design companies.
overall price:Their price is 1600-8000 DK kr.
(Outsider,2016)

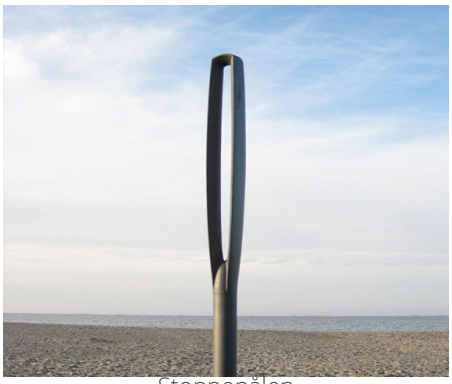
JELLO: by Nation + KSA design
It is a alternative bike rack, which can be used to much more. It is made from the material fiberbeton. The rack only support the front wheel, and it is not possible to lock the bicycle frame to it.

Navigation # 308: designede by Polyform. this hoop stand is made from flat steel which is hotdip galvanized and powder coated. it is possible to lock the bicycle frame to the hoop stand.

Stoppenålen - høj #301: designed by Outsign. This hoop stand is made of steel which is sand blasted, metallized, primed and powder coated. It is possible to lock the bicycle frame to the hoop stand.


JELLO

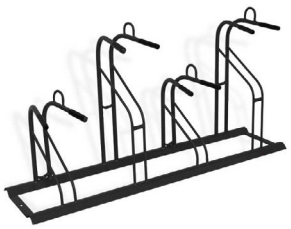

Navigation


Stoppenålen

Outsider (2016) Product. Available at: http://out-sider.dk/da/products/all (Accessed: 20 May 2016).

Vel-O-Matic

Smartstreets



FALCOIDEAL

Triangle

Bikeeper

FalcoEase

Falco: is a large company which sell outdoor urban furnitures, as well as bicycle racks and more. Their main office is in the Netherlands, they have subdivisions in many other countries in Europa and America. They are active on the socials media. They have more than 60 years of experience with bicycle racks.
Overall price: Their prices range is from 225-785 DK kr.
(Falco BV, 2012)

*Falco once sold a bicycle rack where the users could lock by using a padlock, this however did not sell, one of the explanation was that when are architect write that they want to have bicycle rack, the one responsible buys the cheep ones, rather because the do not know that other kind existed.

Vel-O-Matic: is a rack, which hold the bicycle upright and record how long a bicycle have hung, so it is easier to keep track off lost/forgotten bicycles

Smartstreets: is a rack there can be placed aound a standart pole, and it is posible to lock the bicycle with teo locks. its is produces in stainless steel then powder coated.

FALCOIDEAL 2.0: is a traditionell bicycle racks with a twist, there are added a feture which help hold the bicycle secure. it is made in galvanized steel.

Triangle 10: is formed so it is possible to lock the bicycle fram to the rack. The rack is made in steel with a powder coating.

Bikeeper: is a patend bicycle rack, which surpport the front of the bicycle frame. The rack is made in aluminum/ stainless steel or galvanized steel.

FalcoEase: this rack focus on short time use, like parking at the supermarked. it only support the front wheel. the rack is made in solid steel.

Falco BV (2012) Cykelparkering | Falco A/S. Available at: http://www.falcoas.dk/produkter/cykelparkering/ (Accessed: 20 February 2016).

Now that are an overview over what kind of product the different companies sell. It is time to look at their core values, to see what the company's focus on.

G9: values is to be work together with their customers, in order to design a balance between practicality, comfort and quality. they like to challenging tradition with the purpose of creating new possible design of urban spaces

Byform: contributes to the city's pulse, creating outdoor spaces where people thrive. To create inviting spaces is about visionary design, practical functions and durability as well as knowledge of human behavior. Byform Greenline is the first 100 % sustainable urban furniture line in Denmark with classified products

Falco: staff has integrity and great knowledge of the market and the products. All workflow is performed quickly and professionally and the employees are proactive and dedicated to their work and function. It is Falco very concerned that in all our activities is our social responsibility. Our employee health and safety, product usability and function as well as our care for the environment are all the focus of Falco.

Outsider: Vision - Outsider will always be Scandinavia's most challenging provider of experience fixtures for Urban environments

Veksø: mission -is to improve and enrich the stay in and movement through the city. We call it enriching urban life
Vision - is to be the customers' preferred supplier of coherent, sustainable urban solutions.
This can be used as inspiration for our value, as well as mission and vision.

A overall analysis have been made via the strategy canvas. This analysis style was used in order to gain a quick overview. As can be seen in the canvas the companies have been envaluated on 7 different grounds.

Possible to lock frame - this is based on how many different bicycle racks the companie have where it is possible to lock the bicycle frame to the rack.

Versatile in support - where does the racks support the bicycle, is it by the front wheel or the bicycle frame.

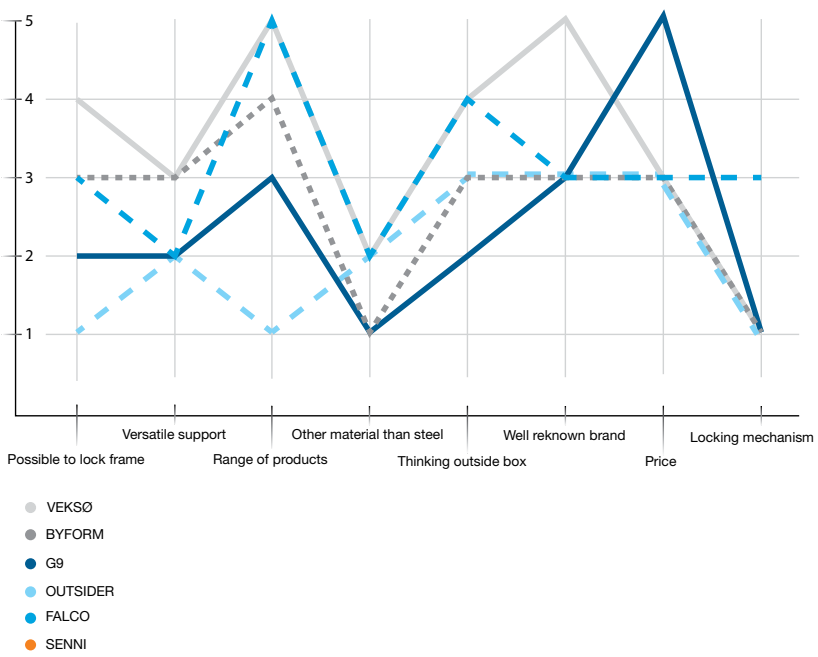
Amount of products - this is the how many different types of bicycles rack the companie sell. Here all bicycle racks are counted.

Other material then steel - how many of the companies operate in other material then steel.

Think out of the box - do they have something else then the competitations, do they dare to take chances

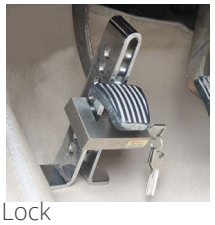
Well known name - how popular are they, do there competiters know them

Price - 5 is expencive and 1 is cheap. what does the compaines take for there bicycle rackes.






Sterring Wheel Lock

Pedal Lock

Bicycle pedal lock

11 ALTERNATIVE LOCKS

(Car) Steering Wheel Lock:

- Steering wheel locks are designed to hinder car thieves abilities to control the car they have stolen, bymaking the lock hit other components inside the car, like the windows, the door etc.

Negative:

- The car can be turned on.
- The car can be steered partly.
- Thieves will can just cut through the steering wheel and remove the lock if they want the car.

(replant, 2012), (My Raslok, 2013).

(Car) Pedal Lock:

- Pedal locks are designed to keep the pedals in a car in place, so that the thieves can not press the pedals down.

(Bicycle) Pedal Lock:

This bicycle lock is made so that the peddles on the bicycle can be removed and then mounted on one of the wheels by looking the two peddles together around it.
(Parrack, 2012)

(Car) Wheel Lock:
- A wheel lock is designed to be mounted around one or more of the wheels on a car. With its shape it is constructed in a way that disallows the wheel to turn around unless ruining the rims and/or the the wheel casing.
- Some wheel locks even makes it impossible to remove the wheel from the axel.

(Jewelry) Traveling Cases for Jewelry:
- Traveling cases for jewelry is mainly used by jewelry sellers to transport the goods between their production and the shop(s). They are often featured with a simple locking mechanism in the form of a padlock or a number code

(Car) Keys Systems:
- Remote Keyless System / Remote Central Locking
There exists a variety of different key systems for cars. The most common car keys in modern times are a type of key system known as a Remote Keyless System (RKS), or Remote Central Locking. With a RKS key the users are able to remotely unlock their cars by pressing a button the key handle. The key transmits an encrypted code with a short range radio transmitter in the form of radio waves, which the car then picks up through the radio reciever and either unlocks or locks the car. The locking or the unlocking of the car is usually signaled through blinking lights and/or a sound.

- Transponder Key
Keys that require the user to manually put the key into the ignition are most often equipped with a transponder. When the key is inserted into the keyhole in the car and then turned, then the car sends an electronic message to the key and if it recieves the correct respond from the key only then can the car be turned on. (Wikipedia, 2016(A))

- Smart Key System
Some newer cars have also been installed with a hands-free technology which makes use of proximity sensors to unlock or lock the car. This kind of key does therefore not require the user to pull out their key in order to press an unlock button. The key is identified via one of several antennas under the car's cover and through the key's radio pulse generator present in the key. Some versions of it unlocks the car simply when you enter the proximity of it, others require the user to take a hold of one of the car's door handles before it will unlock the car. (Wikipedia, 2016(B)). (Wikipedia, 2016(C))

Car Wheel Lock

Traveling Cases for Jewerly

Break Lock

Break Lock + Chain

(Motorcycle) Break Lock:
ABUS Granit DetectoX-Plus 8077
This motorcycle lock is designed to lock around the brake discs of the motorcycle, which would cause the wheel and the brakes to be destroyed if it is not removed. Additionally the lock also comes with an alarm which activates immigiately when the lock is moved just a tiny bit. It also has an LED installed so that thieves can see there is a lock on it to scare them away.

The brake lock can be supplied with an additional chain that can be locked into the brake lock.(BikeBandit, 2013),

Sources:
replant (2012) How to use an anti-theft 'club' device. Available at: https://www.youtube.com/watch?v=JXiSZnhD6m4 (Accessed: 20 February 2016).

My Raslok (2013) Professional thieves break the lock. Available at: https://www.youtube.com/watch?v=Fd2Op5VpUrg (Accessed: 20 February 2016).

Parrack, D. (2012) Pedal lock secures, incapacitates your bike. Available at: http://www.gizmag.com/pedal-lock-bike-secures-incapacitates/23306/ (Accessed: 20 February 2016).

Wikipedia (2016)(A) 'Transponder car key', in Wikipedia. Available at: https://en.wikipedia.org/wiki/Transponder_car_key (Accessed: 20 February 2016).

Wikipedia (2016)(B) 'Smart key', in Wikipedia. Available at: https://en.wikipedia.org/wiki/Smart_key (Accessed: 20 February 2016).

Wikipedia (2016)(C) 'Remote keyless system', in Wikipedia. Available at: https://en.wikipedia.org/wiki/Remote_keyless_system (Accessed: 20 May 2016).

BikeBandit (2013) ABUS RS1 and detector 8077 locks on BikeBandit.com. Available at: https://www.youtube.com/watch?v=1zc1lrTYPbY (Accessed: 20 February 2016).

12 COWI ANALYSIS

Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation.

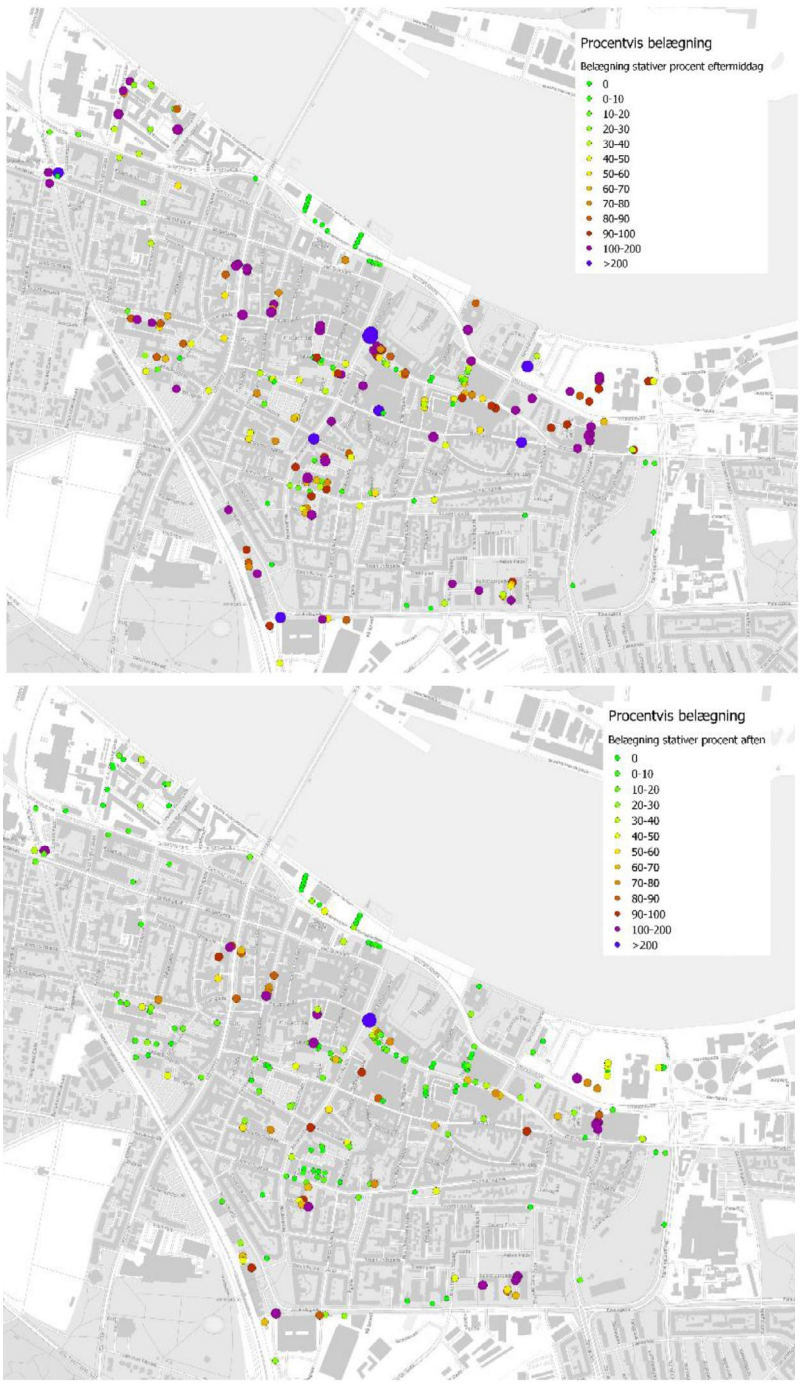
The report on bicycle parking in Aalborg city which was made by COWI they have found out where all of the existing bicycles racks are placed, how many parking spots they have, how filled they are and also where bicycles are parked that does not have a bicycle rack nearby. In the report COWI reports that the biggest clusters of bicycles that are not parked at a bicycle rack is at Utzon, Sallingen and the Trainstation.

It should however also be noted that many of the aalborg's bicycle racks are suffering from being overfilled with bicycles. Some of them reaching more than 200% ithan they are meant to store. The investigation into how many bicycles are being stored at the bicycle racks have been conducted both in the afternoon and the evneing. Depending on the time of the day there are either less or more bicycles, although many of the racks still appear to be filled with more bicycles than they are meant to store in the evening as well.

The investigation during the afternoon can be seen above, while the one conducted during the evening can be seen below.

As can be seen from the investigations, there especially appear to be filled with bicycles at Nytorv if compared to the actual available bicycle rack parking spots.

As can be seen from the investigations, there especially appear to be filled with bicycles at Nytorv if compared to the actual available bicycle rack parking spots.
The bicycle racks on the Nytorv are of a double-sided design with 20 stands in total, but even though there are 20 stands on each of the bicycle racks, there are still more bicycles present than can actually be in the stand and that is on a rainy Wednesday late afternoon. Given the high number of bicycles in these conditions there will most likely be even more bicycles during a summer day afternoon. Additionally the it appears as if only about 25% of all the bicycles placed at the stand on the picture about are actually using the bicycle rack to hold the bicycles.
Even though these bicycle racks are fairly new (2015), they are already starting to be in a bad shape with some of the stands already unusable.



13 FIELD OBSERVATION

Question 1: How long do you entind to park your bicycle here/how long have it been parked here?

Question 2: Have you experienced any problem with the bicycle racks in Aalborg?

Person	location	question 1	question 2
1	Nytorv	A couple of hours	no problems
2		1:30 hour, park sometimes here at night	no problems (had bicycle stolen 5 times)
3		1 hour	not enough parking space for bicycles
4		from 11:40 to 16:00 (4:20 hour)	no problems. At train station got a headlight stolen
5		45 min	the bicycle racks are slightly worn
6		5 min to a couple of hours	not enough parking spaces
7		5 min	no problems
8		a couple of hours	not enough parking space (parked at the side of the rack - locked to it)
9		1 hour	no problems
10		5 min	difficult to find a parking spot, have to look for it.
11		40 min	no parking space
12		40 min	not enough parking spaces
13	Algade(Salling)	8 hours	not parking spaces
14		15 min (bring the bicycle to every shop)	no enough space for bicycles
15		1 hour, sometimes longer	no problems
16		30 min	no problems
17		1 hour	not enough parking spaces
18		5 min	no parking spaces
19	Nytorv	1-1:30 hour	no problems
20	Nytorv	30 min	never uses the racks - not enourgh space
21		7 min	no problems - rarely use the racks

Person	location	question 1	question 2
22		30 min to a couple of hours	the racks are always full
23		10 min to a couple of hours	not enough parking spaces
24		5 min	places beside bicycle racks
25		1 hour	not enough parking spaces
26		5-10 min	no problems
27		15 min	no problems
28		5 min	the racks are always packed
29		10 hours, 5 times a week	no problems
30	Algade (Salling)	3 hours	not enough parking spaces. no good enough bicycle racks

Person	location	question 1	question 2
31	Aalborg Train Station	~ 15 hours (Lives in Holsterbro)	No problems
32	-	30 min or ~ 72 hours (Away in some weekends)	No problems
33	-	~ 60 hours (Visit parents/friends elsewhere)	Rarely uses them but no problems
34	-	~ 15 hours (Lives in Aarhus)	Have not experienced and problems.
35	-	48 hour to 120 hours	No problems
36	-	9 hours (Internship in Hjørring)	No problems
37	-	~ 60 hours (The weekend)	Have not experienced problems on the train station but heard about others in other places in the city.
38	-	11 hours	Someone has messed with her bicycle saddle and stolen her chain cover.
39	-	2 min to ~ 2 hours.	Heard from his mother than she has seen someone walk around with an angle-grinder.
40	-	15 min or ~ 60 hours (If going home to her parents.)	Heard that there is a lot of lights and such that gets stolen.

The results have been placed in a table and later deviede in a pie charth, this is done in order to gain a quick overview. The result form this test show that around Nytorv people manly only park for 5 to 15 min(35,5%), ussaly infornt of the pharmacy and across from the bank. When parking other places around Nytorv the ussaly park their bicycle for 30 min to 1 hour (25,8%) 1 to 2 hours (22,6%). People around Nytorv fround the lack of parking space a big problem(54%)

At Aalborg trainstation, people parked their bicycle for a longer period of time, where there where only 16,7% which was 0-30 min, the avarge amount of time was 2-15 hours (27,8%) and 24 to 60 hours (22,2%) It was expetet that people would be parking longer aournd the trianstation, but it was not expeted that they would park there longer then a work day. Also in the area there are a large amount of bicycle and that 69,2% haven´t experiance any problems is quit unexpetet.

14 FIELD OBSERVATION

The measurements were carried out at the creat building, because there were found a large amount of variations in bicycle types.

It was made sure to measure the most different types bicycle located, in the sceduele underneath the measurements are listed. Hights for, handlebars, saddle and wheel asweel as width for handlebars, wheel and pedals was measured.

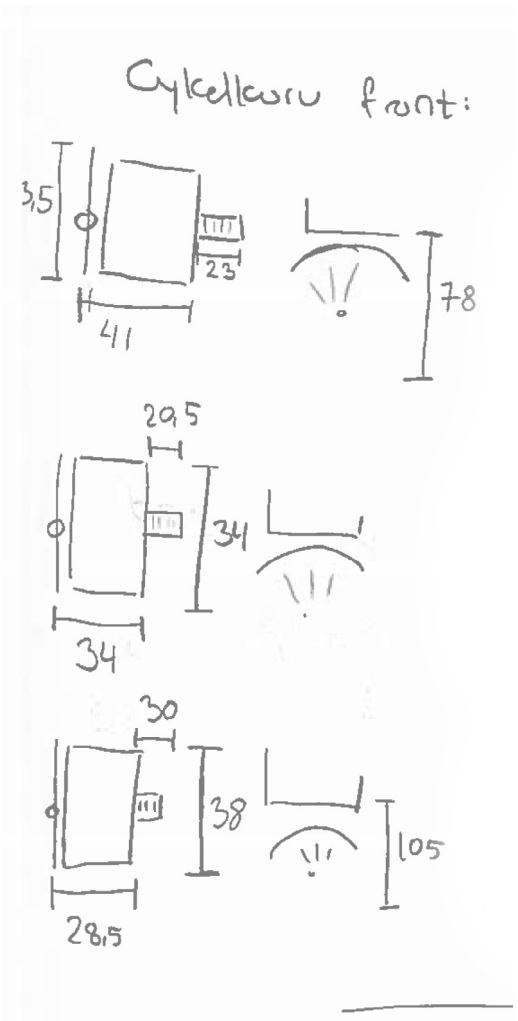
Height

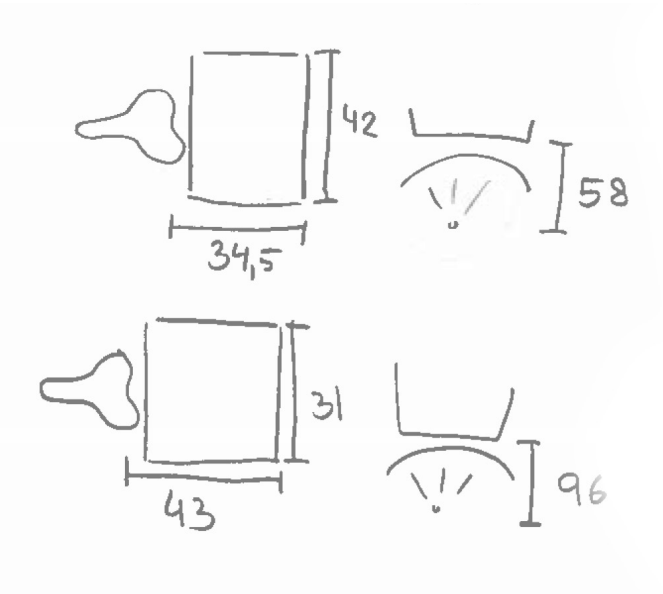
Bicycle nummer	Handlebars in cm	Saddle in cm	Wheel in inch
1	99,5	103	28
2	108	101	26
3	107	95	24
4	98	103,5	24
5	112,5	94	28
6	112	99	27
7	103	95,5	24

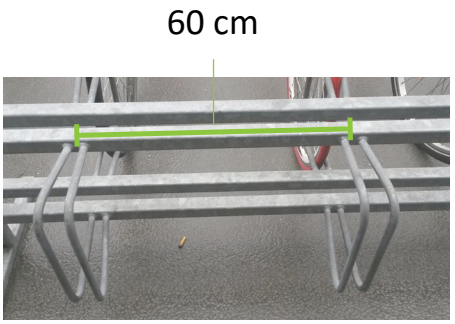
Width

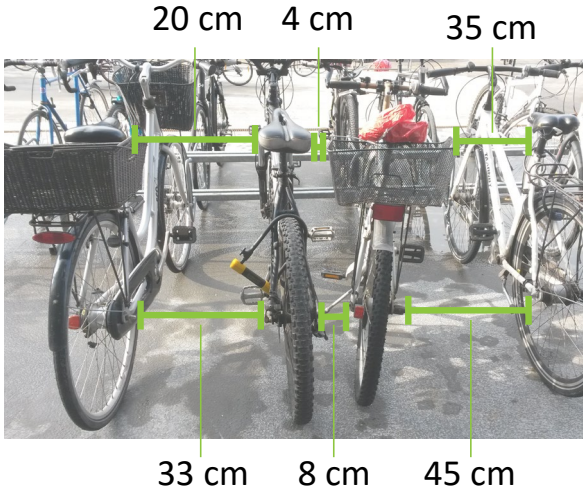
Bicycle nummer	Handlebars in cm	Pedals in cm	Wheel in cm
1	58	35	4,5
2	58	39	5
3	64	36	3
4	48	39	2
5	60,5	35	4
6	68	38	6
7	62	36	4

The different accessories placed on the bicycle was also measured. Child seat, front bicycle basket and back bicycle basket. Their measurements can be seen on the next page.


Cykelkorg front:
35
23
41
78
29,5
34
34
30
38
28,5
105


42
58
34,5
31
96
43

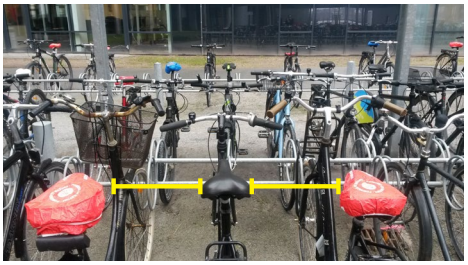

60 cm


20 cm
4 cm
35 cm
33 cm
8 cm
45 cm


19 cm
22 cm

15 USER FRIENDLY TEST

1.



2.

3.

4.

5.

TRADITIONAL BICYCLE RACK

1. The bicycle is parked in a traditional front wheel rack.

2. It can be seen how little space there is between each bicycle and that the bicycle handlebars is blocking the access to the bicycle rack.

3. It can be seen how uncomfortable it is to bent over the steering in order to lock the front wheel to the rack.

4. The handlebars can be seen rubbing against the stomach of the user.

5. At picture 5 it can be seen another difficult position, were in order to lock the front wheel to the bicycle rack the user have gone under the handlebars.

When locking the bicycle to the traditional bicycle rack it was found that can not be done without getting into uncomfortable positions, where the user need to stretch or bend their body in order to reach the rack.

1.

2.

3.

4.

5.

HOOP STAND

1. At Musikkens Hus in Aalborg there have been placed hoop bicycle stands that are formed as bicycles.

2. Here the bicycle was parked at a hoop stand, which already had a bicycle parked, this was chosen in order to simulate a normal situation.

3. Shows the most comfortable position when locking the bicycle to the hoop stand. In this case is was difficult, because the other bicycle frame was also leaning against the hoop stand.

4. The bicycle is locked to the hoop by the back of the bicycle frame, here the body is positioned in a more lean forward position in order to see.

5. The bicycle is locked to the hoop by the front of the bicycle frame. The body here also leans forward a little, but this is more comfortable than on picture 4.

   By having access to the bicycle from the side, makes it easier to lock the bicycle frame to the hoop stand without having to stand in difficult positions. It can however be discussed how good this hoop stand is when supporting the bicycle.

BICYCLE TREE

At Nordkraft and at Vesterå there have been placed these bicycle trees, which can hold four bicycle at a time.
The bicycle was first placed at the upper level which is only possible if you can lift your bicycle and if the bicycle frame is constructed to allow it to hang.
It was difficult to get the bicycle to hang correctly on the rack at first.

1. The bicycle is locked at the most comfortable body position with this rack. There the lock is here put around the bicycle frame and the hole in the rack.

2. The bicycle is locked onto the rack around the top of the frame. The body is stretching in order to reach around.

3. At picture 3 the bicycle is placed on the ground and locked around the top of the bicycle frame. Here the body is in a more neutral state.

These bicycle rack can force the user into uncomfortable body position, mainly when lifting the bicycle up over the head, as it could in some rare cases could end in injury, because of the weight of the bicycle and the cumbersomeness of the placement.

1.

2.

3.

1.

2.

3.

4.

5.

SAFETY RACK

At the back entrance for one of the department of Aalborg municipality, there are placed a safety bicycle racks.
They have two level of stands for the bicycle. The bicycle when placed at the lower level, is fairly easy to lift up, and not much force are needed to do so.

1. 2. In picture 1 and 2 the lock is placed at the top of the bicycle frame and is locked onto the bicycle rack's loop. This can be done with the body in a comfortable position.

3. Picture 3 shows the bicycle is placed at the higher level, this required a bit extra strength to lift the bicycle up.

4. 5. At picture 4 and 5 the bicycle is locked to the rack two different places during the high parking.
At photo 4 the user is slightly bent forward, while at photo 5 the user is in a more upright position.

6. These bicycle racks are placed with large space between them, which makes it easy to get to the bicycle and lock it correctly. Furthermore by using these bicycle racks the user did not need to place their body in any uncomfortable position.

6.

HOOP STAND 2

These hoop bicycle racks are placed at Friis, they are placed with a board even space between them, which makes it easy to place the bicycles up against them.

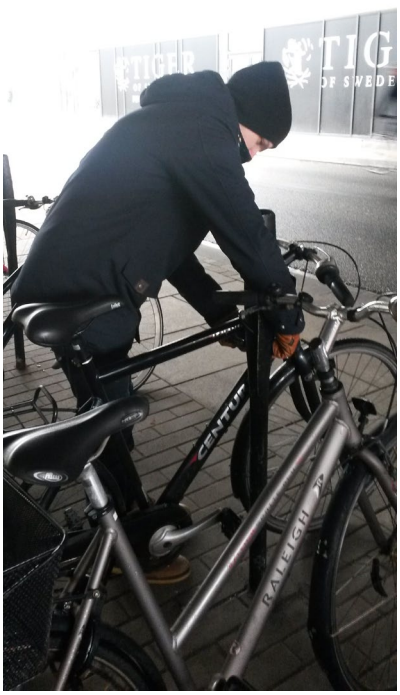
1. At picture 1, 2 and 3 the bicycle is placed up against
2. the hoop stand and the top of the bicycle frame is
3. locked onto the rack. By doing this the user is only slightly bent forward.

4. At picture 4 it can be seen some of the disadvantages by using this hoop rack, there is no support for the bicycle and therefore it is easy for it to tilt.

By using these hoop bicycle racks it is easy for the user to interact with the bicycle and the rack. No uncomfortable position was found for the user. But by using the hoop stand the bicycle is not supported in any way, as can be seen on picture 4, it is easy for the bicycle to fall over.

1.

2.



3.

4.

1.

2.

TRADITIONAL ANGLED RACK

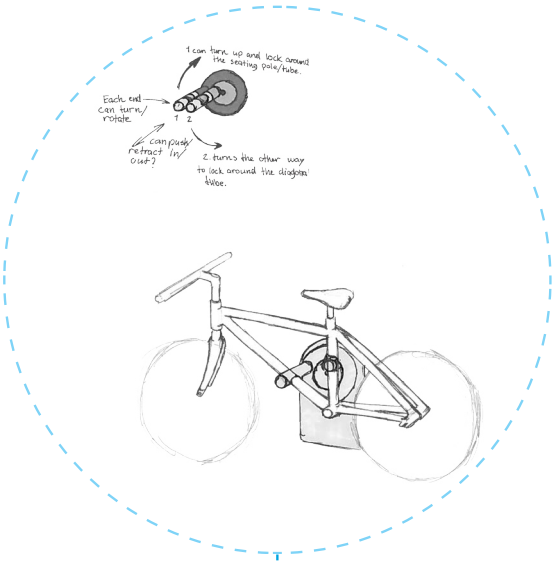
Placed on the other side of the one of the department of Aalborg municipality, are installed a type of traditional bicycle racks which is angled, when parking the bicycle in a angled position there should, in theory, be room for more bicycles and they do not take up much space of the sidewalk.

1. At picture 1 it can be seen that by using this rack it can be a problem to get it the bicycle placed, because the others bicycle handlebars can come in conflict with the user's.

2. At picture 2 it can be seen the same problem as with the traditional bicycle racks. Where the user need to bend over the handlebar in order to lock the bicycle safety.

By using these angled bicycle racks more space can be spared and there are room for more bicycles on a smaller place than with the traditional bicycle rack. But the it is still a problem for the user to lock the bicycle.

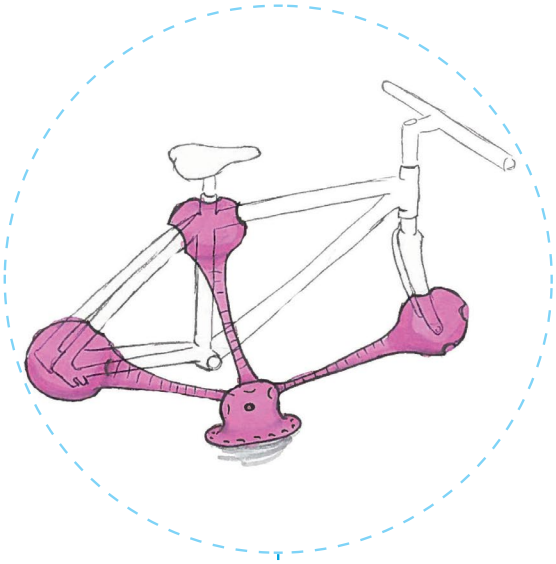
16 EVALUATION OF CONCEPTS



DEMANDS	
Lock around most city bicycls	5
Lock frame	5
Bigger then bolt cutter	5
maximum 42 sec	2
Parking space	2
Wheel Thickness	5
Wheel size	5

WISHES	
No uncomfortable positions	3
Durable	2
Operate witc objects	1
urban enviroment	1
Cumbersome for thieves	4

Total 44 points



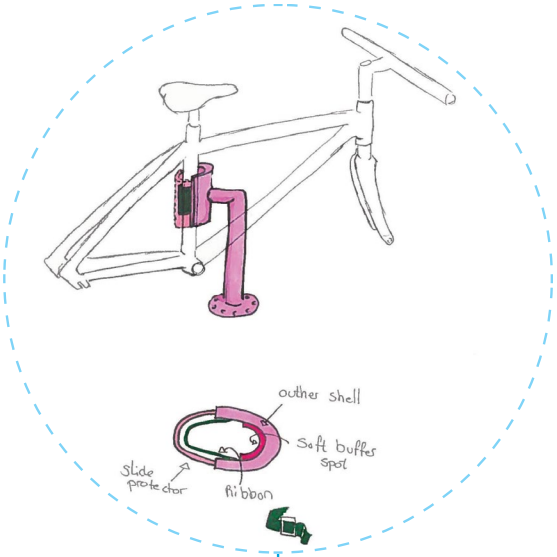
DEMANDS

Lock around most city bicycls	5
Lock frame	5
Bigger then bolt cutter	3
maximum 42 sec	2
Parking space	2
Wheel Thickness	5
Wheel size	5

WISHES

No uncomfortable positions	3
Durable	2
Operate witc objects	1
urban enviroment	1
Cumbersome for thieves	4

Total 42 points



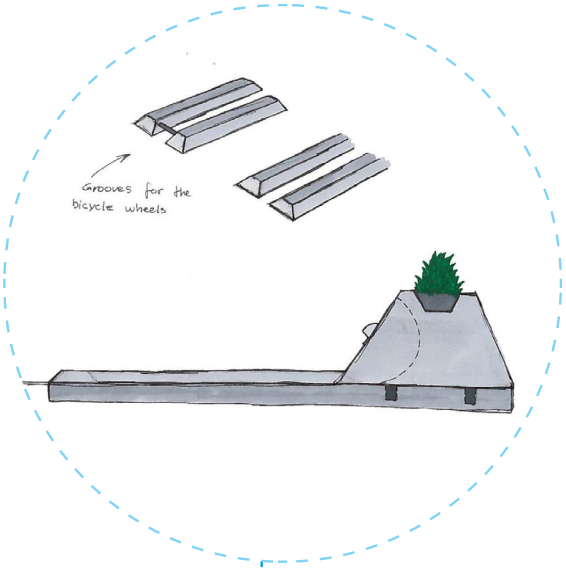
DEMANDS

Lock around most city bicycls	2
Lock frame	5
Bigger then bolt cutter	3
maximum 42 sec	1
Parking space	3
Wheel Thickness	5
Wheel size	5

WISHES

No uncomfortable positions	2
Durable	4
Operate witc objects	2
urban enviroment	1
Cumbersome for thieves	1

Total 38 points



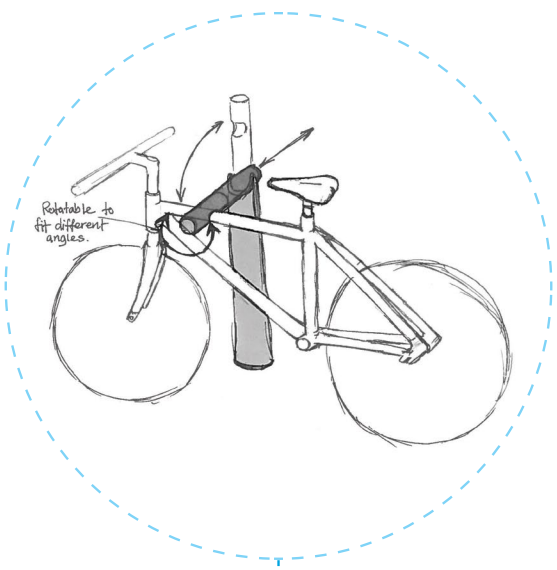
DEMANDS

Lock around most city bicycls	4
Lock frame	4
Bigger then bolt cutter	5
maximum 42 sec	5
Parking space	5
Wheel Thickness	3
Wheel size	2

WISHES

No uncomfortable positions	4
Durable	2
Operate witc objects	5
urban enviroment	1
Cumbersome for thieves	4

Total 51 points



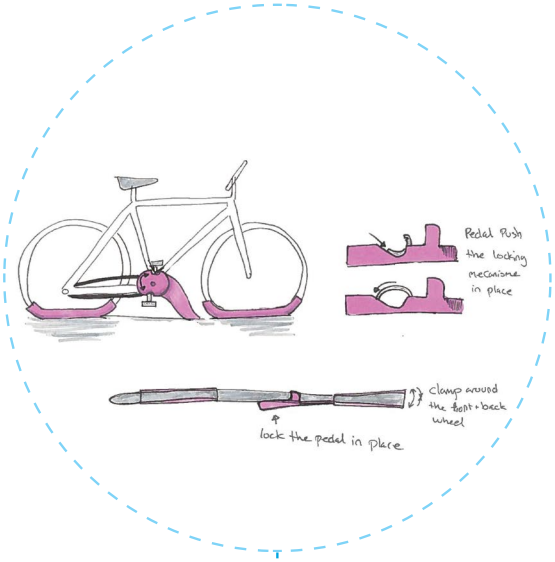
DEMANDS

Lock around most city bicycls	5
Lock frame	3
Bigger then bolt cutter	5
maximum 42 sec	4
Parking space	3
Wheel Thickness	5
Wheel size	5

WISHES

No uncomfortable positions	4
Durable	3
Operate witc objects	3
urban enviroment	1
Cumbersome for thieves	2

Total 47 points



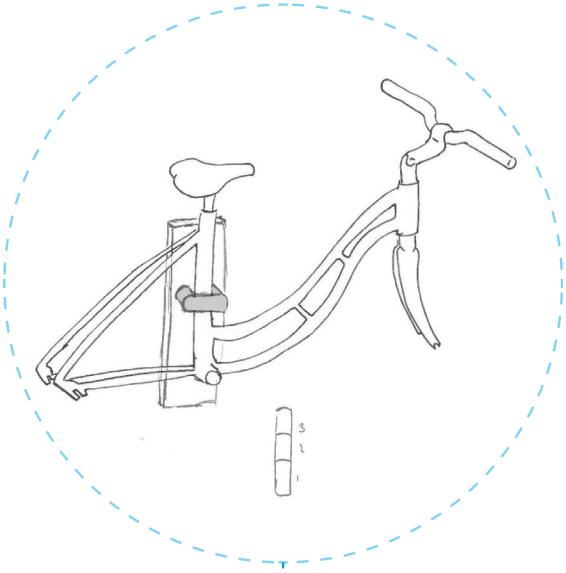
DEMANDS

Lock around most city bicycls	4
Lock frame	5
Bigger then bolt cutter	4
maximum 42 sec	4
Parking space	5
Wheel Thickness	3
Wheel size	5

WISHES

No uncomfortable positions	4
Durable	2
Operate witc objects	4
urban enviroment	1
Cumbersome for thieves	5

Total 50 points



DEMANDS

Lock around most city bicycls	4
Lock frame	4
Bigger then bolt cutter	5
maximum 42 sec	5
Parking space	5
Wheel Thickness	3
Wheel size	5

WISHES

No uncomfortable positions	4
Durable	2
Operate witc objects	5
urban enviroment	1
Cumbersome for thieves	4

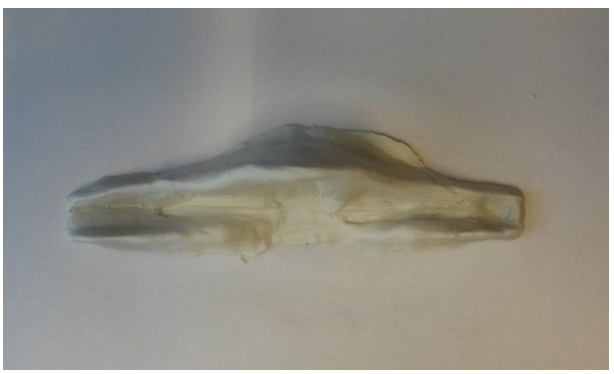
Total 40 points

17 FORM WORKSHOP

In order to have something to evaluate the bicycles with, two city bicycles models, male and female, were made. these was made out of cardboard and were made in scale 1:10.

Concepts

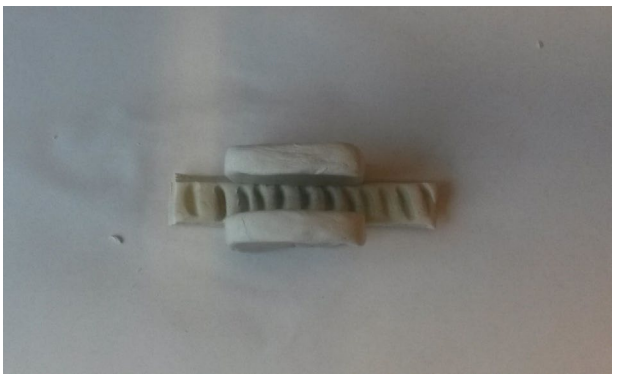
1. concept is a organic form which lock the pedals(on one side) and both wheel. The idea was that it should be made in fiber concrete.

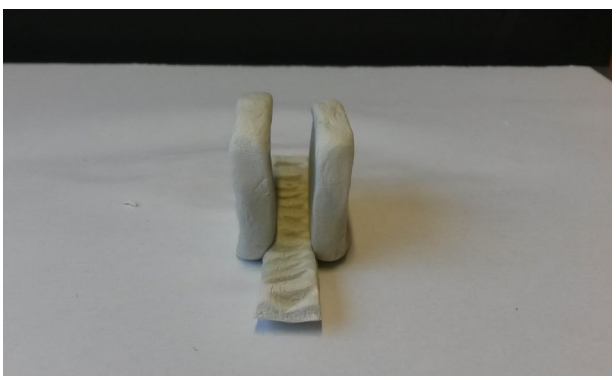


2. concept only locks around the pedals, but do it from both sides. There is no specific material for this, but it would be something so it can close around the pedals. It is possible for the user to slide the bicycle in between it.

3. concept is on same principal as 1 and 2, where the pedals will be locked. The idea is that you lift the front of the bicycle and the slide the pedals into the lock. Both sides are of equal hights. there are no chosen material for this.

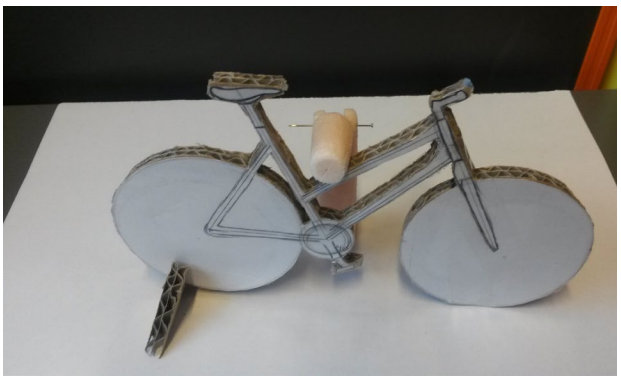
4. concept only lock the wheel. The ground is a conveyors belt, which makes it possible for the user rotate the wheel so the lock can get in between the spokes. This is a very lose concept, and therefor no material is thought into it.

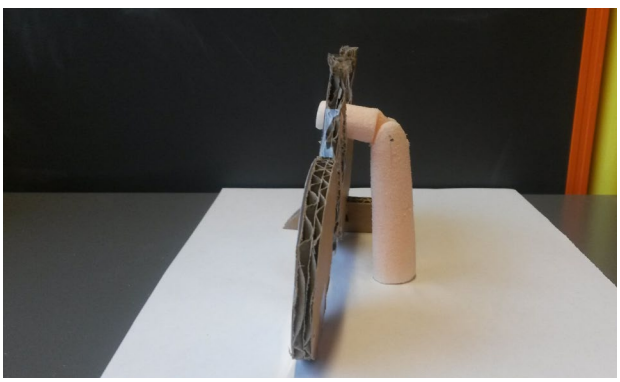


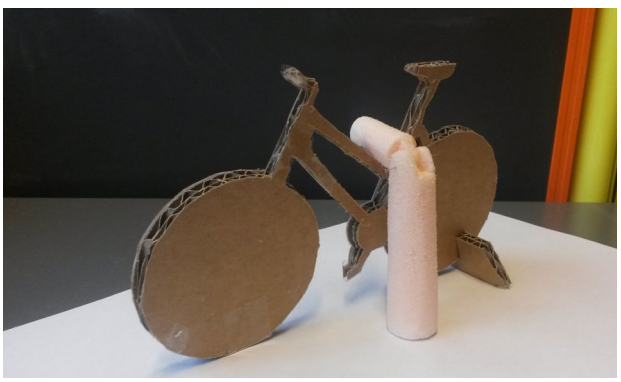


5. concept looks like a bollard, which can rotate the top in two direction. which makes it possible to lock both male and female city bicycles. This could be made of fiber concrete and some kind of steel.

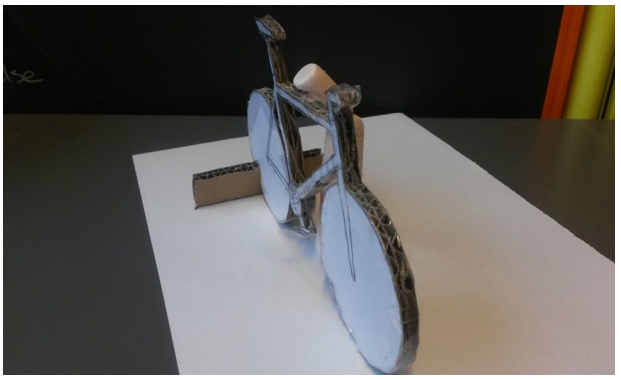
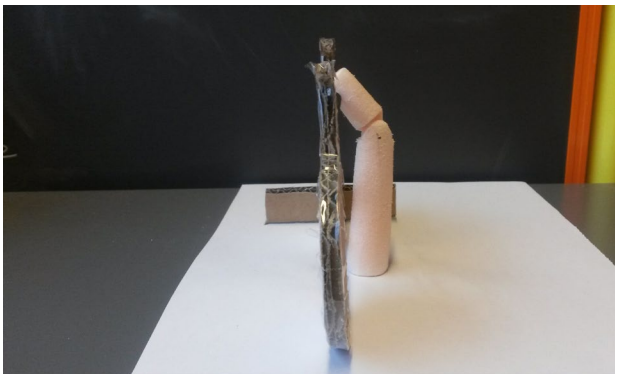
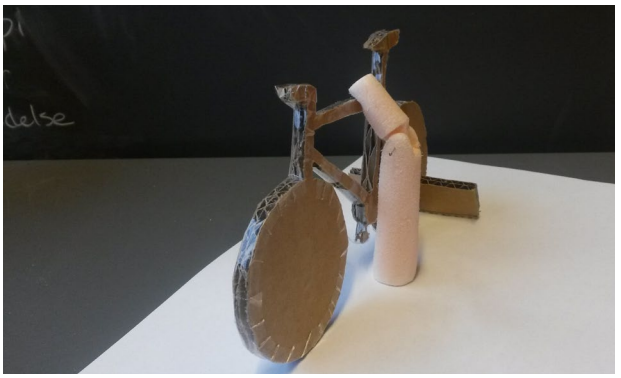
Here is concept 5 in the bend. First is shown the female city bicycle.





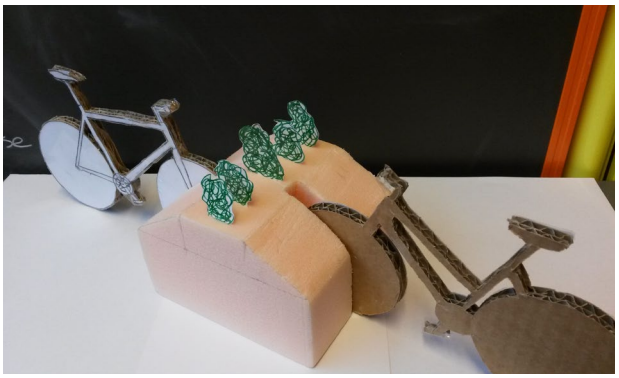
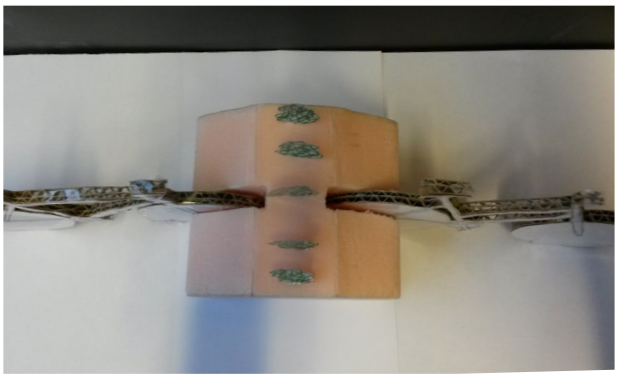


Male city bicycle with the 5. concept

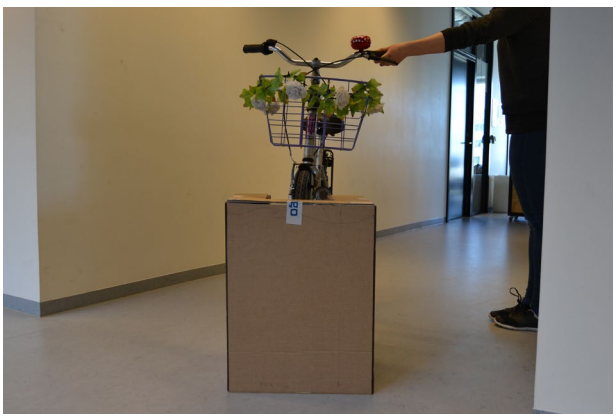
6. Concept is more solid then the others, and have a lock which grasp around the front fork of the bicycle. This is to made in fiber concrete, which some form of vegetation on top.



18 BODYSTORM WITH MODELS

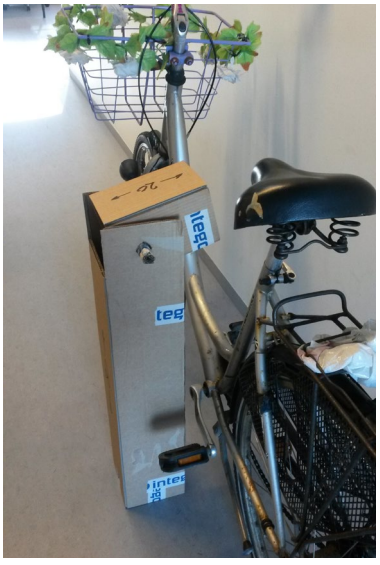
The first concept to be tested was the clam, this concept was made in a smaller sample then the original, but it was still possible to get an understanding of the user feeling. It was evaluated that the concept was easy to use, bit there where doubt if it would damage the front wheel and the front fork.



The next concept was Turning Tower, here bottom parts and top parts where made in different measurements in order to test what hight the different parts should have. As can be seen on the photo, the models all have different measurements. Bottom parts have the measurement: 400 mm, 600 mm and 800 mm. The top have the measurements: 200 mm, 400 mm and 60 mm. These measurements was chosen in order to get the most variety.

The first model to be tested was bottom 800 mm and top 200 mm. s can been seen, it could not reach the bicycle frame on the male city bicycle.

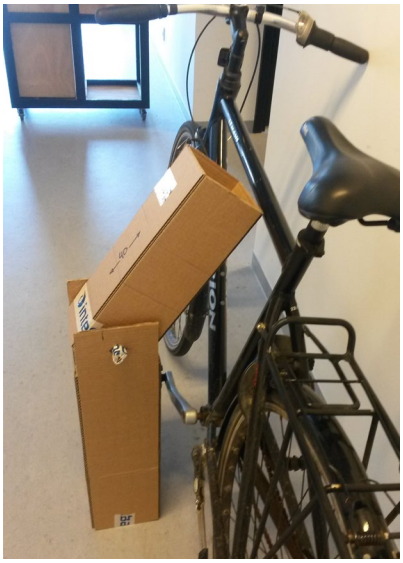
It had could not reach anything on the female city bicycle.



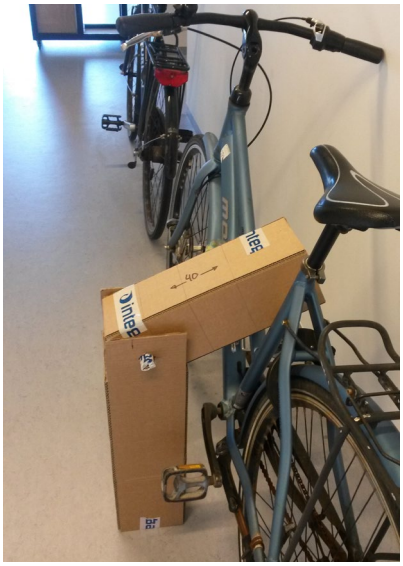
On the old lady city bicycle, there was nothing that the model could reach.

Conclusion:
The bottom (800 mm) have a comfortable height, when you need to operate it. The problem is that the top is not long enough in order to interact with any of the bicycles.

The second model was bottom 600 mm and top 400 mm. at this the top was not large enough in order to reach the top frame of the male city bicycle

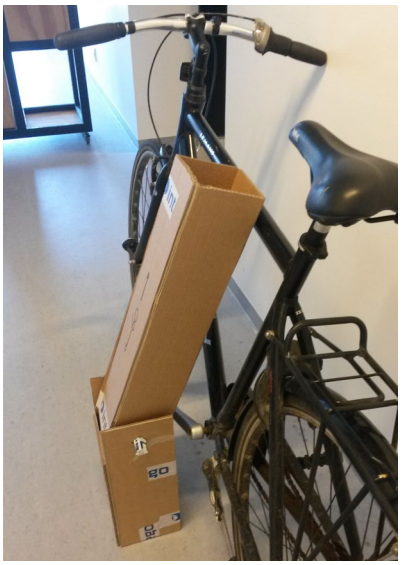


At the female city bicycle, the top was long enough to reach the top of the frame.



the old lady city bicycle, the model could not get low enough in order to reach the frame, but maybe it could react the saddle frame.

Conclusion:
600 mm is still a comfortable heights for the bottom, and the 400 mm top is not to long and unhandy to operate. it did however not fit on the male city bicycle, there for other combination need to be tested.



The third model was bottom 400 mm and top 600 mm. This combination was used in order to see if it would be easier to operate. It was not, by placing the turning so low, it was very unhandy.
This is so far the only model which reach the male city bicycles frame.

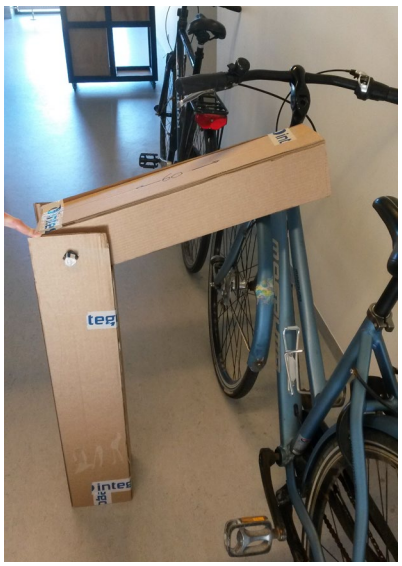
Which this model it is also able to lock the female city bicycle, only the locking would need to be placed two places.

At old lady city bicycle the model could also reach the frame. The problem is that hold on to the frame this low could end in the bicycle falling over.

Conclusion:
By using this model combination it was able to reach all the bicycle frames, unfortunately this model would need to have three locking holes or the three bicycle would need to be placed farer away from the model.

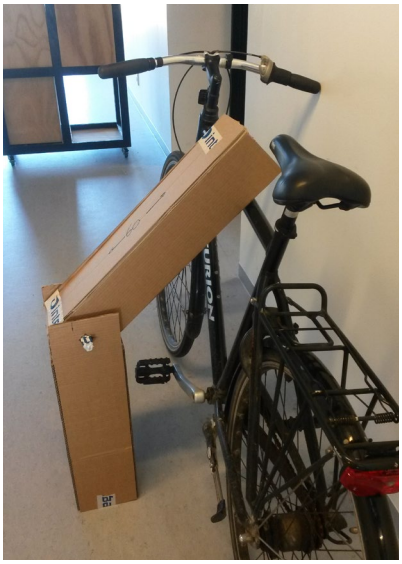
The fourth model was bottom 800 mm and top 600 mm. This was tested in order to see if a bigger model would be more user friendly.

This model was to big and could not reach the frame on the female city bicycle, this would only be possible if the top could rotate further down.



It was not possible for the model to reach the frame on the old lady bicycle. Even it the top could rotate further down, the bicycle would stand very unstable

Conclusion:
This combination was a not a success, it was very big and clumsy. Furthermore it could not reach the female and old lady a bicycles frames. Also by having such a big top, the model was in imbalanced and difficult to use



The the fifth model and last, was bottom 600 mm and top 600 mm. It could easily fit onto the male bicycle frame.

Here it was also possible for the model to reach the female bicycle frame. But it connected further in on the top piece.

Here the model could not reach the bicycle frame, but concept is that in the end of the top there should be a rotary head, which would make it possible for the top to lock onto bicycle seat frame.

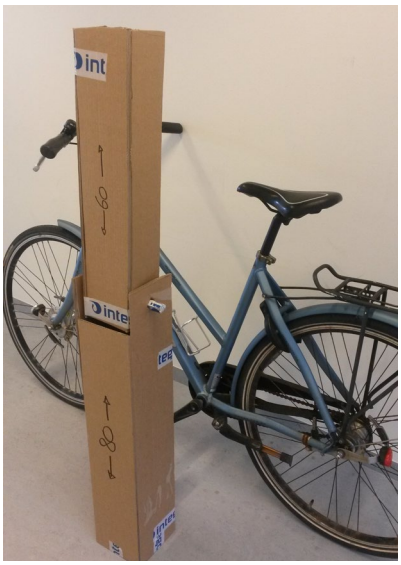
Conclusion:
This model was one of them where it would be possible to reach all three bicycle frames. The only problem would be that the bicycles need to be places in three different distances in order to lock them correctly.

A heigth scale was also done in order to get a impression on how tall the concept would be.

this repecent models:
- bottom 600 mm and top 400 mm
- bottom 400 mm and top 600 mm
- bottom 800 mm and top 200 mm

they are all the same hights, which is 1000 mm

This is the bottom 800 mm and top 600 mm. This model is 1400 mm high.



This is the bottom 600 mm and top 600 mm. This model is 1200 mm high.

Conclusion:
It was chosen, based on the tests, to work further with the model bottom 600 mm and top 600 mm. This model would be made so it was possible for all the bicycle types to fit. Furthermore the model in full heights is not to tall, that it make it difficult to maneuver around and not to small for not be able to see it. The model have a comfortable heights in order to interact with.

This concept is a development of the original Turning Tower, here is was chosen to place the lock on a arm, which would swing in onto the bicycle frame, which is the saddle frame where all bicycle have the same diameters.

By locking around the saddle frame the bicycle is parked more stable then is the arm was supported any other place on the bicycle. it was chosen to work further with this concept.

19 LOCK CONCEPTS

Concept 0:
Pros (80mm diameter arm):
- Simple motion.
- Few components
- Aesthetically nice.
- Hard to break open.
- Circuit for alarm

Cons (80mm diameter arm):
- Not enough space for bicycle frame
- No control over lock movement.

Pros (100mm diameter arm):
- Enough space for the frame (50mm room)
- Simple motion.
- Few components
- Aesthetically nice.
- Hard to break open.
- Circuit for alarm.

Cons (100mm diameter arm):
- Clumsy appearance and usage.
- Difficult to rotate/turn arm.

Concept 1:
Pros:
- Controllable lock movement (mechanical solution).
- Simple blocking of lock.

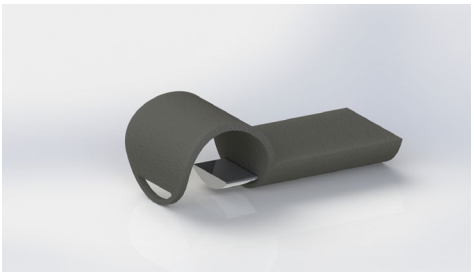
Cons:
- Requires a lot of space.
- Requires extra cuts for the lock rotation outwards.
- Damage to bicycle frame?
- No circuit for alarm.
- Possibly able to bend/break apart from each other.

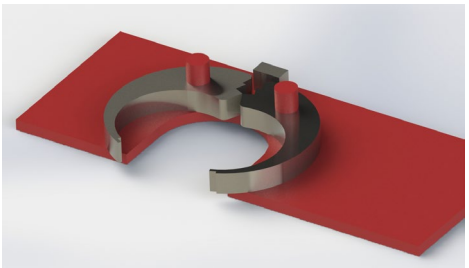
Concept 2:
Pros:
- Controllable lock movement (mechanical solution).
- Simple blocking of lock.

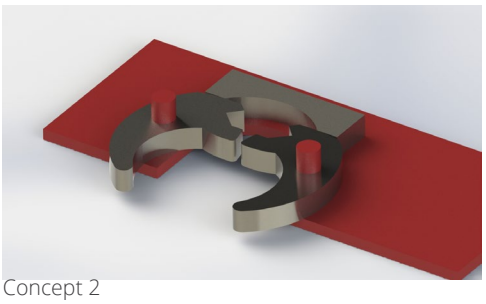
Cons:
- Damage to bicycle frame?
- Requires extra cuts for the lock arms.
- No circuit for alarm.
- Possibly able to bend/break apart from each other.

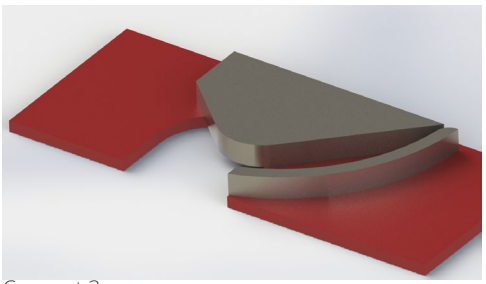
Concept 3:
Pros:
- Rotation gives extra space compared to straight movement of the lock.
- Control-able lock movement (mechanical solution).

Cons:
- Requires a lot of space.
- Requires oblique movement to activate lock.
- Might hit the bicycle frame.
- Might intervene with itself.


Concept 0

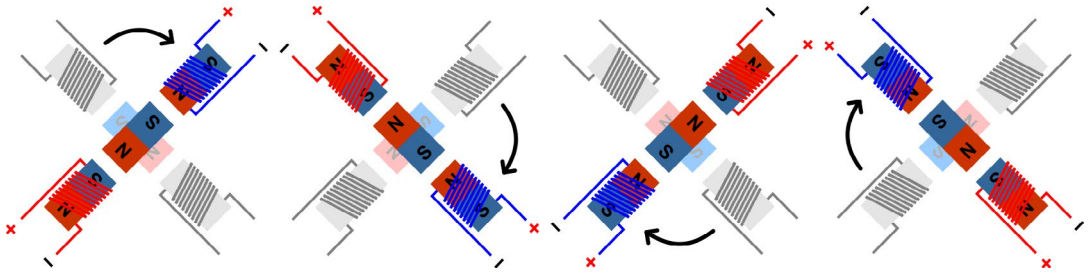

Concept 1


Concept 2

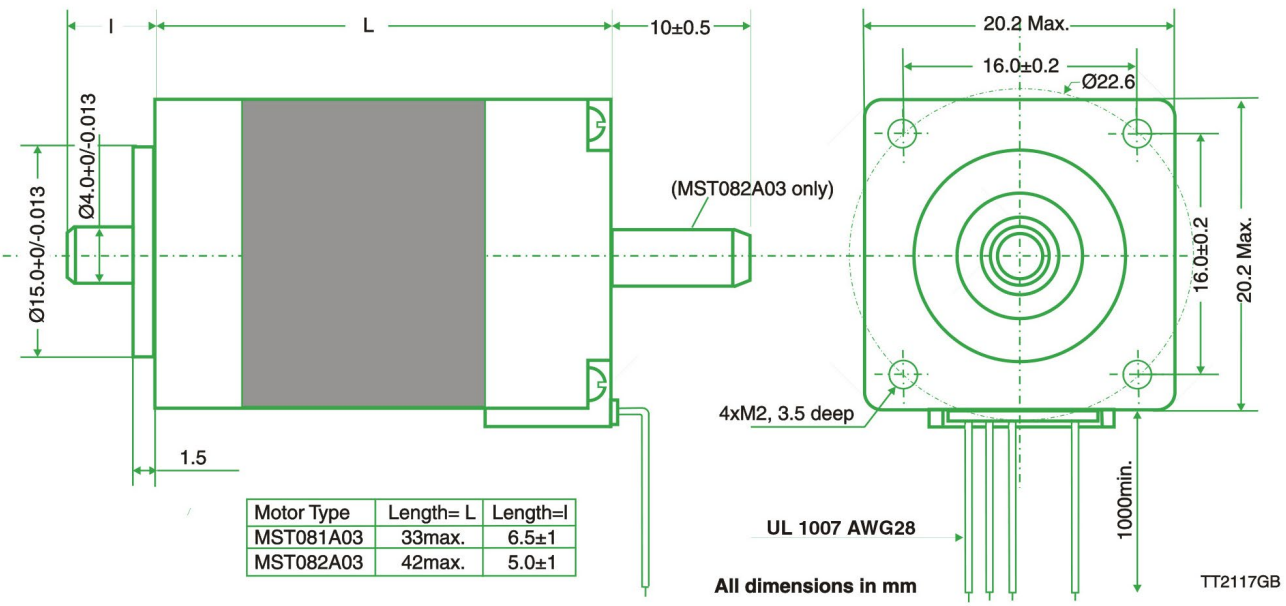

Concept 3

20 LOCK CONCEPTS

Illustration there show the principal behind the stepper motor.



Data sheet over the stepper motor, stepper motor MS-T081A03.
Source: JVL Industri Elektronik (2016) *Mini Stepper motors MST081A03 and MST082A03 from JVL industri.* Available at: http://www.jvl.dk/345/mini-stepper-motors (Accessed: 5 May 2016).



Motor Type	Length= L	Length=l
MST081A03	33max.	6.5±1
MST082A03	42max.	5.0±1

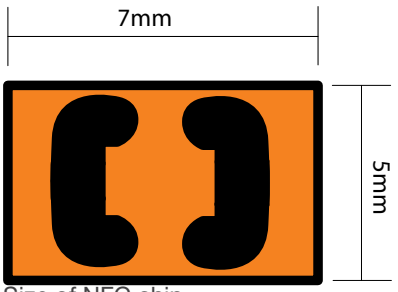
General specifications			Electrical specifications		
	MST081A03	MST082A03		MST081A03	MST082A03
Step angle	1.8 Deg±5%		Rated voltage	3.9V	4.32V
Number of phases	2		Rate current	0.6A	0.8A
Insulation resistance	100Mohm Min. (500VDC)		Resistance per phase	6.5±10% ohm	5.4±10% ohm
Insulation class	Class B		Inductance per phase	1.7±20% mH	1.5mH±20%
Rotor inertia	2.0 gcm²	2.6 gcm²	Holding torque	18 mNm	30 mNm
Weight:	65 grammes	85 grammes	Detent torque	gcm	gcm

21 TRAVEL CARD TECHNOLOGY

Inside the travel cards/rejsekort is a NFC chip, as can be seen on the illustration 1. Connected to it is a antenna. When the travel card gets near a NFC reader, the NFC chip gets power and sends information to the reader, the reader then sends that information to a data processing device, see illustration 2. The NFC technology is based on the RFID, and work the same although RFID readers can reach longer then NFC readers.

In Turning tower there will be a need to have a NFC reader, which will be connected to a data processing device, which will be located outside of turning tower. When the data from the Data processing device have confirmed that a travel card is being used, it shall send a signal back, which activate the locking system, and turn off the light in the Turning tower.

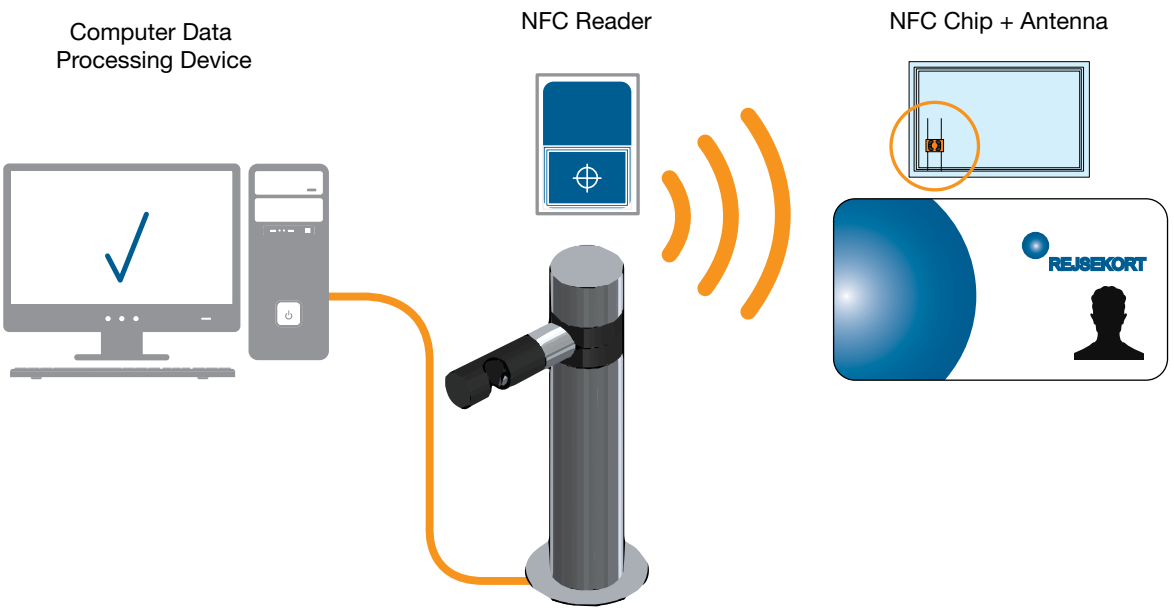
Thrasher, J. (2013) RFID versus NFC: What's the difference between NFC and RFID? Available at: http://blog.atlasrfidstore.com/rfid-vs-nfc (Accessed: 10 May 2016).



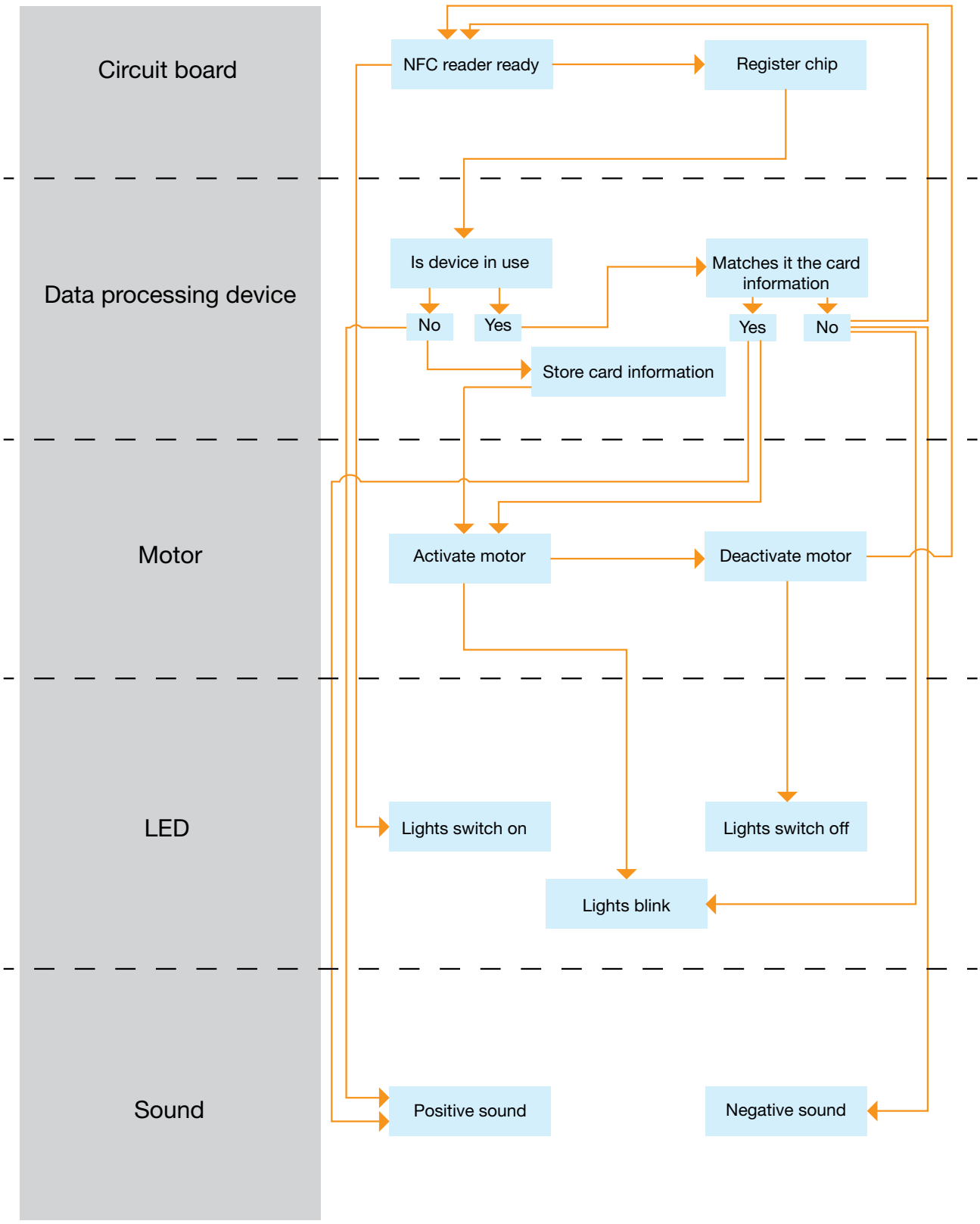
Size of NFC chip

Illustration 1

Illutration 2



22 FLOWCHART



23 POWER CALCULATION

To calculate Watt ohm's law is used.

In order to find out how much watt a diode LED use, a example was taking on similarity of what is used in the Turning Tower (Diode Online, 2006).

The example is taken from the blue and the with diode. Voltage is 3,5V and the current is on 0,025A, therefore

3,5V*0,025A= 0,0875 Watt

The NFC reader have a voltage on 2,8 to 5V, in this calculation the 5V will be chosen, in order to find maximum power needed. The NFC reader have a current on 0,05A.
5V*0,05A= 0,25Watt

The Speaker uses 0,25Watt (Sparkfun, 2015).

This gives the components on the circuit board a total of 0,5875Watt.

Source:
Dioder Online (2006) *Dioder-Online.Dk*. Available at: http://www.dioder-online.dk/1-8mm-lysdiode.html (Accessed: 15 May 2016).

Sparkfun (2015) *Speaker - PCB mount*. Available at: https://www.sparkfun.com/products/10722 (Accessed: 15 May 2016).

24 FRAME MEASUREMENTS

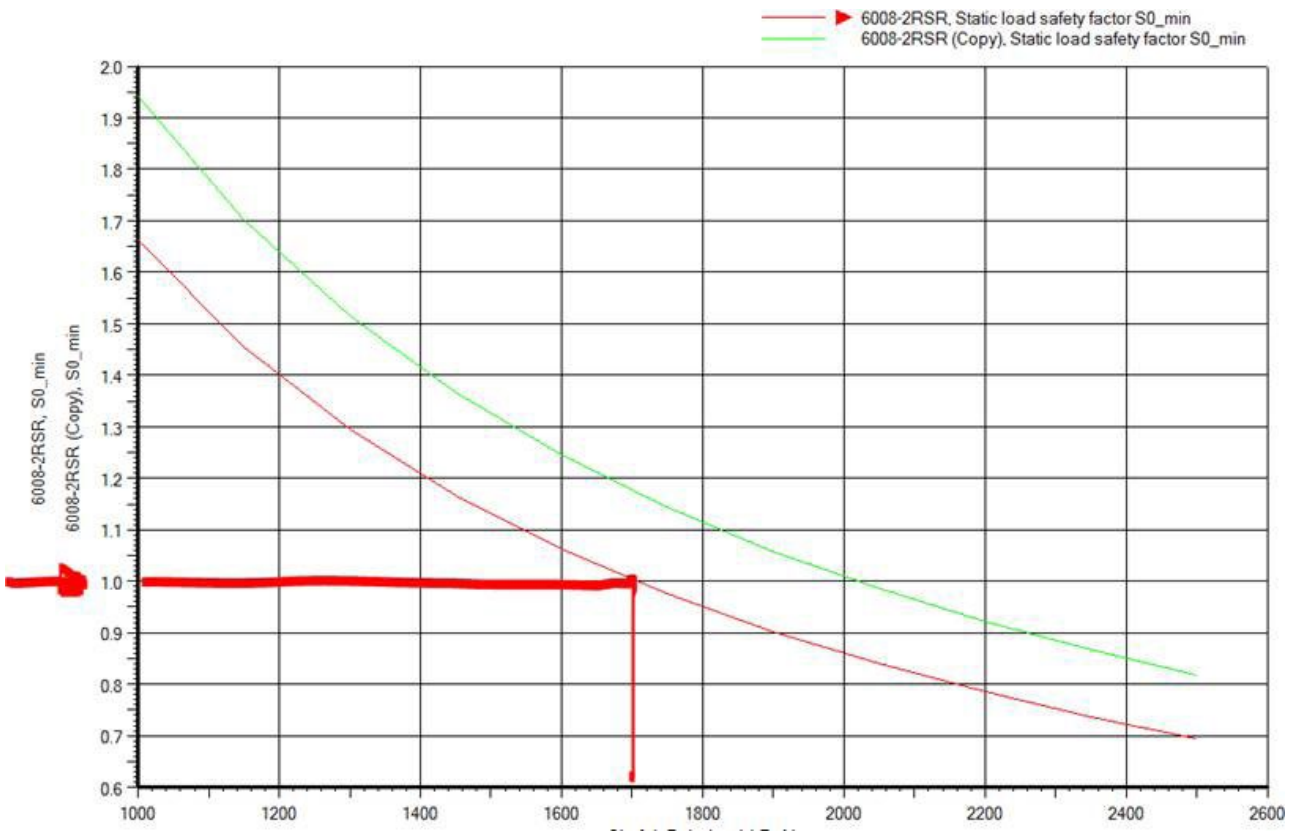
25 bicycle was measuremt, from the ground up to the point on the saddle frame were there would be most room for our lock. There next the frames diamention was measuret.

hights in mm	width in mm
620	30
630	30
610	35
630	35
620	40 x 35
640	30
650	30
620	35
640	55 x 30 (pump)
630	35
650	40
610	35
660	35
600	40
580	30
630	35
670	30
630	50 x 35
630	30
600	65 x 45
620	45 x 35
570	35
600	65
650	40 x 30
660	35
620	35 (bottle carrier in the way)

The average height, based on this investigation, is 625mm. The majority of the diameters is 35mm.

25 BALL BEARING CALCULATION

A correspondent have been made with Henrik Grøn from Schaeffler. He suggested that we choice ball bearings 6008-2RSR. underneath is the strength calculation of the ball bearing.



26 TOLOK COST

Production cost

Salary for person operation molding	**no. of people**	**Time to solidify (sec.)**	**Parts produces per hour**	**Salary**	**Salary cost per product**
Production	5,00	60	0,12	715	DKK 6.128,57
Salary for person assembling		**Time for assembling (Sec.)**	**Products assembled per hour**		
Turning Tower	3	18000	0,20	143	DKK 715,00
Material price	**Material**	**Mass(g)**	**Material price(kg)**	**Material price(g))**	**Price per part**
Rubber socket	TPE	0,28	DKK 131,57	DKK 0,13	DKK 0,04
Nylon ring	PE	0,22	DKK 26,31	DKK 0,03	DKK 0,01
Rint holder	ABS	0,72	DKK 19,74	DKK 0,02	DKK 0,01
Steel parts	Stainless steel	70000	DKK 32,89	DKK 0,03	DKK 2.302,30
Molds (plastic parts)			**Mold cost**		**Price per pcs**
Print holder			80.000,00		DKK 44,13
Rubber socket			80.000,00		DKK 44,13
Nylon rings			80.000,00		DKK 44,13
molds (metal parts)					
Arm lid			80.000,00		DKK 44,13
Holder 1			80.000,00		DKK 44,13
Holder 2			80.000,00		DKK 44,13
Price in total DKK					**DKK 9.410,71**

INVESTMENT

Project budget

2 man full time for a year, a year = 1,900 hours. Hourly 500kr. / Hr)	
Salary	kr. 1.900.000
Approvals/test	kr. 800.000
Prototypes / materials	kr. 700.000
2 man full time for a year, a year = 1,900 hours. Hourly 500kr. / Hr)	
Outsourcing of application development	kr. 1.900.000
tools	kr. 900.000
Other expenses	kr. 200.000
In total	kr. 6.400.000

Product coverage

Retail price	kr. 17.645
Tax (25%)	kr. 3.529
Retail price without tax	kr. 14.116
Sales price (Company)	kr. 14.116
Coverage (Company 50%)	kr. 14.116
Cost price	9.410,71

Break even

	Number of people	Percentage of potential	Estimated costumers
Potential costumers (DK)			
Aalborg hospital	7000	8%	560
Aarhus municipality	540	100%	540
Copenhagen metro ring	300	100%	300
Aalborg Eternitten	300	8%	24
Aalborg train/Nytrov	630	8%	50,4
Aalborg municipality	5000	100%	50000
In total			474,4
			6474,4
BUDGET			
	1 year	**2 year**	**3 year**
Percentage of customers who buy the product	5%	8%	15%
Products	324	518	971
Price	DKK 14.116	DKK 14.116	DKK 14.116
Cost price	DKK 9.411	DKK 9.411	DKK 9.411
Revenue	DKK 4.569.651	DKK 7.311.442	DKK 13.708.954
Cost	DKK 3.046.434	DKK 4.874.295	DKK 9.139.303
Contribution margin	DKK 1.523.217	DKK 2.437.147	DKK 4.569.651
Break even Analysis			
Investment	DKK 6.400.000	DKK -4.876.783	DKK -2.439.636
Coverage	DKK 1.523.217	DKK 2.437.147	DKK 4.569.651
Remaining	DKK -4.876.783	DKK -2.439.636	DKK 2.130.016
Profit	**DKK -4.876.783**	**DKK -2.439.636**	**DKK 2.130.016**
Rate of profit	**-76,2%**	**-38,1%**	**33,3%**

ARKITEKTUR & DESIGN