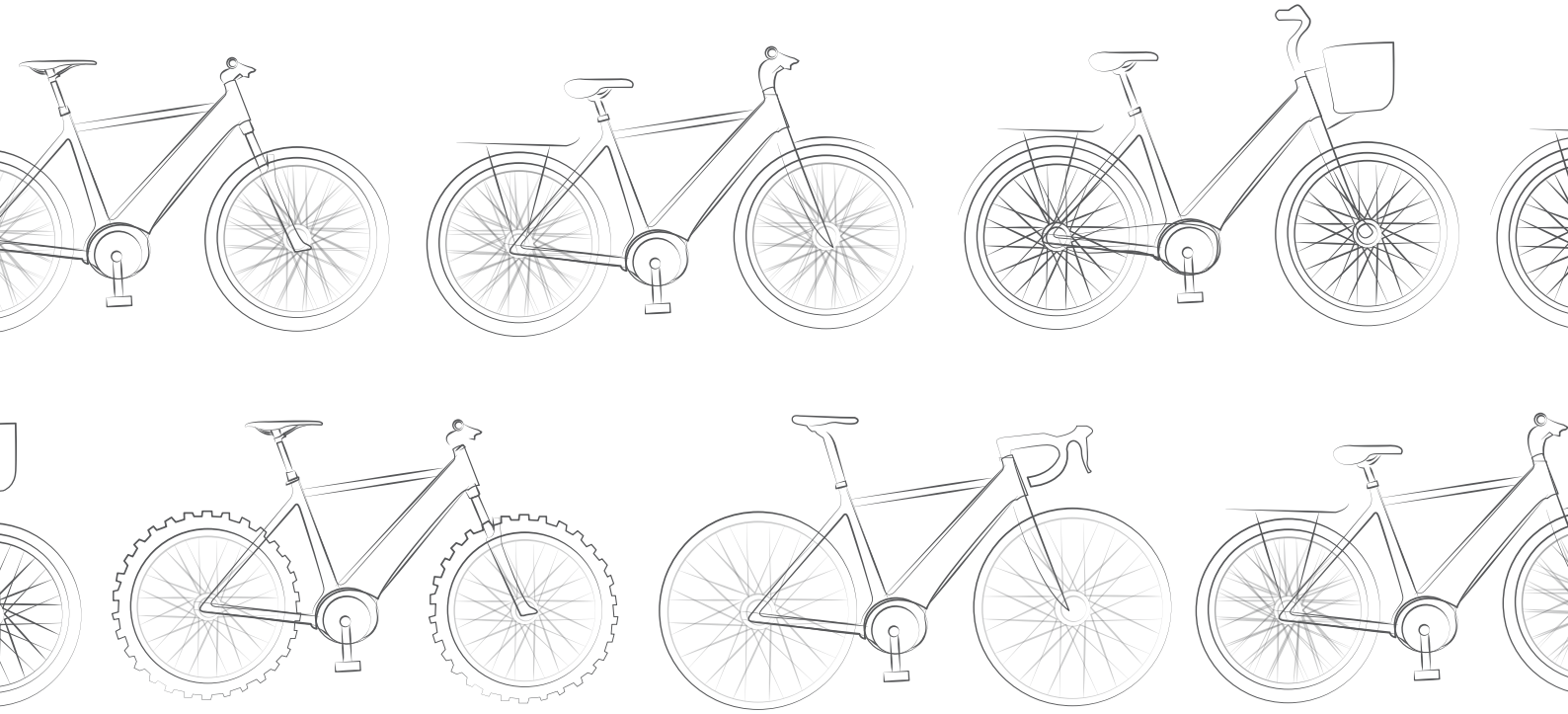

CANVAS

Process report

MSc04- ID1 June 2022

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Title sheet

Industrial Design

Aalborg University

Master Thesis in Industrial Design

MSc04 - ID1

Process Report

01/02/22 - 25/05/22

Supervisor:
Christian Tollestrup

Technical supervisor:
Brian Lau Verndal Bak

Pages: 89 excl. front and back

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Abstract

Dette projekt er udarbejdet af en gruppe afgangsstuderende på kandidatuddannelsen Industrielt Design på Aalborg Universitet i løbet af foråret 2022. Projektet omhandler udarbejdelsen af 'Canvas', der er en produktplatform for elcykler, der gør det muligt for brugeren at tilpasse cyklen efter sine egne behov på tværs af de gængse cykelkategorier, City bike, klassisk cykel, Mountain bike, Hybrid cykel og Racercykel. Oprindeligt udsprang projektet i et ønske fra cykelproducenter om en modulær cykelopbygning for at simplificere produktionen, men ændrede framing til at fokusere mere på brugeren.

Fokus under projektet har været at lave et cykelstel, der æstetisk fungerer i forskellige sammenhæng med cyklens resterende komponenter. Dertil er udarbejdet interaktionsflader, der muliggør tilkobling af forskellige komponenter, såsom motor, batteri, hjul, sæde og styr.

Projektet er baseret på desktop research og ekspertviden omkring cykelindustrien samt tests, mock-ups, interviews og undersøgelser foretaget af gruppens medlemmer. Denne rapport giver læseren en gennemgang produktudviklingen og tilblivelsen af Canvas.

Acknowledgement

Throughout this project supervisor Christian Tollestrup and co supervisor Brian Lau Verndal Bak has been a great help for support and guidance. For that, they deserve a great thanks.

Additionally, a great thanks goes to CTO of Butchers and Bicycles, Morten Mogensen, who have been used as an extern supervisor with knowledge from the bicycle industry, and Professor John Rasmussen from Aalborg University, who helped understand muscle optimization of bicycles.

Reading guide

The following project is reported in three parts: Product report, process report and technical drawings. The process report is structured to be transparent and give the reader an insight into the design process. The sections of the process report are primarily divided into three parts: purpose, study, and conclusion. 'Purpose' tells why the study is done, 'study' tells how it has been done and the results of it, and a 'conclusion' which points to the most important findings.

Throughout the report, important section or pointers are highlighted with the following icons:

Circles around image or text to indicate that this is selected from the various options.

Marks partial conclusion on the previous section.

Highlights supervision, milestones or recapitulatio.

Exclamation marks marks an important point that has an impact on the rest of the project.

Checkmark indicates that a requirement or wish has arisen for the final product proposal.

Definitions

The words mentioned below are used throughout the report. The definition of these words are explained, to reach a common understanding:

High performance: Developed for special scenarios with unique requirements.

Butchers and Bicycles: A company that develops cargo bicycles based on the user's needs.

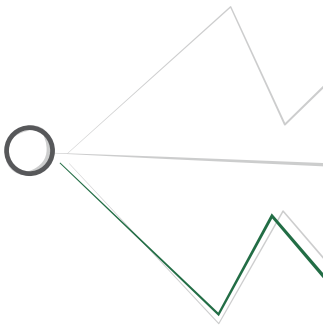
A to B bicycle: A bicycle primarily used as transportation

Table of contents

Introduction

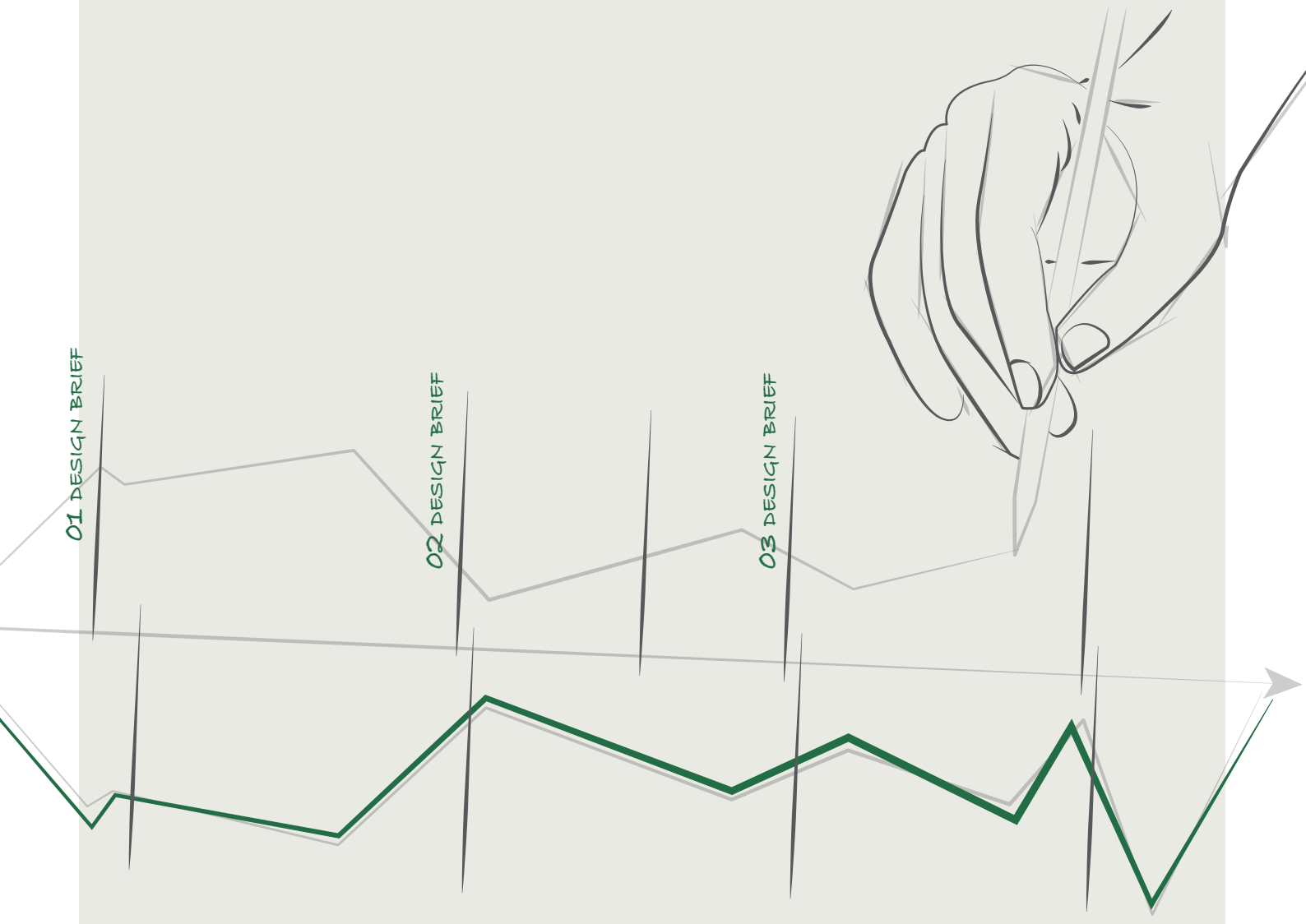
The bicycle industry is a growing market internationally, with countries like Denmark, the Netherlands and Germany as leading nations. A trend is seen across larger European cities to change the infrastructure to be more centered around bicycles instead of cars. This is heavily fueled by the rise of electric bicycles and the awareness of climate changes. Thanks to electric bicycles people now can get around long distances while getting a bit of exercise and not sweating too much, without burdening the environment. People are therefore becoming increasingly more dependent on their bicycles in everyday life and are more aware of their individual needs for the bicycle. In some cases, these individual needs exceed what is available for standard bicycle types and must modify their bicycles to fulfill their needs. Meeting those individual needs are also a challenge for the bicycle industry that must develop more bicycles, which are a long and expensive process for each new bicycle frame that must be designed and tested.

The focus of this project has therefore been to develop a solution that gives the user the opportunity to customize their bicycle to their needs, while keeping the production and development process to a minimal. This resulted in the product proposal Canvas. Canvas is a product platform existing of a bicycle frame that can be fitted with a limited selection of different wheels, motors, and other components to meet individual user needs. This could be the ideal solution for producing individual electric bicycles.



00 SCOPE

The following section provides insight into the project's process as well as which method the development process is inspired by.



Ill. 01 Scope

METHOD

Kolbs learning cycle

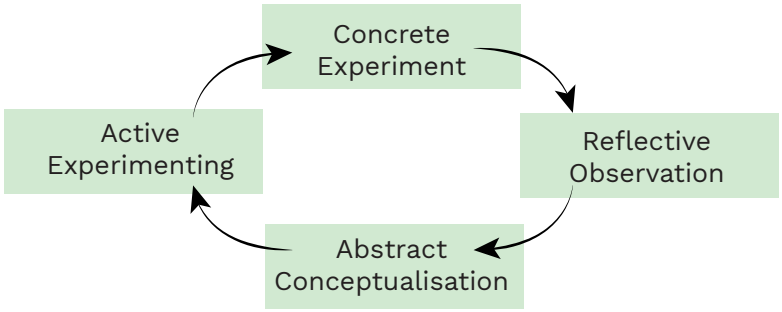
Kolb's learning cycle has been continuously utilized throughout the development process. Kolb's learning cycle is a process based on experience. This means that through the design process, new knowledge is constantly accumulated which leads to new studies (McLeud, 2007).

Concrete experience: Tests and research are executed, and results are noted.

Reflective observation: The result from the 'concrete experience' is analyzed and mapped to get a better understanding.

Abstract conceptualization: A theory is formulated based on the results of the previous studies.

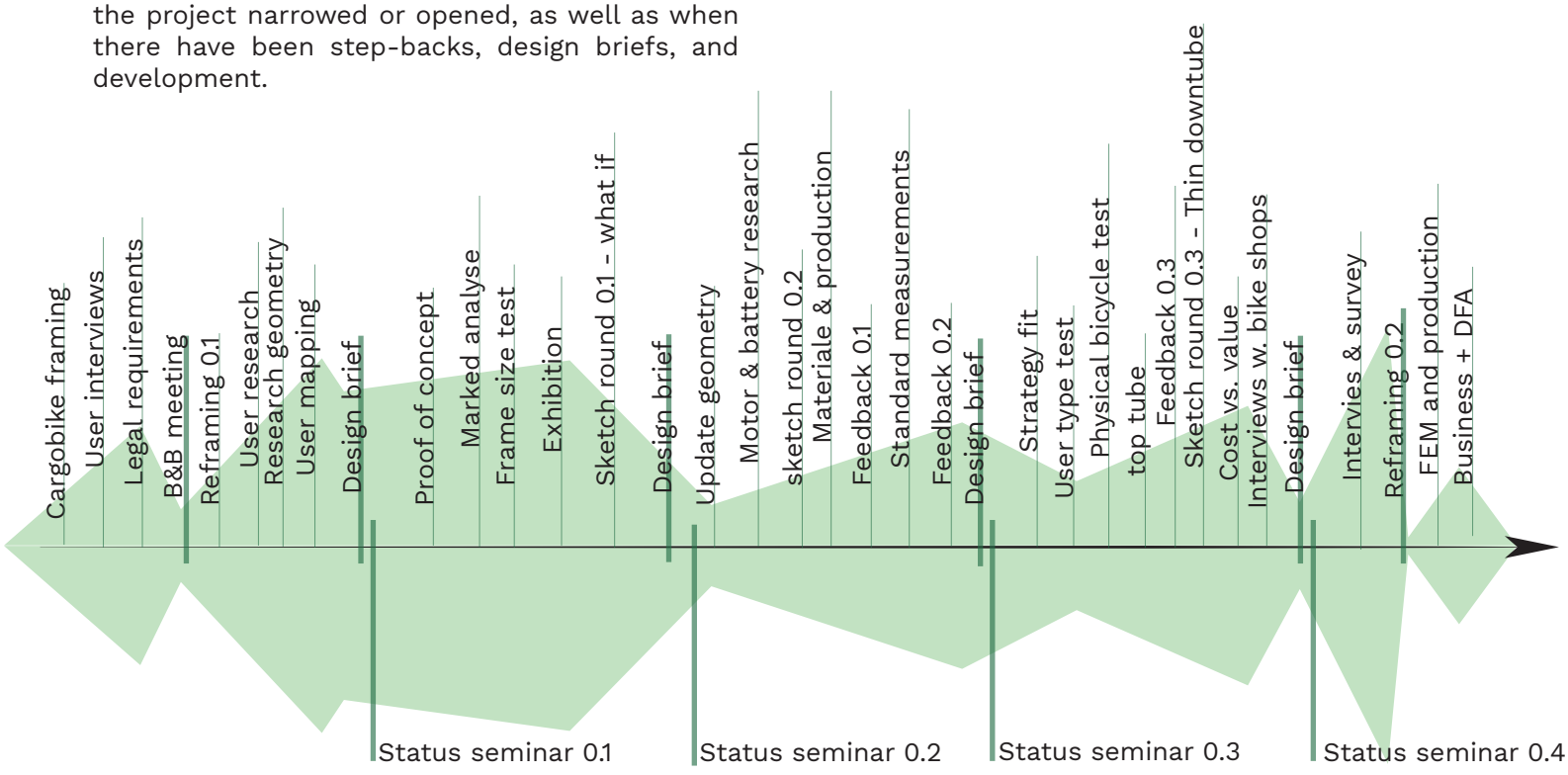
Active experimentation: New test or study is set up based on the knowledge from previous studies.



Ill. 02 Kolbs learning cycle

Procesline

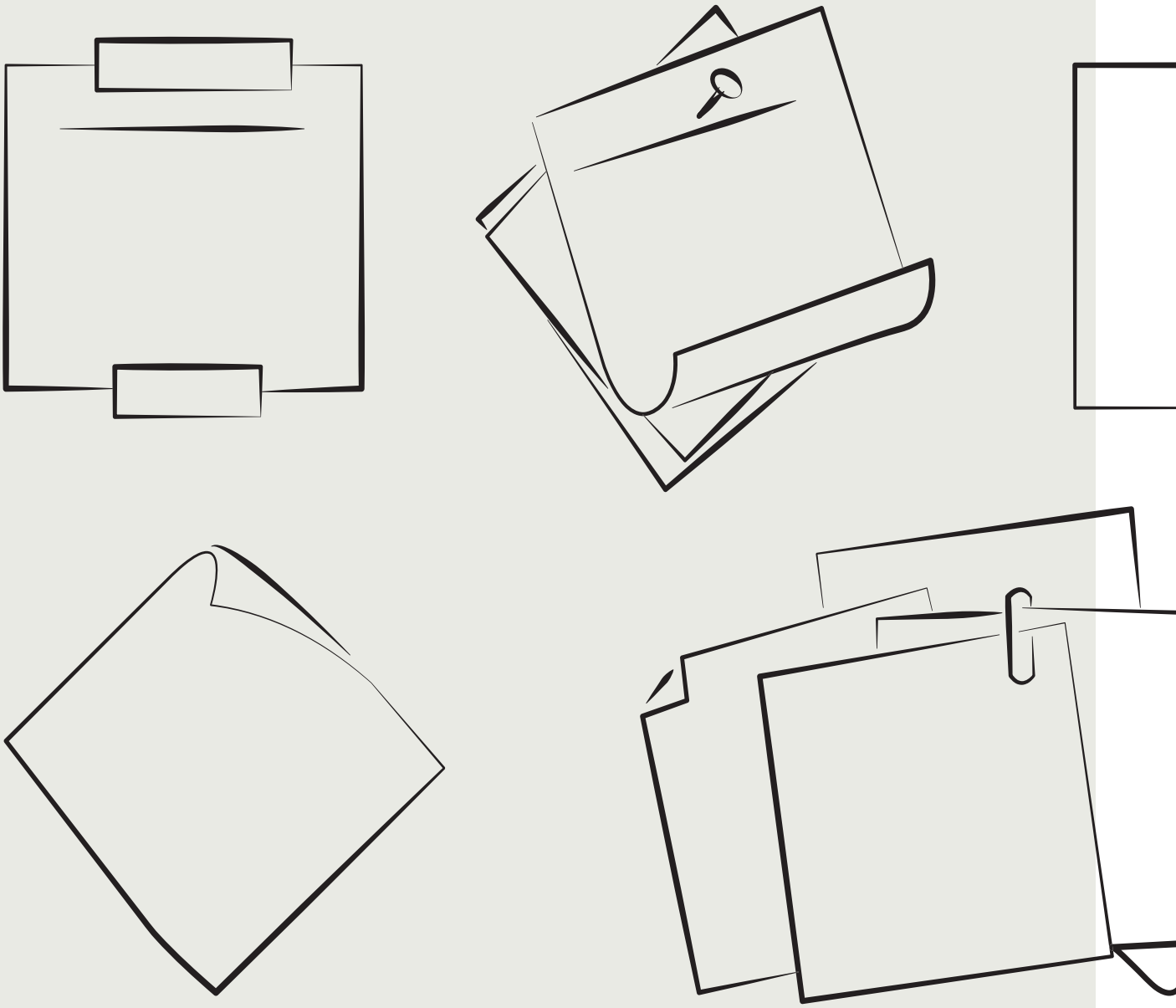
The process line below illustrated the actual process of the project. The process line shows when the project narrowed or opened, as well as when there have been step-backs, design briefs, and development.



Ill. 03 Process line

01 FRAMING

In this phase, different directions for the project was examined. In the process, it was important that the topic was close to reality and relevant to the outside world. The direction of the project was found through brainstorming, mail cross-examinations and research.

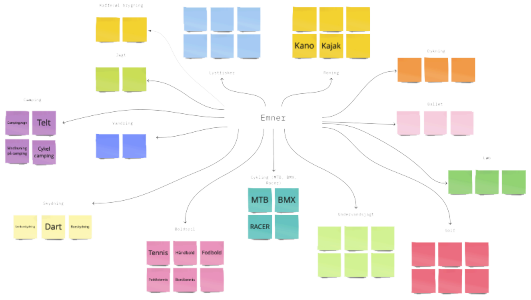


Ill. 04 Framing

Choice of direction

IDEA GENERATION

In the start of the project, a brainstorm was made over different categories that could be interesting to investigate further. Amongst those were hunting, cycling, and ball games. None of these categories had greater interest for the group in the beginning.

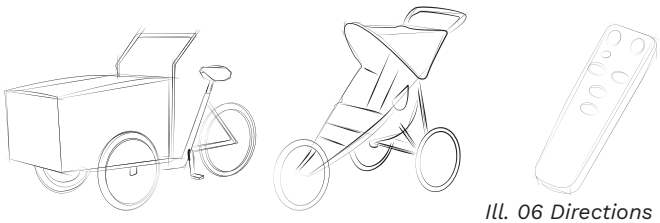


Ill. 05 Brainstorm

Various companies that could be interesting to work with throughout the project, was therefore mapped out. Amongst the mapped companies were e.g., Promovec, Odder barnevogne, and Viking. These companies were then contacted to hear if they had any potential 'wicked problems'.

Both Promovec and Odder barnevogne were interested in entering cooperation and had some thesis:

Modular cargobike Trolley remote control



Ill. 06 Directions

Both Promovec and Odder barnevogne suggested working with cargobikes.

2 IN ONE CARGOBIKE

Two of the companies was interested in developing the next generation cargobike. Their briefs were to investigate whether one could use the basic structure of the cargobike for several different purposes. In other words, a modular cargo bike where the front part could be removed so the user could adapt his bicycle to a two-wheel everyday bicycle. A cargobike takes up a lot of space on the bicycle paths and is not as easy to maneuver as a regular bicycle resulting in users needing two different bicycles.

User interviews

To find out if there was a need for a removable cargo bed several interviews were made. The interviews were primarily done over teams or phone because most users of cargobikes lived in Copenhagen. The questions were primarily about them and their family but also about how many bicycles they had besides the cargobikes, which problems they were experiencing with their cargobikes and how often they used their normal bicycle compared to the cargobike (Appendix 01). The interviews showed that there was a huge demand for a modular cargobike, and the users often have many different bicycles for different purposes.

interviews with bicycles experts

To find out what parameters the group should consider in the development process and to see if the bicycle dealers saw a market for it, interviews was done with three different bicycle dealers. They did not believe in the concept because a group of engineers had tried something similar before and failed

Supervision with butchers and bicycle

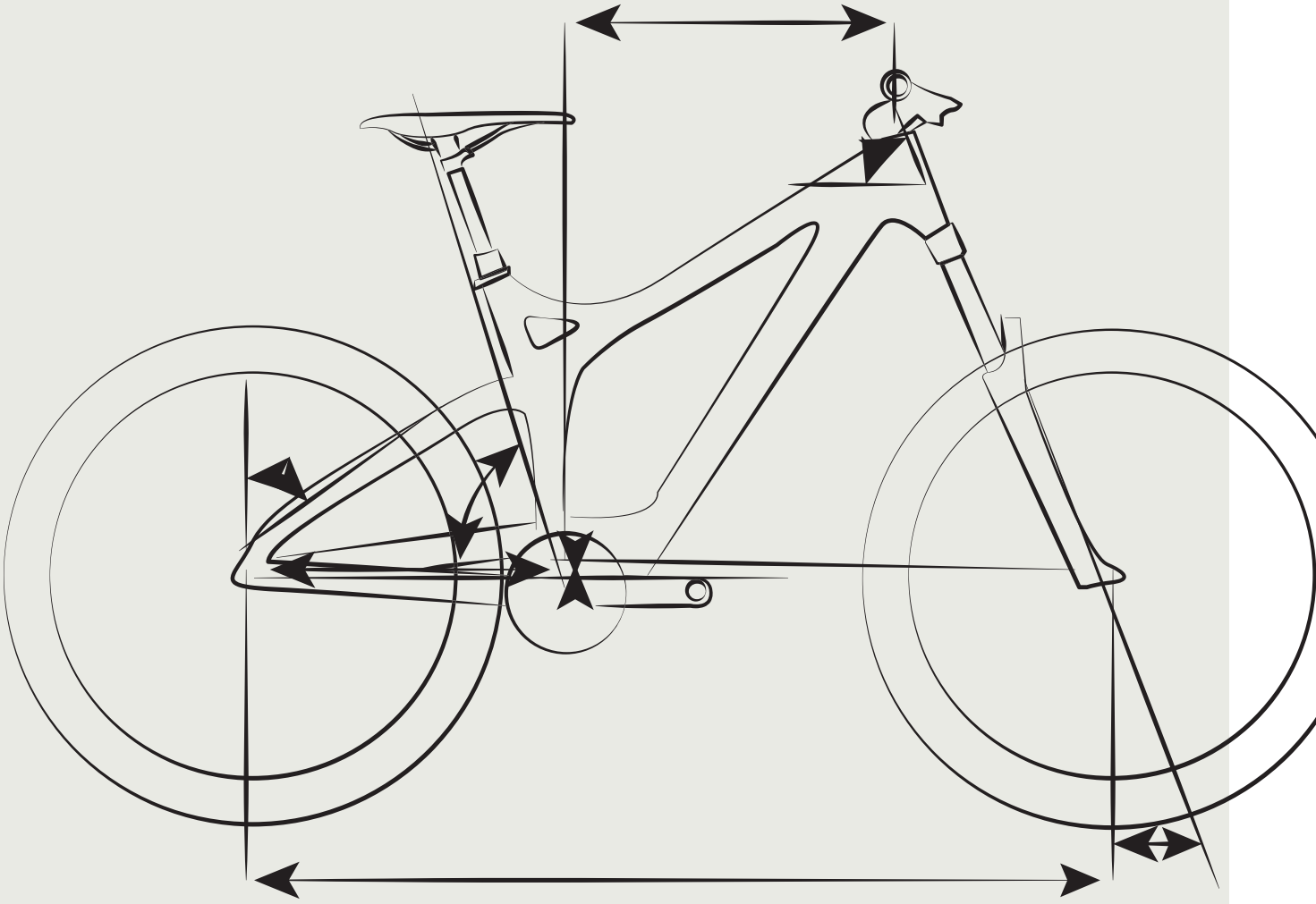
A meeting was set up with Morten Mogensen from Butchers & Bicycles. The purpose of the meeting was to gather more information about their design process in relation to their cargobike and what problems they encountered. The development of the special steering mechanism had taken them 1.5 years and made it clear that developing a modular cargobike with a removable bed would be challenging within the timeframe of the project. Instead, he recommended making a basic frame that can be turned into different bicycles (Appendix 02).

Conclusion + problem identify

After hearing another bicycle company be skeptical about a modular bicycle for the consumer, and instead recommend **making a standard frame for easier production of different bicycles**. The direction was changed to a platform for bicycles that were production and business-oriented, but with great focus on the product and consumer needs.

02 UNDERSTANDING

Phase two examines whether the new framing is feasible. This is done through studies of the geometry of the bicycle to gain an understanding of its structure. In addition, it will be looked at which users a bicycle platform can potentially hit and what requirements they have.



Ill. 07 Understanding

Bicycle geometry

Purpose

To understand the bicycle geometry and how the dimensions impact the handling, stability, riding style, and mobility. The bicycle geometry was investigated, trough desktop research, to figure out how the specific changes in length or angles would affect the usability of the bicycle.

The respective angles and lengths are marked on the illustration with the appertaining colors below.

Seat Tube Angle

The seat tube angle is the angle measured in relation to the seat tube and the ground surface. This angle does not differ much across bicycle types and is usually between 71° to 74° (Paul Boyle and Jans, 2017). This parameter positions the user for either the optimized pedaling position or the usage of a specific muscle group.

Mountainbike	73 °
Roadbike	73 °
Touringbike	71 °- 73 °

(Denham, 2013)

Wheel Base

The wheelbase is the horizontal distance between the center of the wheels. A longer wheelbase results in a more stable bicycle but too long a distance could give difficulties handling abilities. (Denham, 2013)

Mountainbike	-
Roadbike	995 mm
Touringbike	1050-1070mm

(Denham, 2013)

Bottom Bracket Height & Drop

The drop is measured from a horizontal line between the center of the wheels to the center of the bottom bracket (BB). The drop relates to the height of the saddle as well as the center of gravity. The greater the drop, the lower the gravity point and thereby relates directly to the handling abilities. (Denham, 2013)

Chain Stay Length

The chain stay length relates to the rear length of the bicycle in terms of giving stability while sycling. The length relates to the ability to mount different wheel sizes of various bicycle types. (Denham, 2013)

Stack & Reach

Stack and reach relate directly to the user's body type and posture while riding. Stack is measured vertically from the center of the BB to the center-top of the headtube whereas reach is measured horizontally from the center of the BB to the center of the center-top of the headtube. The relation between stack and reach is one of the main deterrents to the posture of the user among other components such as the handlebar. (Denham, 2013)

Slackangle

The slack angle is the angle at which the head tube and road surface meet. Changes in the slack angle will impact stability, handling, and riding style. A steeper angle would result in better handling but decreased stability. The length of the head tube relates directly to the riding positioning where a longer head tube will get the user in an upright position and the other way around. (Paul Boyle and Jans, 2017)

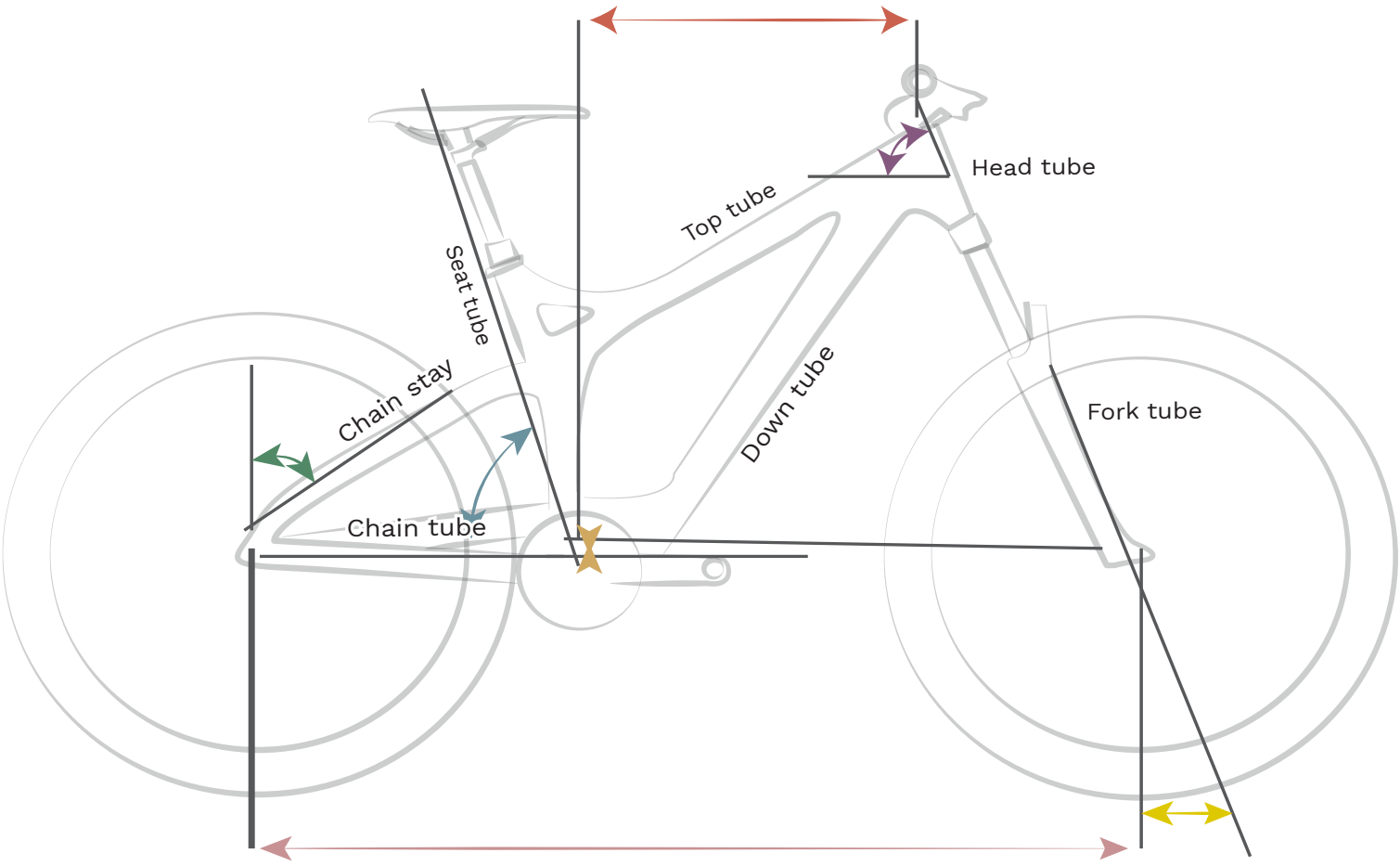
Mountainbike	62 °- 73 °
Roadbike	73 °- 74 °
Touringbike	71 °- 72 °

(Brett, 2020) & (Denham, 2013)

Trail comparison

The length of the trail is measured in a straight line following the angle of the head tube to the road surface and a vertical line from the center axes of the front wheel to the road surface. The distance between those lines determines the trail length which impacts handling abilities - a long trail gives slow handling. (Paul Boyle and Jans, 2017)

Mountainbike	-
Roadbike	50-60 mm
Touringbike	55-65 mm



Ill.08 Bicycle geometry

Conclusion

For the geometry of a bicycle, various elements relate to each other both across bicycle types and user scenarios whereas. Dimensions such as seat tube angle, trail length, head tube angle, and reach are the main dimensions to focus on. These parameters would result greatly in handling, stability, riding style, and mobility.

To create a universal bicycle frame, these parameters should be tested in various combinations to finalize a working frame both aesthetically and functionally.

The next step was to look at what design processes the bicycle goes through to understand where a platform could accommodate.

Slack angle = 72-73°

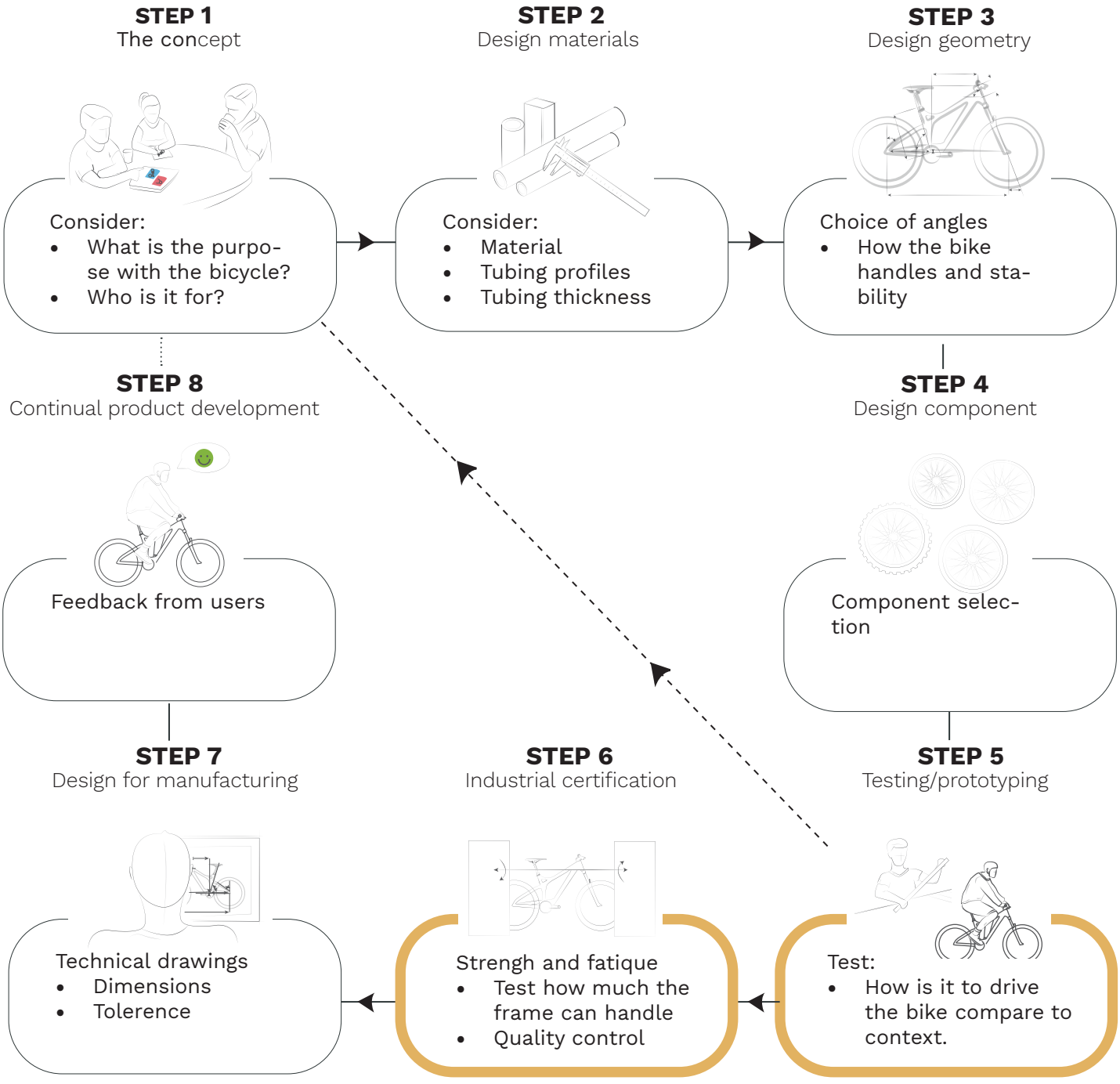
Seat tube angle = 73°

Design proces for a bicycle

Purpose

After gaining a deeper understanding of the geometry of the bicycle, the processes existing bicycles go through before they come on the market were examined.

The purpose was to figure out where a bicycle platform could provide value in relation to the existing solutions that are on the market.



Ill. 09 Design proces

Conclusion

The most expensive part of the design process is steps 5 and 6. This is because testing can take a lot of time and send you back to step 1 if it does not work as intended. It would therefore make sense to develop a platform (a frame) for different types of bicycles, so the design company does not have to go through all the design steps for each bicycle type, but only one. However, this is not possible for high performance bicycles due to the performance needs.

LEGAL REQUIREMENT

Purpose

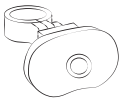
As a bicycle platform can minimize steps in bicycle development, it has been investigated what legal requirements it must be able to meet to be approved on the market. Therefore, the legal requirements for bicycles, cargo bicycles and electric bicycles are examined.

The legal requirements were found through desktop research of Danish legislations (Færdselsstyrelsen n.d.) (Sikkerhedsstyrelsen n.d.). As no legislations for cargo bicycles were developed yet in Denmark, the German legislations were used instead (BAST):

Bicycles

2 independent brake systems

Reflectors visible from all sides



Visible lights from 300m

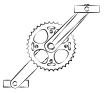
Cargo bikes

Secure seating for everyone

Maximum 7 persons including driver

Electric bikes

Maximum 250 W motor



Only assist when pedaling

Only motor assist up to 25 km/h

Ill.10 Legal requirement

CONCLUSION

The relevant requirements are listed above to be used as requirements for the solution as well as parameters for design decisions. To figure out what other requirements there are for the product, various user research's will be made.

- The frame must allow 2 independent brakes to be attach.
- The frame must allow the application of reflectors that are visible from all sides

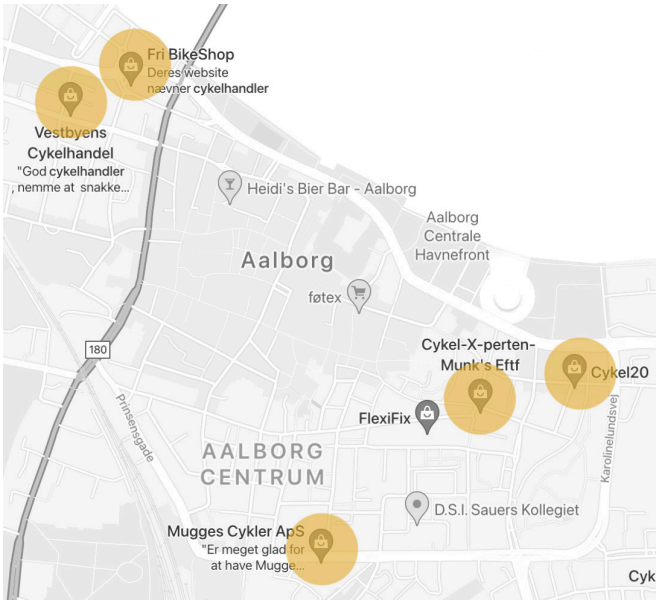
User research

Purpose

After researching the geometry of the bicycle it was investigated who the typical users are for the different bicycle types, their use, and their needs.

Bicycle shop interviews

Semi structured interviews (Doyle, 2020) were carried out in five different bicycle shops, to gain insight in what costumers ask for and which types of users buys which bicycles (appendix 03).



Ill. 11 visited bicycle shops

It was clear that it is very individual who buys which bicycles, however the interviews gave useful insight to the bicycle market in Denmark and some generalizations:

> ***Almost three out of four sold bicycles are electric*** *and are sold to most users except men between 35 and 55 years.*

> *Classic bikes and city bikes are by far the most popular, where classic bikes typically are sold to users prefer comfort over speed, while city bikes typically are sold to users that just needs to get quick from A to B.*

> *Fixie bikes are typically sold in bigger cities with no hills, like Copenhagen.*

> *Cargo bikes are most popular amongst families with kids.*

> *MTB and road bikes are typically dependent on the users' hobbies but are also sold as transportation from A to B as some users prefer the aesthetics.*

Field observations

Field observations (Raitz, 2001) were carried out in a two-hour period from 8 till 10 in the morning at two major traffic hubs in Aarhus. It was then observed and noted which genders and ages drove which bicycle types. All ages and sex were estimated from observation (appendix 04).

Women

Age	10-19	20-29	30-39	40-49	50-59	60+
City bike		25	8	5		
B-bike	1	7	7	4		
Classic		15	4	3		1
Cargo			2			
Hybrid			1		1	
Fixie						
Racer				1		
MTB			2	1	1	

Men

Age	10-19	20-29	30-39	40-49	50-59	60+
City bike		13	15	4		
B-bike		1	3			
Classic		7	6		1	
Cargo			7			
Hybrid		1	3		1	
Fixie						
Racer		2	3	1	1	
MTB		2	2	1	1	

The observations gave a good indication of the most used bicycle types and some insight on who uses which bicycles.

Interviews and questionnaire

To gain more insight directly from the users and their needs, semi structured interviews (Doyle, 2020) were carried out with students at Aalborg University and random people at the streets of Aalborg. Furthermore, a questionnaire (Aryal, 2022) was made and shared online Appendix 05). The participants were asked their sex, age, which bicycle type they have, what they use it for and what their most important needs are for a bicycle.

Key findings

A notable key finding was that all bicycle types by some users primarily were used as transportation from A to B when going to work, school or shopping. Some user needs were also general for most users. Those needs include high quality, comfort, low weight and easy to maintain. Other needs like equipment were more dependent on user types, and it showed that users who owns more bicycles tend to be more specific about their needs and equipment.

Full vesion see app. xx:

Ill. 12 User scheme

Conclusion

All the collected data gave some insight to the bicycle market user demands and needs that were all used to create an understanding of user types. The data were therefore used as a base for further user mapping (interaction-design, 2022) and gave some insight that were useful throughout the project.

The concept must be electric, as the majority of the bikes sold are electric.

- Lightweight - possible to drive without help from motor
- Classic bike user prefer comfort over speed
- Easy to maintain - low top tube
- MTB and road bike has two user groups, transportaion (a-b) and hobby.

User-mapping

Purpose

Based on the previous research, clustering (Tollestrup, 2019) was made to concretize who the typical users of the different bicycle types are, what their use and needs are, as well as create an overview of the most commonly used bicycle types as could be relevant for a platform.

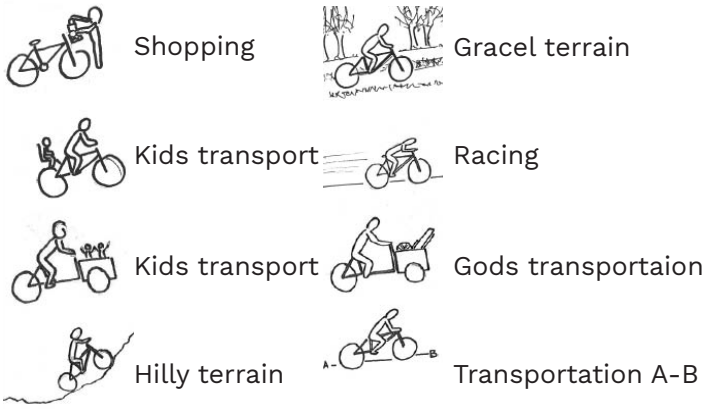
The clustering was generalization based on stereotypes that were defined and mapped based on prior knowledge experience and the collected data.

User types and needs

12 different user types, as shown below, were defined based on the collected data, including the user's needs. These users were then connected (Ill. 26) to the typical bicycles that user type would buy.

User scenario

The different use scenarios identified from the data were defined and illustrated. The scenarios were then connected to the users of the different bicycles.



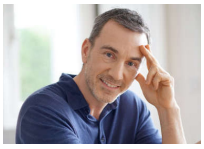
Ill. 13 Usage scenario

30+ years old family mom- Modern woman
Typically in biger city

NEEDS:
- 7 gears
- Comftable
- Simple and reliable
- Cargo sace for shipping
- Transportation for kids
- Quality over price

Ill. 14 Family mom

30+ years old family dad - Modern man



NEEDS:
- Cargo for shopping
- Transportation for kids
- Reliable
- Quality gear and brake

Ill. 18 Family dad

40+ years old man - Typically in bigger city
Bussy life

NEEDS:
- Reliable
- Quality over price
- Fast
- Light

Ill. 22 +40 man

65+ yeers old pensioner - Both men and women

NEEDS:
- Stability
- Not to heavy
- Electric motor
- Basket for shopping
- low maintanance

Ill. 15 Pensionister

25-40 years old man - Lives in bigger city
Creative "Hipster"

NEEDS:
- Cargo for transport
- Look smart
- reliable
- Flexiblity

Ill. 19 Hipster

16-30 years old man - Student

NEEDS:
- Sporty look
- Good gear and brake
- Reliable
- Low maintanance

Ill. 23 Young man

25+ years old business man - Lives in bigger city
Busy life - Quick from a to b

NEEDS:
- Simple and reliable
- Fast
- No maintanance
- Simple look

Ill. 16 Business man

25+ years old business woman - Lives in bigger city - Busy life

NEEDS:
- Simple and reliable
- Fast
- low maintanance
- Not sweating
- Look smart

Ill. 20 Business woman

25+ years old dedicated hobby sportsman Invests in equipments and gadgets

NEEDS:
- Quality over price
- Sporty look
- Speciliced bike for every scenario
- Newest and smartest gadgets

Ill. 24 Semi pro sportsman

40+ years old family man "in mid life crisis"
Wants to look pro

NEEDS:
- Good gear and brake
- Speciliced bike for every scenario
- Sporty look
- Newest and smartest gear

Ill. 17 Man on bike

20-45 years old woman - very active lifestyle
Practical

NEEDS:
- Good gear and brake
- Reliable
- High quality
- Sporty look
- The newest and smartest gear

Ill. 21 +45 year woman

Professional/ semi professionel sportsan/ woman

NEEDS:
- Everything optimised
- low weight
- Very specialised need dependant on sport

Ill. 25 Pro cyclist

Ill. 26 User mapping

Conclusion

The mapping made it clear that the most common use across all bicycle types was transport from A to B. The most universal bicycle were city bikes while the choice of other bicycles vary depending on the users' visual preferences or practical needs such as more cargo space, comfort, or electric assistance. Mountain bikes and road bikes were also used by some users for A to B transportation, while others use them for sport and extreme situations. These use cases have the same aesthetic need but not the same performance needs.

It was concluded that it seemed possible to make a platform that through components, adjustable seat/handlebar and painting, can be used to produce bicycles that meets the user needs of A to B transportation. The platform will therefore be limited to suit A to B transportation, and not performance-driven MTB and Road bicycles.

- Limited to City bikes, Classic bikes, Hybrid bikes, MTB, Road bikes and Cargo bikes
- Limited to only include electrical bicycles with the primary use of A to B transportation

01 Design brief

Based on the initiating 'understanding' phase. This design brief is presented to provide a summary of all the findings that the 'understanding' phase has brought:

PROBLEM DEFINITION

"How do we design a bicycle platform that simplifies the design and manufacturing process of everyday bicycles"

Summary

In the 'understanding phase', the structure of the bicycle was examined to gain an understanding of the significance of it on the riding experience.

The development of the bicycle was examined to figure out where a potential platform could make sense.

In addition, the Danish and German requirements were examined to figure out which important parameters the bicycle must meet

Finally, it was investigated what type of users each bicycle has and what requirements they need for the bicycle. This was done to figure out what bicycle types a platform would be able to hit.

The result of this are these findings:

Important points

- Lightweight - possible to drive without help from motor. (p. 16)
- Easy to maintain- low top tube on classic bike (p. 16)
- Primary use of A to B transportation.

Requirements

- Slack angle = 72 - 73° (p. 12)
- To be electric (p. 16)
- Space for 2 independent brake systems (p. 15)
- Frame must not shield for retrofitted reflectors. (p. 15)

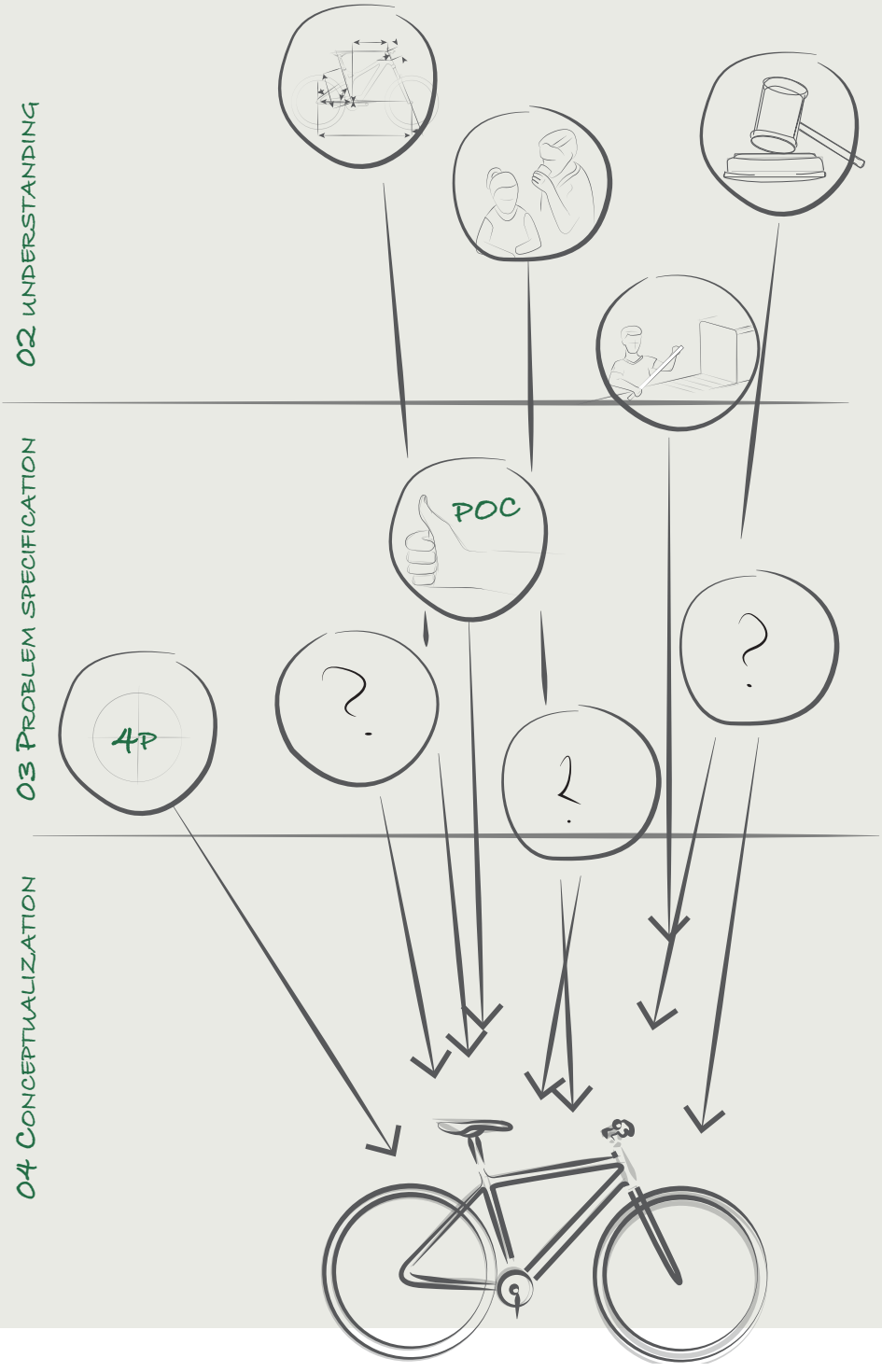
Statusseminar 1 - Feedback

At the 1st status seminar, the feedback indicates misunderstanding between the group and supervisors which highlighted the need of concretizing the concept. The supervisors needed to know explicitly what the concept is. Is it to minimize the number of bicycle types or to minimize the components used to manufacture a bicycle? Is it a production-related problem? The questions were mainly based on the production of the variety of existing bicycles, but the concept was to create one universal frame for the use of multiple bicycle types.

The framing of the project needed to be evaluated and specified to enable a common understanding within the group as well to enable understanding for supervisors and other stakeholders of the milestone. Lastly, comments on the complexity within the world of bicycles were questioned. Supervisors mentioned the need for deep inside knowledge of the construction, production, and complexity of the design process of both bicycles and components within the portfolio of the bicycle world.

03 Problem specification

The third phase is the 'problem specification' phase. In this phase all the collected knowledge was concretized to a clearer framing. Furthermore, new knowledge and data were collected through investigations.



Ill. 27 Problem specification

Mass customisation

Purpose

Due to the unclear direction that was stated at the status seminar, mass customization has been examined in deeper detail to gain a better understanding of where the bicycle platform can make sense to implement. This is made to get a better understanding of what mass adaptation is and to be clear in the design of the project.

Experiment

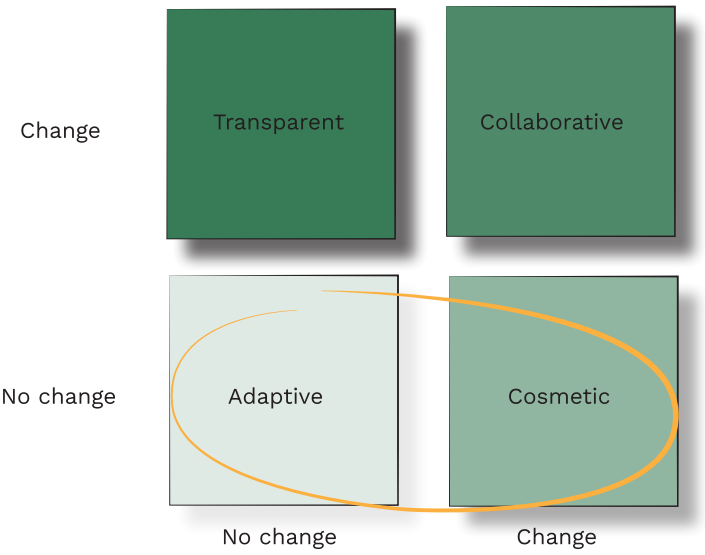
The four approaches of customization are transparent, collaborative, adaptive and cosmetic which each serves the potential customer in different manners. It is up to the company to examine which approach would suit their customers' need the best. Companies could either implement one, a mix of some or all four approaches to serve their customers (Gilmore et al., 1997).

Transparent:
- Provide customers with a product without letting them know that it has been specially made for them.
- Typically used if the customers' needs are predictable

Collaborative:
- Developed product with the help of dialogue with the customer to concretize their precise needs.
- Typically used if the customers' struggle to figure out their needs.

Adaptive:
- Provide one standard which the customers could customize with additional products
- Typically used for companies with a product used in different scenarios

Cosmetic:
- Present a product with different aesthetic appearances for example color
- Typically used with product for the same scenario but customers like different appearances



Ill. 28 Mass customization

Conclusion

This project will implement the approaches of adaptive and cosmetic.

These approaches both provide the customers with a standard product which can be customized to fit the specific users' need individually. The adaptive approach offers one standard, that user' could customize by adding a list of different components to their specific bicycle.

The cosmetic approach relates closely to the adaptive approach but differs by altering only on the aesthetic values of for example color.

The remaining two approaches were deselected because each customer customizes the bicycle by themselves and would thereby know it is specially made for them and they would know their precise needs.

4P MODEL

Purpose

It was investigated how the concept innovations is in accordance with the 4P model (Sawhney et al., 2006). This was done to analyze the potential from a business perspective.

Experiment

The 12 different ways for companies to innovate highlight 12 version of innovation: Offerings, platform, solutions, customers, customer experience, value capture, processes, organization, supply chain, presence, networking, and brand. This section highlights four ways of innovation Platform, Processes, Organization, and Supply chain (appendix 06).

Platform

With a common set of components, the product platform will exploit the power of commonality. By utilizing the same components in construction of the frame, the platform creates a variety of opportunities for constructing the bicycle as the individual customer wants. Furthermore, the user can exploit the industries standard components (handlebar, pedal etc.) to create the specific identity of the bicycle they want.

Processes

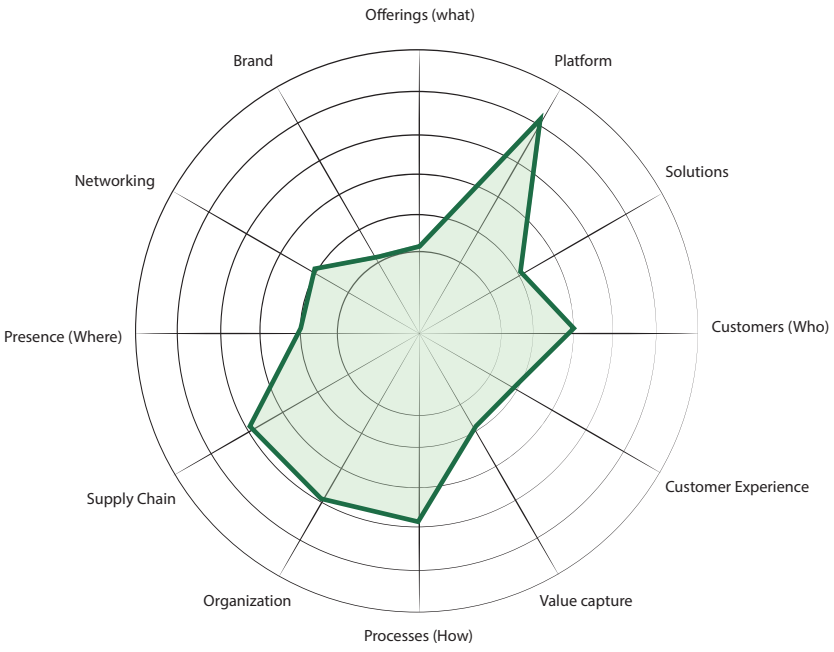
By having the same processes across bicycle types, the concept limits process complexity and gives the possibility to specialize within these.

Organization

Alongside processes, organizational partnerships would be strengthened by having less processes in production compared to companies with multiple bicycle frames.

Supply chain

In extension of processes and organization, the supply chain minimizes by limiting the production processes. By having one exact method of producing and constructing the frame, the supply chain relationships could be strengthened.



Ill. 29 4P model

Conclusion

By minimizing the complexity of the business, everything else would be limited in complexity. On the other hand, stakeholder would be deeply dependent on each other, so for example it could be necessary to have multiple production locations to minimize the risk of a failed production.
Since a platform for bicycles makes sense in terms of business, it must be investigated whether it also makes sense for the consumer.

Proof of concept user

Purpose

Because of the doubt about the concept at the status seminar a 'proof of concept' (Pratt, 2022) were made to evaluate the concept.

The aim was to prove that a wide arrange of bicycle expressions and types could be made from the same frame.

All bikes were based on the frame shown below:

Experiment

Six different bicycles were made from the same frame in photoshop and shown to seven persons. The persons were then asked about each bicycle how they would describe it, which kind of bicycle they would call it and who they think the typical user for it would be. One of the focus points during the interviews was to hear people's responses on which sex they would describe the bicycle for (Man, woman, or unisex). This task was set up as situated interviews (Bagger et. Al, 2003) and data can be seen in Appendix 07.

It is a cargo bike often used by families with children. It can be either the father or mother that use the bike and they often use it for groceryshopping or pick up children. -Person 2

It looks like a mountain bike but it is a bit long. Thinks it is for a sporty type and typically men, but could also be used by women. *-Person 3*

It is a racing bike for sport and people that would like to go fast. Does not know if it is for men or women but says it is probably mostly for men just because he thinks that more men do professional cycling. - Person 4

It is also a city bike. It is a bike for women because the top tube is lower and the handle indicates that you sitting more erect. *-Person 5*

This is a bike that stands out. It is a kind of mountainbike but you can also use it in the city. I dont think it is a pratical as a mountainbike. It is offen younger guys or middelage men that like to stands out. *- Person 3*

It is a citybike for people that lives in the city, which is practical and easy to use. Could be used by students or family people who just need a bike to get around. It is unisex and there is not a big diference on who would use it. *-Person 4*

Ill. 30 Proof of concept - User

Conclusion

Most of the participants did not notice that the bicycles has the same frame. Some of them have it in the subconscious with some of the bicycles. This was mostly with the women's city bike and the mountainbike. The user comments most of the detail, as wheel, seat and handle, when they must describe the bicycle type and mentions that some of them looks like their own.

Proof of concept bicycle shops

Purpose

To confirm the findings from the proof of concept with users, the same hypothesis was tested from a different perspective with insights from bicycle mechanics and salesmen.

Experiment

The same six different photoshopped bicycles were shown to employees of three local bicycle shops, Cykel-xperten, Vestbyens Cykelhandel and FriBikeshop. They were then asked to describe each bicycle, comment on the typical buyer of that bicycle and their thoughts about the concept. This task was set up as situated interviews (Bagger et. Al, 2003) and data can be seen in Appendix 08.

It is a cargo bike. It will typically be used as a company bike and for transportation of cargo. If it has seats and a canopy it could also be used by families for kids transportation. It is a unisex bicycle and in theory every bicycle is unisex.
-FriBikeShop

It looks like it has to small wheels compared to the frame. Thinks it would not be the best bicycle to drive on because of the distance between the wheels. -Vestbyens Cykelhandel

It is a racing bike with nice thin tires and a higher seat as it should have. It is unisex, and racing bikes are racing bikes, so they are the same for both men and women. - FriBikeShop

It is a citybike, but a more modern retro version. This could be used by both men and women, but the top tube is relative high compared to a typical woman's bicycle. -Vestbyens Cykelhandel

This is a fatbike. It is not a type of bike that you often see in Denmark and it is most of all a gadget bike. - Vestbyens Cykelhandel

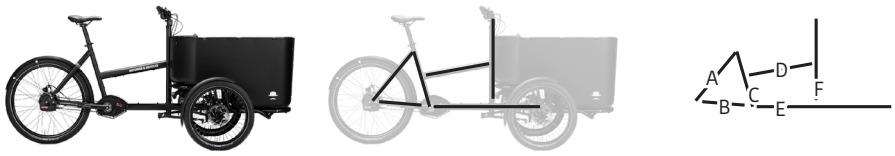
*It is a citybike and **we have this bike**. It is typically for younger students and can be for both men and women. I call it a citybike because it is a complete bicycle with no suspension, internal gears, fenders, chain cover and lights.* -FriBikeShop

Ill. 31 Proof of concept - Bike shop

Conclusion

Some of the older bicycle dealers were skeptical about the concept and seemed very conservative in their opinions and in general not open minded to any change. However, the younger employees were open to the concept and saw potential. When asked about e-bicycles they were all more flexible in their definition of the different bicycle types and gender and mentioned that low entrance was important. Furthermore, all dealers confirmed that the angles do not have that big variation for everyday A to B bicycles and that it is mostly the seat height that determine the body posture. It was also confirmed that it would not be possible to use the same platform for performance-oriented users.

Cargo bike (B&B)



City bike

City bike (woman)

Classic bike

Flexie bike

Hybrid bike

Mountainbike

Racing bike

Cargo bike

- New product element
- Repeat form element from another product line
- Moderate form reference from another product line
- Weak form reference from another product line

Ill. 32 Styletype

Styling types

Purpose

Due to bicycle dealers skepticism and to get a better understanding of how different the existing bicycle types are, a study was made on how large the variation is across bicycle types in a structural expression.

Experiment

An analysis were conducted on nine different bicycle frames within nine structural bicycle types. The method of the analysis was based on Anders Warell Ph.D. Design Syntactics: A functional Approach to Visual Product Form (Warell, 2001).
Each tube were given a letter and were color coded as shown to the right in illustration 32.

Conclusion

Tubes A, B and C is consistent through the bicycles type except the last cargo bike and only shift slightly in their shape. Component G, H and I is also consistent through the typical bicycle types and only differentiate slightly despite varies performance levels. Components D, E, F, J, K, L, M, and N is only used in cargo bicycle and are thereby widely different from every other bicycle in this analysis.

IDEA GENERATION – ”WHAT IF?”

Purpose

while the group investigated how much of the platform could be standardized, A ’what if’ idea generation was made to open the imagination before the group became too enlightened.

The purpose of the ’what if?’ (Tollestrup, 2004) exercise was to suspend the framework of reality to get some crazy ideas that maybe could be used for something in further development.

Experiment

Three different sketch parameters were chosen. No tubes, no seat tubes, and all organic forms.

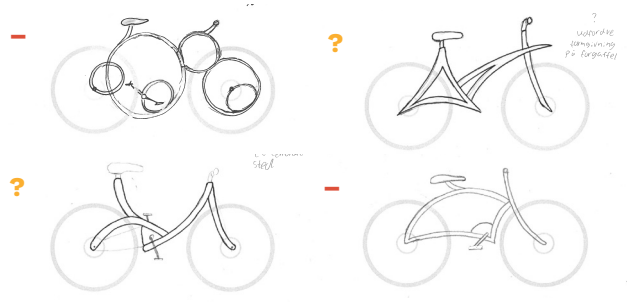
The sketches were evaluated, with a converging analysis (Tollestrup, 2004) where usable and interesting elements were marked with:

+ for directly useful element,
? for element with possibility to explore or
– for discarded ideas.

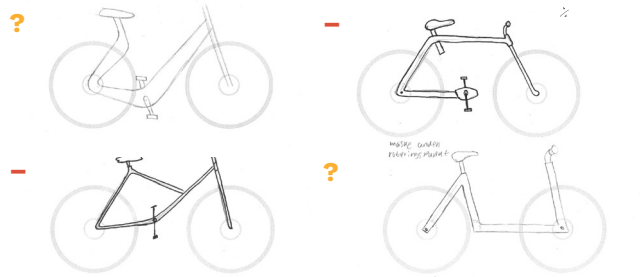
Conclusion

The sketches created a base for further investigation in terms of design language, users’ likeliness to buy the bicycle and possible solutions for having the bicycle stand out from the rest of the marked.

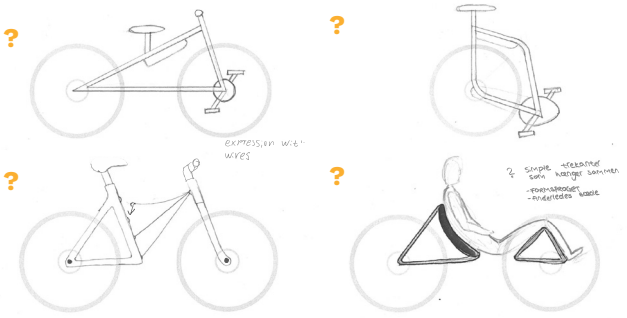
All organic:



No seat tube:



No tubes:



Ill. 33 What if - sketch

Standard components

Purpose

The 'proof of concept' showed that the frame must be able to fit different types of bicycle accessories. It was therefore investigated how much difference there are in the dimensions of the seat tube, guide tube, and front fork.

Experiment

This investigation was primarily made as desktop research through a comparison of different components found online and then followed up by clarifying questions for bicycle mechanics at FriBikeShop. The varying dimensions were shown in a table.

> *"he dimensions of the bottom bracket, steering fittings and saddle tube varies a lot."*

> *"Every brand has their own dimensions."*

> *"Dimensions of the back triangle are more fixed."*

Steering tube

Diameter in mm	22.2	25.4
Amount	5	11

Front fork

Diameter in mm	25.4	28.6

Saddle tube

Diameter in mm	25.0	25.4	25.8	26.0	26.2	26.6	26.8	27.0	27.2	28.6	30.0	30.4	30.9	31.4	31.6
Amount	1	3	1	1	1	1	1	1	7	1	1	1	3	1	6

Conclusion

As the steering tube and saddle tube varies in diameter, the solution will need to be adjustable between 25 to 31,6 mm for the saddle tube and 22,2 to 24,4 mm for the steering tube. For the fork, the solution should fit to a 25,4 mm and 28,575 mm tube. To find out what can be further standardized, the geometry of the bicycle must be examined.

- The seat tube must be able to fit a saddle tube between 25 to 31.6 mm
- The head tube must be able to fit a fork pipe on 25.4 mm and 28.575 mm.
- The head tube must be able to fit a handle tube between 22.2 to 24.4 mm.

Test of frame size

Purpose

The geometry study (p. 12) showed that the geometry of the frame itself did not vary much between the different bicycle types. Therefore, it is investigated further on; how much of the bicycle can be standardized.

Experiment

Participants' height, stride length and saddle height were measured to compare data.
In total three different tests were conducted:

- The effective length (the length between seat tube and head tube)
- Top tube height
- Handlebars effect on the seatig position

Participant	Peson's height	Stride lenght	Saddel height
P1	194 cm	92 cm	21 cm
P2	162 cm	80 cm	4 cm
P3	188 cm	95 cm	14 cm
P4	168 cm	82 cm	7 cm
P5	177 cm	82 cm	12 cm
P6	175 cm	81 cm	13 cm

Test bike:

Ill. 34 Test bike

Handle 1:

Ill. 35 Handle 1

Handle 2:

Ill. 36 Handle 2

Top tube lenght:
To figure out how much the effective length differs from person to person, the six participants were asked to put the front fork in a maximum and minimum length from themselves where it still feels natural. The length was then marked on the floor and noted (Ill. 37).

	Handle bar 1 (cm)	Handlebar 2 (cm)
P1	Min 52 Max 57	Min 47 Max 57
P2	Min 47 Max 57	Min 37 Max 49
P3	Min 41 Max 57	Min 45 Max 62
P4	Min 34 max 52	Min 32 max 52
P5	Min 37 max 40	Min 37 max 42
P6	Min 40 max 42	Min 40 max 43

Partial conclusion:
Most of the participants prefer a reach length of 40-43 cm

Ill. 37 effective length test

Top tube heigh:
It was tested how high the top tube could be and still give the user an easy entrance.
A piece of cardboard was adjusted at different heights by 10 cm between each step. The participant was then asked to get on and off the bicycle for each step.

Partial conclusion:
The participants only swing their legs around the bicycle at the last 3-4 steps (in +30 cm height from the crank) if they do it at all.

Ill. 38 Top tube high

Seatng position:
To figure out which seating position the participant preferred, they got two different handlebars they had to ride with and say which they liked the most.

Partial conclusion:
The participants prefer to get an upright siding position because it is more comfortable.

Ill. 39 Siding position

Conclusion

The effective length of the top tube varied from 32-57 with handlebar 1 and from 32-62 with handlebar 2. The average effective length for both handlebars is 42 cm.

The top tube height influenced how the participants entered the bicycle. If it the hight from crank to top tube was lower than 30 cm, they took the leg through the bicycle and if the top tube was over, they took the leg behind the bicycle.

Everyone wanted to sit upright while riding and most of the participants entered the bicycle from the left side.

The **reach length** should be **440 – 455 mm**.

Seat tube studies

Purpose

The geometry study (p. 12) showed that the angle of the seat tube had a great influence on the utilization of the muscle capacity in the legs. Therefore, the seat tube angle was investigate further.

Studies

Based on an article with experiments on muscle activation among other subjects from the Department of Health Science and Technology at the University of Aalborg (Verma et al., 2016) an interview was conducted to elaborate on the matter. The interview with John Rasmussen as well as the article gave scientific data on the optimal saddle height and seat tube angle based on 21 participants (14 males and 7 females) (Verma et al., 2016).

Conclusion

The position of “downward seating position” maximizes the muscle activation and would be the most beneficial seat tube angle as well as saddle height. The seat tube angle should be 73,5 degrees and saddle height 98 % of the neutral position (neutral position were 106 % of crotch height for males and 107 % for females). The saddle height cannot be controlled and was therefore not relevant for the context.

The seat tube angle should be 73,5 degrees to make the best use of muscle capacity.

Bicycle exhinbition

Purpose

While the geometry of the bicycle was investigated, the bicycle exhibition Copenhagen Bike Show was attended to gain insights into the future in the bicycle market, as well as bicycle designers' feedback on the concept. This also resllted in additional information and insights on the process of designing and manufacturing bicycles.

Ill. 40 folder

Experiment

At the bicycle show serial companies were shown and asked to comment theconcept.
Trek saw a great potential within the bicycle types as city-, cargo-, classic- and hybrid bicycles because of their similar riding capabilities. Meanwhile, the MTB and road bicycle would become too performance driven to be involved in the platform.
Both H.F. Christiansen and Trio Bike saw the benefit of minimizing the number of components and especially for companies with low sales numbers mainly because of a minimum order size from manufactures around the world. Trio Bike had a hard time seeing how the cargo bicycle would fit the concept because they already tried and failed (appendix 09)

Lastly, CPH Bike Company enlighted with his knowledge of angles and sizes on his bicycle. His view on the A to B bicycles confirmed former research and test on users wish to sit upright while using everyday bicycles.

Conclusion

The outcome from the bicycle show highlighted elements for further investigation. A business strategy was essential and preferred for a company with low sales numbers both in terms of production and customizability for the customer. With a look into the future, E-bikes are only growing in sale and is the future. Therefore, it was necessary to investigate battery sizes and how to implement multiple sizes into the design of the platform. Furthermore, the cargo bike will be discarded from the concept due to the structural differences compared to the rest of the bicycle types. Lastly, the design of the bicycle in various configurations was important. For example, the saddle could seem misplaced if it is all the way up or down.

- Because the cargo bike variat to much in the construction and shape will it not be a part of the platform.

Updated bicycle geometry

Purpose

This section is an updated version of the Bicycle Geometry section on page 12 and will elaborate on already mentioned elements of the bicycle geometry as well as new elements.

parameters as wheelbase and trail are not included in this section due to not being controlable in thedesign of a frame. They will defer relative to other parameters such as shape of the fork.

Previous mentioned parameters:

Seat Tube Angle

Based on former desktop research alongside with an interview with John Rasmussen (p. 32) an angle of 73.5 degrees was chosen. Commonly used angle are 73 degrees but research on muscle exploitation stats 73.5 degrees as the ideal angle.

Chain stay

The chain stay length main function are to provide stability to the bicycle and varies between 380 and 420 mm across different non-electric bicycle types (Appendix 10).

Roadbike	400-415 mm
MTB	380-400 mm
City bike	380-410 mm
Classic bike	420 mm

To accommodate for the different bicycle types, different wheel sizes and the size of the motor, a chain stay length of 458 mm was chosen.

Bottom Bracket (BB) drop

On road bicycles stability are prioritized over pedal clearance over obstacles. For road non-electric bicycles the BB drop typically are 78 mm. As stability is an important factor as well as pedal clearance while having a centered motor a BB drop of 75,3 mm was chosen.

Slack angle

Slack angles across bicycle types does not vary much and are typically between 72 and 74 degrees. The slack angle influences the stability and handling, especially while at higher speeds. A slack angle of 73 degrees was chosen.

Stack & Reach

Based on frame size test (see p. 30) and desktop research (Appendix 10) a reach length between 440mm and 455 mm was chosen.

New parameters :

Seat Tube profile

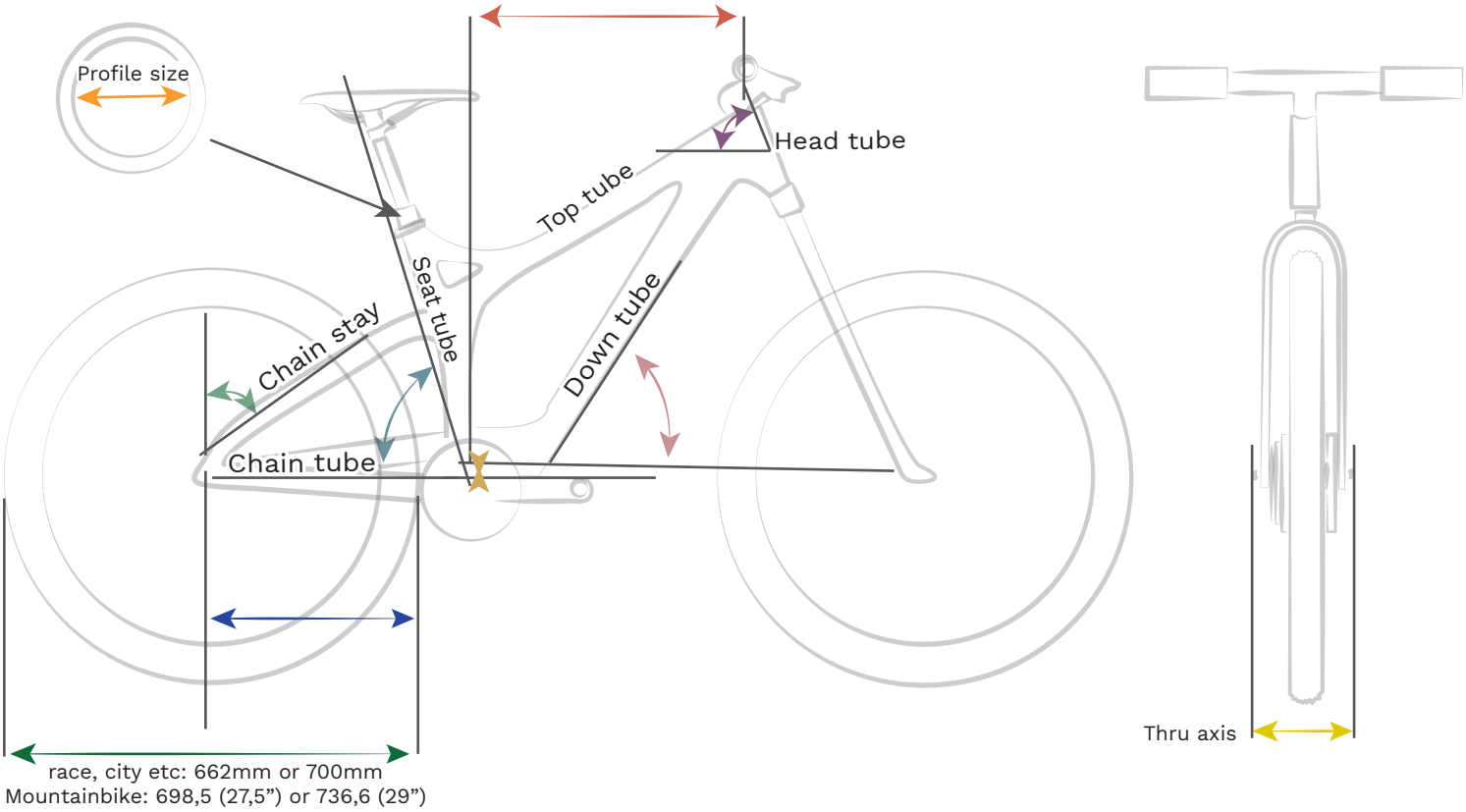
The seat tube inner diameter is suited for the saddle stem size that is sold in the highest number and is therefore 27,4 mm.

Thru Axle length

To accommodate for multiple sizes of wheels from road to MTB, the thru axle length should be determined. Thru axles attach to the frame by different methods but does not defer much in width. A thru axle length of 120 mm enables both MTB and road bicycle wheels to attach.

Down Tube angle

The angle of the down tube determines the entrance point and wheelbase. The longer the wheelbase, the better stability but more difficult to handle. The down tube angle varies from 45 degrees to 59 degrees on different bicycle types depending on use purposes. An angle of 45 degrees was chosen for concept to create the greatest entrance point as well as keeping the wheelbase short. The wheelbase is kept short because the chain stay length makes it longer than normal.



Ill. 41 Bicycle geometry 2

Conclusion

The basic structural parameters of the frame was set in theory but to confirm them in pracis a bicycle frame with the before mentioned measurements were constructed and tested on participants of various heights and sizes.

The **seat tube inner diameter** has to fit to the highest number of saddle profile: **27.4 mm**

- To accommodate for the different bicycle types, different wheel sizes and the size of the motor **the chain stay length should be 458 mm.**
- **The thru axle length was set to 120 mm** which enables both MTB and road bicycle wheels to attach.
- **The down tube angle should be 45º** to create the greatest entrance point as well as keeping the wheelbase short.

02 Design brief

Based on the initiating 'understanding' and 'problem specification' phase. This design brief is presented to provide a summary of all the findings that the section has brought:

PROBLEM DEFINITION

"How do we design a bicycle platform that simplifies the design and manufacturing process of everyday bicycles"

Summary

In the 'problem specification phase', it was proven by three different proofs of concept that the users looks more at wheels, handlebars, saddle, etc. than the frame itself when they categorize a bicycle.

In addition, it was investigated how the concept could stand out in the market and what type of mass customization would be relevant to use.

Finally, the structure of the bicycle was further investigated to find out how much of it could be standardized.

The result of this are the following findings:

Important points

- Lightweight - possible to drive without help from motor. (p. 16)
- Primary use of A to B transportation.

Geometry requirements

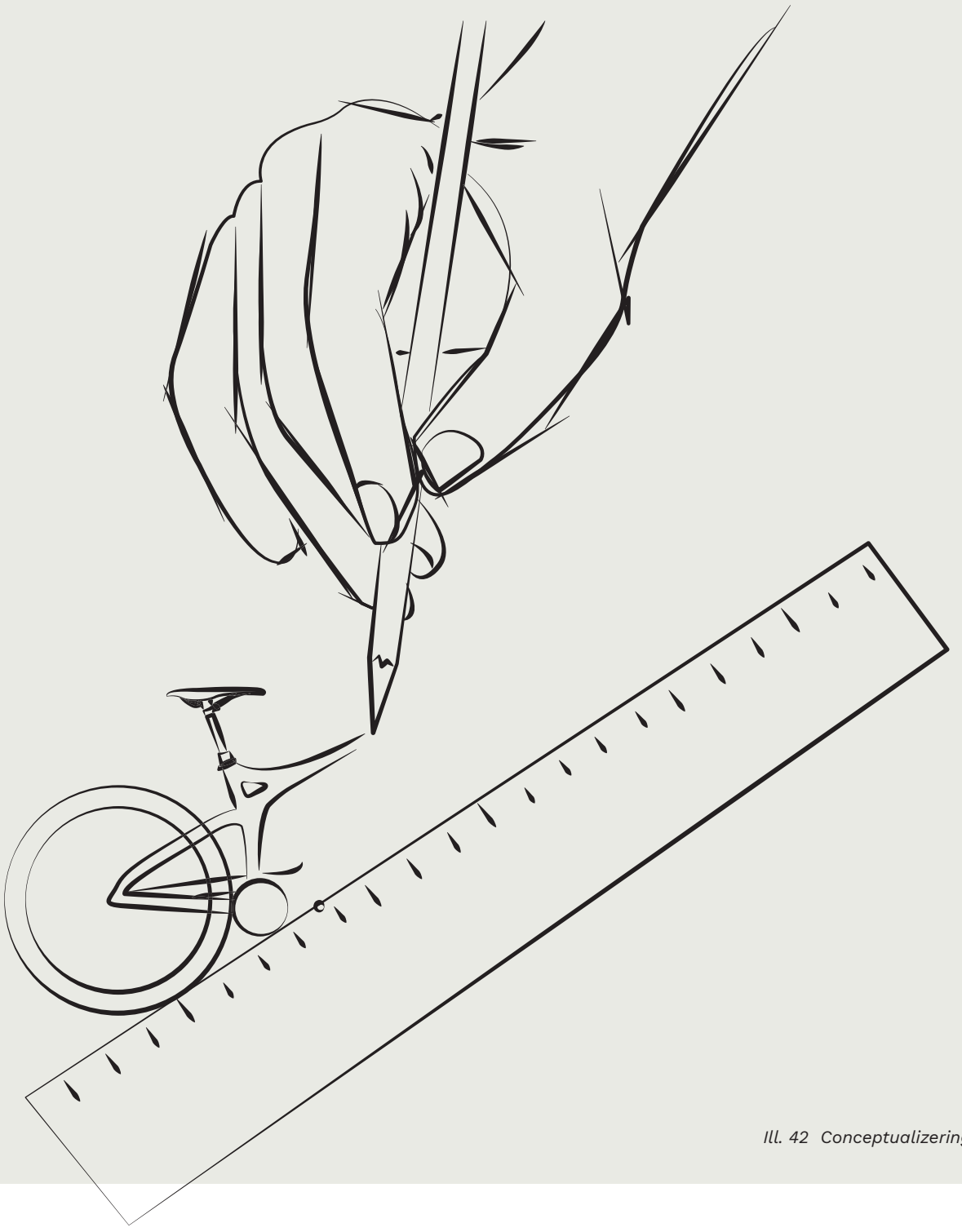
- Slack angle = 72 - 73° (page 12)
- the chain stay length 458 mm (p. 34)
- seat tube inner diameter need to be 27.4 mm (p. 34)
- The thru axle length is 120 mm (p. 34)
- The down tube angle is 45 º (p. 34)
- The seat tube angle should be 73,5 degrees (p. 32)
- The reach length should be 440 – 455 mm. (p. 31)

Requirements

- Must be electric (p. 16)
- Space for 2 independent brake systems (p. 15)
- Frame must not shield for retrofitted reflectors. (p. 15)

04 Conceptualizing

The fourth phase is the conceptualizing phase. In this phase, various tests will be made with a focus on feedback from users and sketching on the frame. This phase will also provide greater insight into the ideas behind the concept.



Ill. 42 Conceptualizering

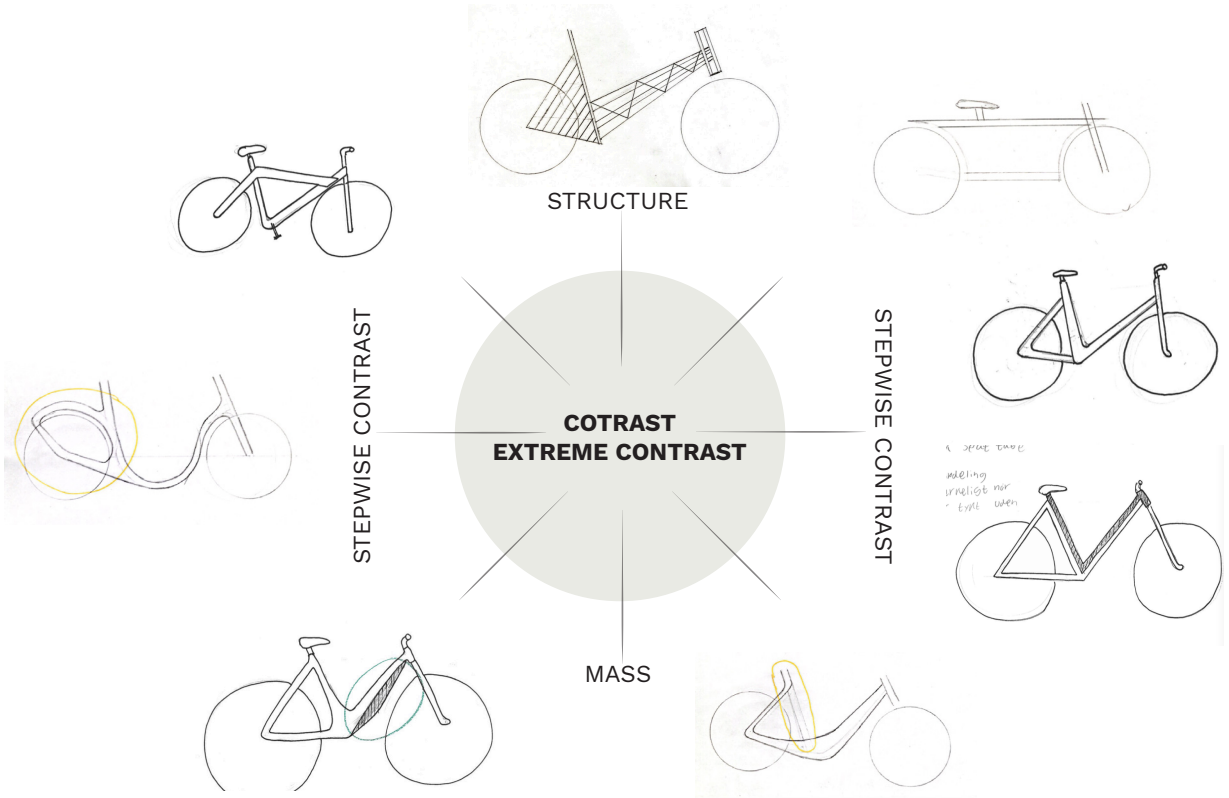
SKETCHING

Purpose

As the bicycle needs elements from five different bicycle types and suit the user groups of these, the bicycle aesthetic needed detailing and structured development. To structure this process, the book of Thomas Jaeger and Linda Nhu Larsen Formgiv, giv form (Jaeger et al., 2022) was used.

Experiment

The book describes different steps to work with shaping of a concept and thereby working at a detailed level. Three of the book's steps were used during this process
First step was to design the bicycle as a 'one unit design', 'two-unit design', 'three-unit design' and 'multi-unit design'.
Second step to to design the bicycle 'structural', 'mass' and a 'combination of structural and mass'.
Third step was to design the bicycle as a 'geometric unit', 'organic unit' and a 'combination of geometric and organic'.



Ill. 43 Form circle

Conclusion

Through evaluation of the concept sketches each sketch was marked either usable, non-usable or potential elements that could be used in other ways than illustrated. As seen in illustartion 43 elements were highlighted in the sketches and should be incorporated in the final concept. The element was:

- Material/color changes mark function
- Joints incorporated in the form
- Joints are either smooth or a design feature
- Connection in design throughout the frame
- Division in the separated frame make sense
- Simplicity
- No bullshit in the design language – it is the
- components that must take the focus not the frame
- Components define the bicycle type (the frame does not)
- Sharp lines create speed
- Size/material differences makes the frame lighter (it is hovering)

The outcome of this method were two concepts that then could be 3D modeled and presented to users for feedback.

3D MODELING

As an extension of the outcome of the method sketching, the two concepts were modelled in 3D.

01 FEEDBACK ROUND

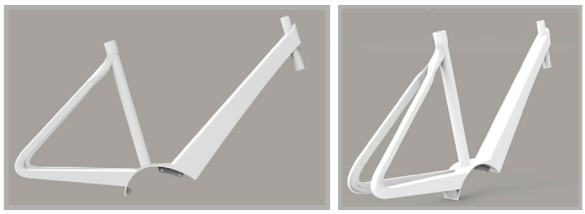
Purpose

The purpose of the user feedback session was to gather information about what the users like and dislike about the concepts. What works and what does not? As well as for which bicycles the concepts work.

Experiment

Contradictive comments were stated on both frames such as “Frame 1 looks too fragile and thin” and “Frame 1 looks more like a mountainbike in the back” and “Frame 2 looks wired and too soft for the MTB” and “The mountainbike looks too bulky and heavy with frame 2” (Appendix 11).

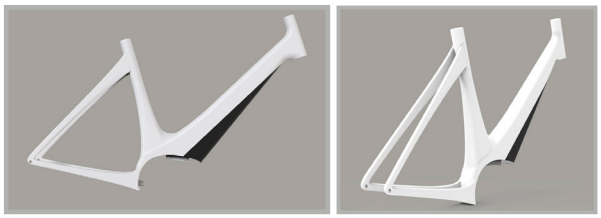
Frame 1:



Ill. 44 Feedback - frame 1

- Looks universal and budget, but not Bilka
- Looks too fragile and thin
- Looks more like mountain bike in the back
- Looks big for the road bike

Frame 2:



Ill. 45 Feedback - frame 2

- Likes the 2nd frame more and it looks more expensive with better finish and like someone spend more time on designing it
- Looks wired and too soft for the MTB
- Likes the shape and profiles on the back triangle of frame 2
- Likes the design of frame 2 better especially for the classic bike and the road bike
- Looks too curvy and big for the MTB and Hybrid.
- It should like more aggressive
- Suits the road bike better even though it is thicker
- MTB look too bulky and heavy

Comparison comments on both frames:

- The connections of frame 1 looks smoother and connected and would work better on frame 2
- Frame 2 is more organic in the front but the connection at the seat tube and seat stay from frame 1 suits the design better

Conclusion

Generally users reacted positively to the curved frame and frame 2 were described as futuristic and modern. On the other hand, it was described as more feminine which worked best for the city and classic bike, while comments as “too bulky” for the MTB and Hybrid were mentioned.

As a guideline for a new frame proposal, a middle-ground between curved and geometric should be investigated. A common ground between the robustness of frame 2 and the simplicity of frame 1 as well as the connection point between seat tube and seat stay from frame 1 should be incorporated into the new frame proposal.

Battery and motor

Purpose

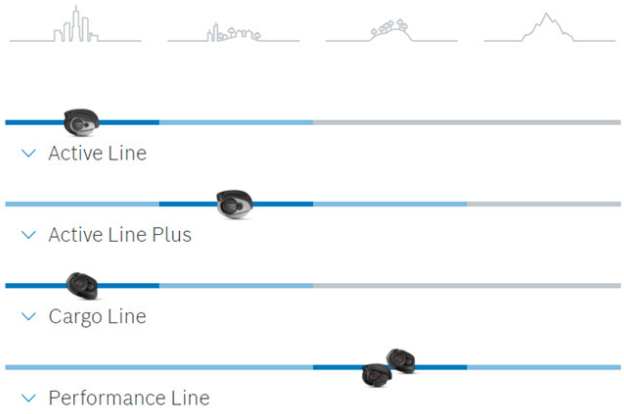
As it was chosen to limit the concept to E-bikes it was necessary to choose which motors and batteries the concept should be compatible with, to the scope and to be more specific and detailed.

Motor and battery criteria

When choosing batteries and motors the main criteria were to pick a brand of high quality and with a wide range in price and performance. From previous interviews with bicycle mechanics (Appendix 03) and the meeting with Morten from Butchers and Bicycles (Appendix 02), it was clear that a mid-drive motor would be the best choice. The battery had to be an integrated battery to achieve the desired aesthetics.

Why BOSCH?

BOSCH eBike Systems were chosen because they meet the criteria of being high quality and making reliable components in a wide performance range, that are all compatible with each other. Their batteries range in capacity from 11 Ah to 16,7 Ah, while their motors range in maximum torque from 40Nm to 85 Nm. Additionally, all the motors are made in two versions, one compatible with hub gears and one compatible with derailleur gear (Bosch, n.d.).



Ill. 46 BOSCH motor overview

SPECIFICATION:

Voltage: 36 V
Capacity: 11,0 Ah
Energy content: 400 Wh
Weight: 2,9 kg

Ill. 47 PowerTube 400

SPECIFICATION:

Voltage: 36 V
Capacity: 13,4 Ah
Energy content: 500 Wh
Weight: 2,9 kg

Ill. 48 PowerTube 500

SPECIFICATION:

Voltage: 36 V
Capacity: 16,7 Ah
Energy content: 625 Wh
Weight: 3,5 kg

Ill. 49 PowerTube 625

Conclusion

The choice was made to limit the concept to only be compatible with BOSCH eBike Systems motors and Power Tubes. The next step in the concept development was to analyze the geometry and interfaces of BOSCH motors and Power tubes.

Solution should be compatible with BOSCH eBike Systems

BOSCH INTERFACE

Purpose

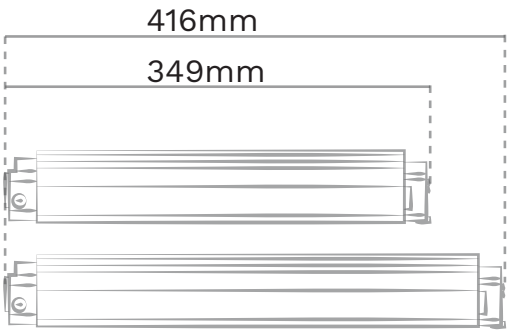
After figuring out which motor the concept should be convertible with, the different interfaces for all BOSCH motors and batteries were investigated, so that solutions for adapting the bicycle frame to all interfaces could be developed.

Data

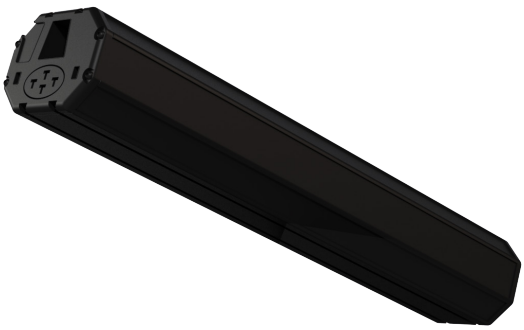
It was not possible to obtain any technical data or measurements of the interfaces from BOSCH, as it is only shared with partners and customers. Instead, the mapping was based on outer dimensions and illustrations from BOSCH's website (bosch, n.d.), that were used to muck up the different motors and batteries in 3D.

Battery

All PowerTube batteries has the same interface and profile, with the length being the only varying factor. It would therefore be possible to make a solution with adjustability to compensate for the varying lengths.



Ill. 50 PowerTube dimension



Ill. 51 PowerTube

Conclusion

Due to this mapping being based on illustrations the measurements are inaccuracy to the real scenario but gave a fair view of the different interfaces and what would be possible. An adjustable solution for the battery and an adaptor for motor type 2 will have to be explored, however the exact solutions will be dependent on the geometry of the frame.

Motor

When comparing the motors, it became clear that BOSCH has two different motor designs with different interfaces. One motor design was smaller than the other meaning that it was possible to design the bicycle frame with an interface for motor type one, and with an adaptor for motor type two.

Type 1

Ill. 52 Active line, Active line+ & Performance line.

Ill. 53 Type 1 interface.

Ill 54 Type 1 on bike.

Type 2

Ill. 55 Cargo line, Active line speed & Performance line CX.

Ill. 56 Type 2 interface.

Ill. 57 Type 2 on bike.

3D models

Ill. 58 Active

Ill. 59 Performance.

- An adjustable solution is needed for the battery.
- An adaptor for motor type 2 is needed.

Battery interaction

Purpose

Since the battery is incorporated, it was necessary to test how the user should interact with the battery and where on the down tube the battery access should be.

Adjustable mechanism

To adjust for the varying battery lengths a solution with a spring to hold the battery in place was proposed.

Ill. 60 Spring mechanism

Battery access test

The battery access was tested with users that had to simulate changing the battery on a cardboard mock-up, with access from both sides, bottom and top.

Ill. 61 Bicycle muck-up for testing

Battery access top

Ill. 62 Battery access top.

Pros/cons:

- Easy to see what you are doing
- Accessible from both sides
- possible to use both hands

Battery access side

Ill. 63 Battery access side.

Pros/cons:

- Hard to see what you are doing
- Possible to use both hands

Battery access bottom

Ill. 64 Battery access bottom.

Pros/cons:

- Hard to see what you are doing
- The wheel are in the way
- not possible use oone hand

Conclusion

The tests showed that the most comfortable interaction for the user would be to have the battery access on the top of the downtube. The next step for the battery would be to test the spring solution and explore other possibilities, as well as explore the shape and aesthetics for a battery lid. It was therefore important to further explore the overall aesthetic and shape of the bicycle frame, to achieve a coherent design.

- More focus on the overall design language and form were needed

Form analysis

Purpose

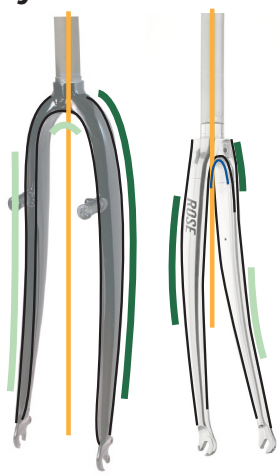
The purpose was to analyze the design language of different bicycle types to better understand how to make a platform that would work aesthetically across bicycle types, and what users perceive as high quality.

Analysis of forks

The form language of three different forks were analyzed as this is one of the large varying components that all should fit to the platform.

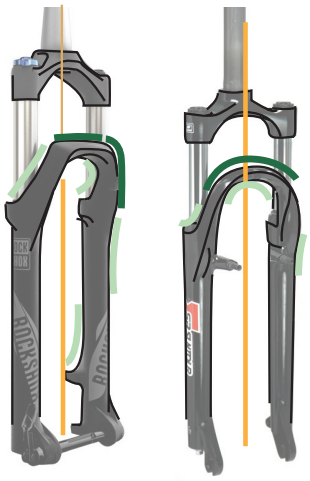
Symmetric Concav Concvex

Citybike fork



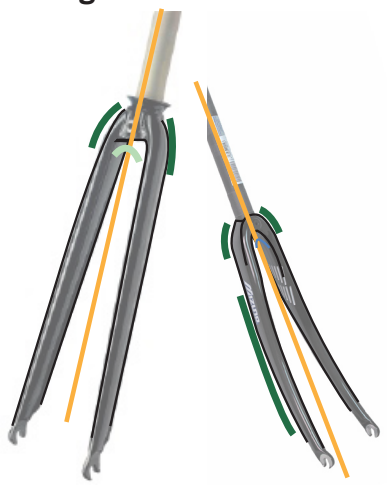
Ill. 65 Form analyse//city

MTB fork



Ill. 66 Form analyse//MTB

Racing fork



Ill. 67 Form analyse//Racing

Perceived quality

To understand what users, associate with high quality besides external components participants were showed five different bicycles and asked to range them after quality and comment on their choices. More data can be found in appendix 12.

The data showed that detailed connection, smooth transitions, and the fewer standard profiles were used resulted in a higher perceived quality.

Low quality → High quality

Ill. 68 Bike 1

Ill. 69 Bike 2

Ill. 70 Bike 3

Ill. 71 Bike 4

Ill. 72 Bike 5

Conclusion

The form language varies a lot for the specific forks, so to make one platform that would work for all forks the logical approach would be to make a natural frame that does not become the focus point of the bicycle.

It was therefore decided to keep the overall geometry simple and close to minimal, while some profiles and transitions could be detailed to heighten the perceived .

- The overall geometry should be kept simple.
- Transitions and profiles should be detailed.

02 Feedback round

Purpose

Based on feedback from the first two 3D models and previous tests, a new version of the bicycle frame was modeled.
The purpose was to show the latest iteration of the bicycle frame to the users and get feedback for further development.

Experiment

The new version of the frame was then photoshopped as six different bicycle types and shown to users for feedback. All feedback can be found in Appendix 13.

Ill. 73 02 Feedback round

Ill. 74 Feedback round 2 - side

Ill. 75 Feedback round 2 - Perspevtive

Comments for improvement

- Something looks strange with the bend on the top edge of the downtube.
- Could have a better coherency in the design language between back and front.
- The battery cover looks like a cheap solution at the top.
- The wheels looks to small for the MTB and hybrid bike.

Conclusion

The feedback was generally positive; however, it was clear that more coherency between the back and front were needed. Most people also commented on the slight bend on the down tube and the top end of the battery lid. These comments were taken into consideration for further development.

It was also noted that the feedback was very dependent on personal preferences, and it would make sense to ask the same users that was positive about the design for further feedback rounds. The new frame as well as the feedback and the previous findings were subsequently presented to Morten from Butchers and Bicycle.

Supervison with Butchers & bicycles

The supervision with Morten Mogensen from Butchers and Bicycles helped point out some of the aspects that needed to be clarified and detailed further and gave some critical information of the bicycle industry. The main takeaway was that more focus was needed on who the concept benefits, and who the target company could be.

The most common design process of bicycles was explained, where all parts including frame are chosen from a big catalog and ordered from Taiwan where most bicycles are produced. An important information was that the lead time for ordering parts from Taiwan can be up to 2,5 years. This means that as the market is now, bicycle companies will have to know how many bicycles of each type they can sell almost three years in advance. All notes from the supervision can be found in appendix 14.

Value chain

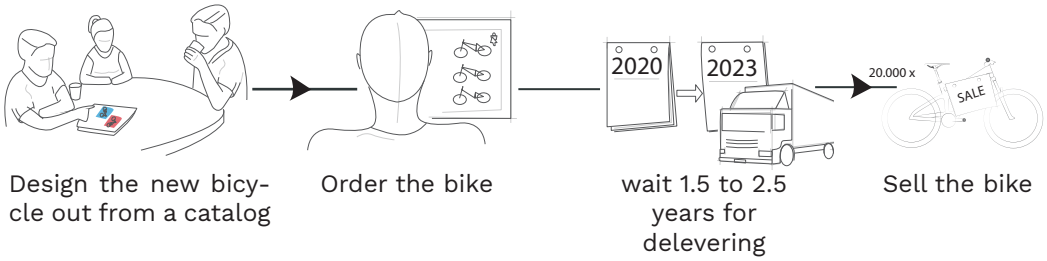
Purpose

To figure out what companies' development process of bicycles is and what value the concept provides and to who?

Experiment

Different development processes was mapped to see where it made sense to implement the concept

Process 1:



Ill. 76 Design proces 1

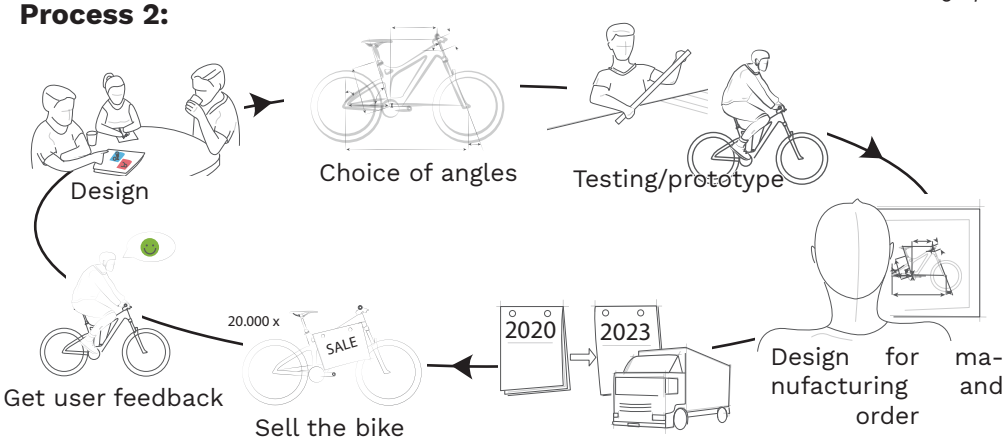
Pros

- Low development price

Cons

- High risk for residual stock

Process 2:



Ill. 77 Design proces2

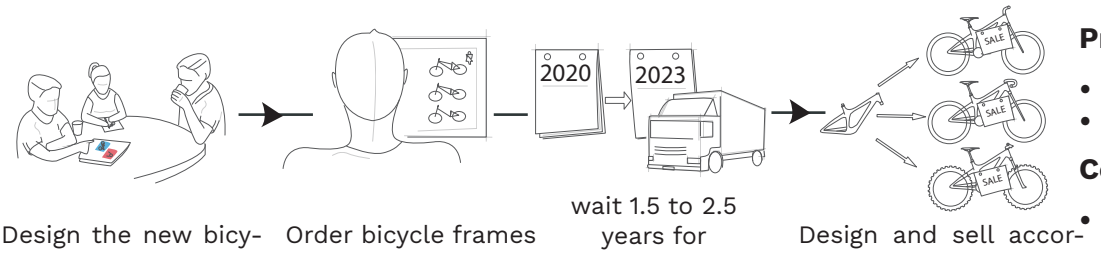
Pros

- User and performance orientated bicycle

Cons

- High risk of residual stock
- High development cost

Our concept



Ill. 78 Our concept design proces

Pros

- Low risk of residual stock
- Low development cost

Cons

- Expensive to bypass platform

03 Design brief

Based on the 'Conceptualizing phase' the design brief is presented to provide a summary of all the findings that the 'conceptualizing phase' has brought:

Summary

In the 'conceptualization phase', different ideas have been investigated to figure out what worked and what did not work. It resulted in two feedback rounds and analyzes of existing bicycle accessories and frames.

It was conducted which battery solution the frame should be compatible with, and which interaction path is best for its implementation.

In the end, the concept's value chain were ilustrated including what pros it gives. The result of this is these requirements:

Important points

- An adjustable solution is needed for the battery
- An adaptor for motor type 2 is needed
- Transitions and profiles should be detailed
- More focus on the overall design language and form were needed
- The overall geometry should be kept simple.

All requirements:

Geometry requirements

- Slack angle = 72 - 73° (page 12)
- the chain stay length 458 mm (p. 34)
- seat tube inner diameter need to be 27.4 mm (p. 34)
- The thru axle length is 120 mm (p. 34)
- The down tube angle is 45 º (p. 34)
- The seat tube angle should be 73,5 degrees (p. 32)
- The reach length should be 440 – 455 mm. (p. 31)

Requirements

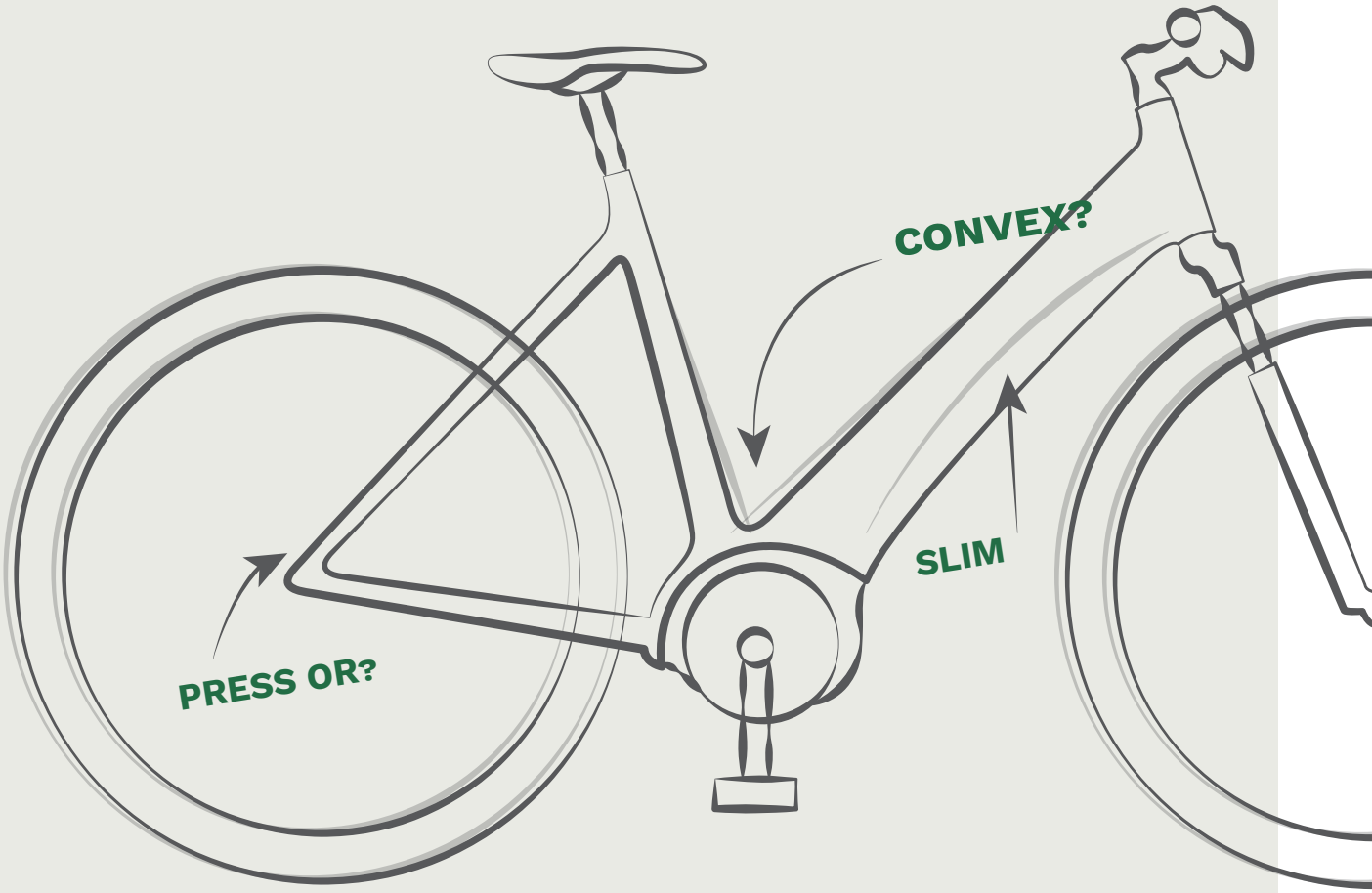
- To be electric (p. 16)
- Frame must not shield for retrofitted reflectors. (p. 15)
- Space for 2 independent brake systems (p. 15)
- Solution should be compatible with BOSCH eBike Systems (p.40)

Statusseminar 2 - Feedback

At the statusseminar all groups supervisor and co-supervisor were present which gave a broader focus on the feedback but kept concretely on the concept. Comments as 'What are the success criteria?' and 'when will the frame be good enough?' were giving alongside with 'Why should customers buy THIS bicycle compared to any other bicycle on the market?' These comments led the group to conclude that the user perspective of the concept was not focused enough upon. Lastly, it was questioned how the bicycle would look when components are changed.

05 Detailing

The fifth phase is the ‘detailing phase’. In this phase the concept will be matured trough further investigation of the user needs related to aesthetics, and investigated materials, manufacturing, and FEM analysis. Furthermore the phase contains a reframing at the end.



Ill. 79 Detailing

BUISNESS USER VALUE

Purpose

To explore and discuss how different business strategies could bring value to the different stakeholders, with great focus on the user value. More awareness on the values of the concept could also help frame the project.

Business considerations

Six possible business strategies/scenarios were set up in a table and divided into pros and cons for the four main stakeholders, user, storage, supplier, and designer. The table was mostly used as a point of discussion and a tool to start reflecting on the consequences of different business strategies.

		ADJUSTABLE (Mass customization)	STATEMENT (Unique frame)	NEEDS CUSTOMIZATION (Limited costumization)
PROS	USER	• Adjustable to individual • Always available • Easy to change component • Unique bike = Unique personality	• Unique bike = small user group • High end segment (High quality) • Statement (aestetic)	• Controlled uniqueness • Adjustable to individual (performance) • Needs customization (extra equipments)
	STORAGE (assembly)		• Low storrage capacity	• Medium storrage
	SUPPLIER (Taiwan)	• Less production supervision (Only need to check production)		
	DESIGNER (Company)		• Controll over the design • Limited B2B • Brand loyality	• Controll over the design
CONS	USER	• Too many user options • Long delivery time • Expensive (assembly time) • Need to know needs • Cant try the bike before	• High end = More user requirements • Risk of out of stock	• Expensive (assembly time) • Need to know needs • Cant try the bike before
	STORAGE (assembly)	• Logistic nightmare • Big storrage • Local production (surface treatment) • Expensive		• Medium storrage • Order assembly
	SUPPLIER (Taiwan)		• Expensive production • More supervising • Expensive (Smaller market)	
	DESIGNER (Company)	Uncontroled design (Brand) Difficult to start up (Branding)		• Difficult to start up (Branding)

Business strategy based on needs customization.

Conclusion

It was concluded that the business strategy that benefited most stakeholders and added most value to the users would be **needs customization.** The business strategy would be to give the users a limited option to customize the bicycles based on needs, such as which motor, battery, seat, handlebar, and color they want. The decision was made through discussions on the six strategies and how the strategy could benefit the customers.

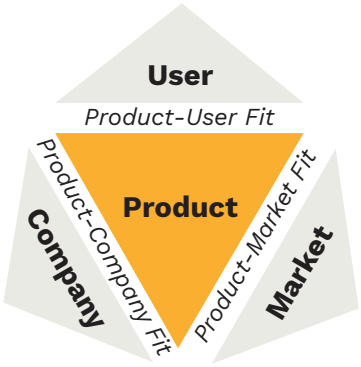
RETURN SYSTEM (Swap to new bike)	CHEAP REPAIR (For user)	STANDARD BICYCLE (Pick and buy)
• Chose cheap option • Sustainable (feeling) • Easy	• Cheap in long term • Easy to repair • Easy to upgrade	• Pick and buy
• Reuse components	• Low storrage capacity	• Low storrage capacity
• Controll over the design • Brand loyality	• Brand loyality • Modularity	• Controll over the design • Cheap (Modular) • Small design process • B2B
	• Expensive components • Limited choices	• Non pros for user
• Expensive • Big storrage • Big logistic		
• Quality controll of returned bikes • Frame can be outdated	• Design special components • Expensive design process	• Big competition

Ill. 80 Business value

Strategic fit

Purpose

After figuring out what user value the product should provide, the concepts strategic was analysed. The purpose understand competitive advantages and credibility regarding Product-User Fit, Product-Market Fit and Product-Company Fit. These aspects are vital to enhance strategic strengths and achieve a strong market position.



Ill. 81 Strategic fit

Product-User fit

To achieve a strong Product-User Fit it is important that the product fulfills one or more user needs. As discovered in User-mapping (p. 18) needs for an A to B bicycle varies from user to user. Choosing a needs customization business strategy could therefore give the user the option to customize the product to their needs (p. 48) resulting in a strong product-user fit.

The car industry is an example of an industry where this user customization approach is used effectively to enhance Product-User Fit, with companies such as Tesla (Tesla, n.d.) where the user has limited choices to customize and build their own car on a website.

To further strengthen the Product-User Fit it became clear that more focus on users' latent needs were needed to understand which visual details makes the user chose different types of bicycles over another.

Product-Market fit

A strong Product-Market Fit can give competitive advantages and result in users choosing a product over a competitor's product. Building upon the strengths of needs customization, could be used to achieve a unique market position. The modularity and platform approach could also open for a unique service and sales experience controlled by internal sales channels or strategic partners.

From a brief examination of the market, it was clear that companies with customization options do exist, but only within a small segment either specialized in one type of bicycle or few components (Appendix 15). To better understand strengths and competitive position on the market, it was clear that a mapping of competitors was needed.

Product-Company fit

The product should align with the company's core values, competences and strengths to achieve a strong Product-Company fit. When reviewing the strategic fit and business strategy, it became apparent that building the whole business strategy around the platform was necessary for a strong Product-Company fit.

Earlier in the process the concept of a bicycle platform was seen as a valid case that could benefit existing small sized bicycle companies. However, the small sized companies that earlier was identified as a company fit, did not have core values that aligned with the strengths of the platform. The decision was therefore made to further develop the project as a start-up company.

Conclusion

By analyzing the concepts strategic fit, it was clear that a needs customization business strategy was aligned with utilizing the product strengths of a modular platform and would be a viable approach. It also became apparent that analyzing the users discission of choosing one bicycle over another, and mapping competitors could help further strengthen the strategic fit.

- In depth analysis of user decisions for choosing bike was needed.
- Mapping of competitors was needed.
- The project will be developed as a start-up.

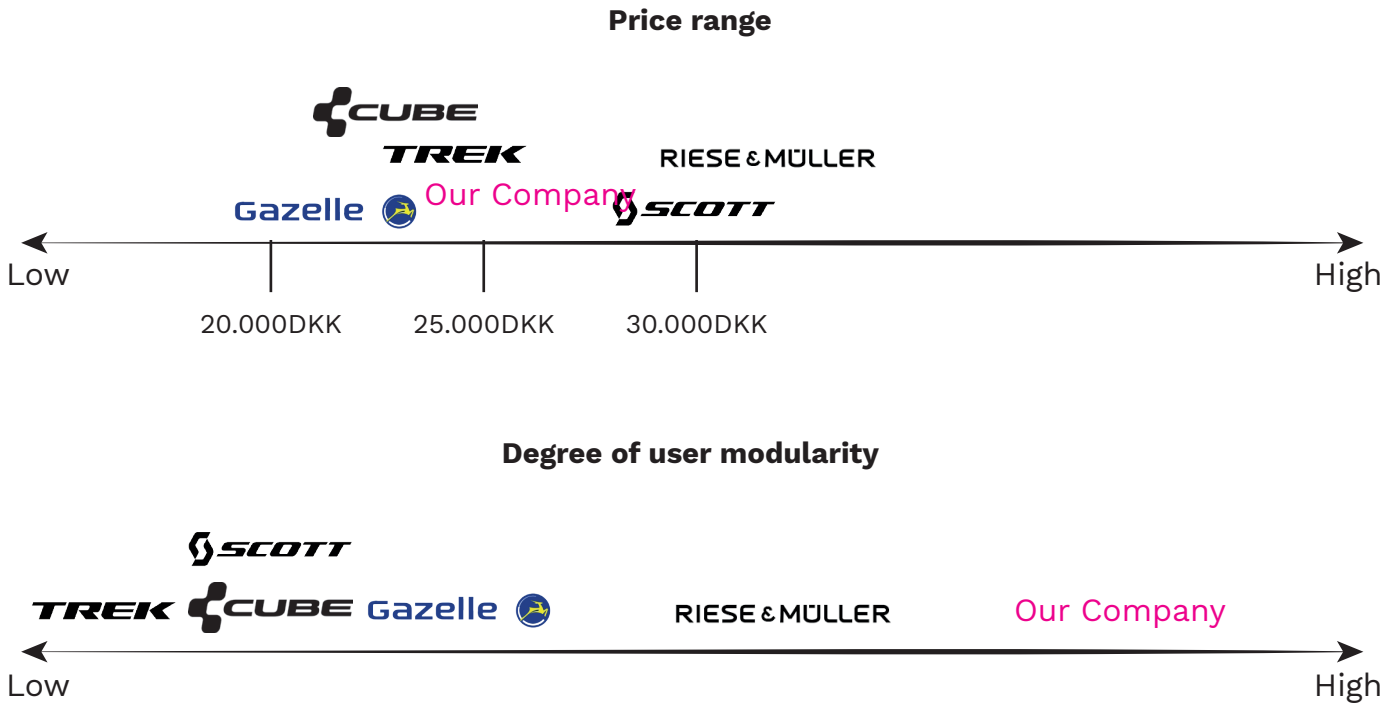
Competitor mapping

Purpose

A mapping were made of existing bicycle companies to better understand the concepts market position compared to established brands and utilize the strengths.

Mapping

Five of the market leaders for A to B e-bicycles in Denmark, RISE & MÜLLER, SCOTT, TREK, CUBE and Gazelle, were mapped on price, and degree of user customization. The mapping was based on information from their websites, and the pricing was based on city bikes. It was then evaluated where our company and concept would be placed compared to the competitors.



Ill. 82 Competitor mapping

Conclusion

Mapping competitors made it clear that the general price range were between 20.000 and 30.000 for an electric city bicycle. It was evaluated that it would be realistic to aim for the same price range as the concept are similar quality of motor and battery.

It was also important to not be too expensive compared to the competitors, or too cheap where the price might lower the quality perception. Instead, it was clear that the degree of modularity would be the strong selling point and give a unique market position.

Physiscal bike frame

Purpose

Previous research (p. 34) and tests (p. 30) showed that it in theory would be possible to make one size bicycle frame that would fit most users in varying height.

To test this thesis in practice a bicycle frame with the concluded measurements were made, to test op people.

Experiment

With the measurements from Updated Bicycle Geometry (see p. 34) a bicycle frame was welded from parts of used bicycles and standard steel profiles. The frame was made with the ability to adjust seat and handlebar height and two different handlebars to fit participants individually needs and wishes.

Ill. 83 Physiscal test bike

13 participants ranging from 162 cm to 202 cm in height rode the bicycle and commented on the riding experience including turning, handling, comfort and size. For all comments from participants, see appendix 16.

None of the participants commented on anything wrong with the size of the frame and participant stated that it drived as good or better than their everyday bicycle. A male participant of 202 cm in height mentioned the 1st handlebar made it difficult for him to make sharp turns because of his knees came in the way.

> ***Feels very natural to drive on,***
> ***The turning is good***
> - Male 1.94 m

> ***Likes the bike and I think it drives fine***
> ***The size is good and I do not think anything feels off***
> - Female 1.62 m

> ***It doesn´t steer that good***
> *Lower the handlebar*
> ***Now is the steering is like my bicycle***
> - Male 1.82 m

> ***This is an awesome bicycle, it drives really well***
> - Male 2.02 m

> ***Something is off***
> *moves the seat a bit higher*
> ***It works very well***
> -Female 1.64 m

> ***It is just as good as my own bike if not better, because i need a new chain on my bike***
> - Female 1.64 m

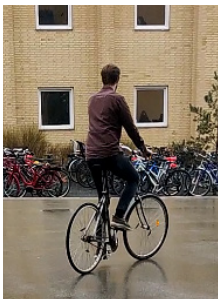
Conclusion

The experiment confirmed the hypothesis that users does not notice the size of the frame and that participants of all sizes could use the same frame except for the 1st handlebar to the male participant of 202 cm height. The scope of the project was therefore limited to a standard size frame recommended for persons between 160 to 195 cm.
None of the participants pointed to any critical aspects of the frame and by adjusting seat- and handlebar height and change handlebar, all participants could find a configuration that suits their needs and wishes.
For the handlebar height, it was noted that when participants were asked to adjust the height themselves, they preferred a high handlebar. However, when they were given a height and asked after a test ride, all participants said the height was perfect. This stat that most users does not pay attention to the handlebar height and often comfortable with what is given.

Test










Ill. 84 Physiscal bike test

User type test

Purpose

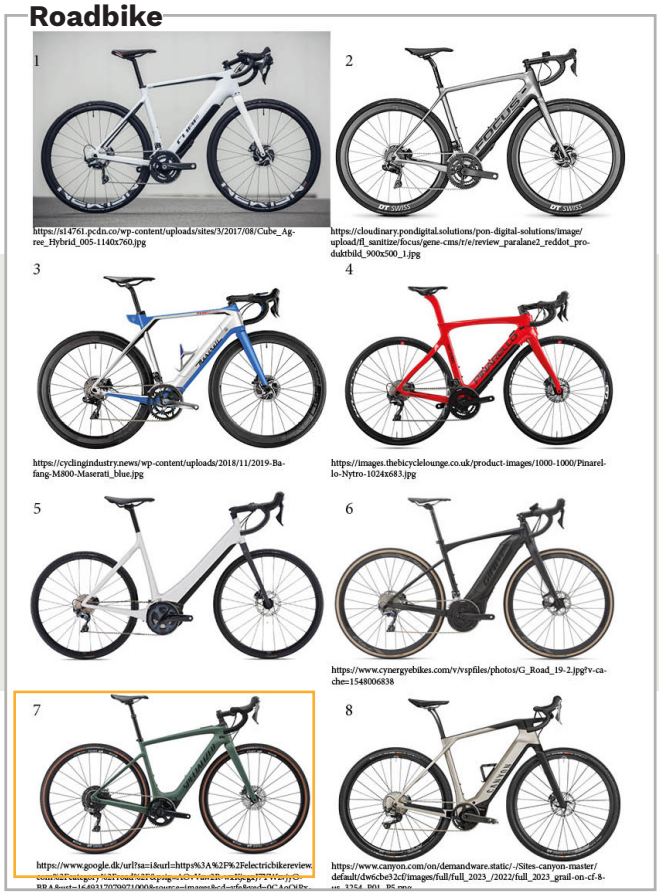
When the theory was confirmed that a bicycle could fit several different size users, it then had to be investigated more detailed how a frame could fit several different types of users purely aesthetically. To understand what the different types of users choose bicycle based on when the practical things are met. Therefore, it has been investigated which design elements distinguish bicycles from each other and which design features users seek in the decision-making process on an aesthetic level.

Investigation

Five product catalogs with each bicycle type were made with eight bicycles each as an offset in interview with users of each category.

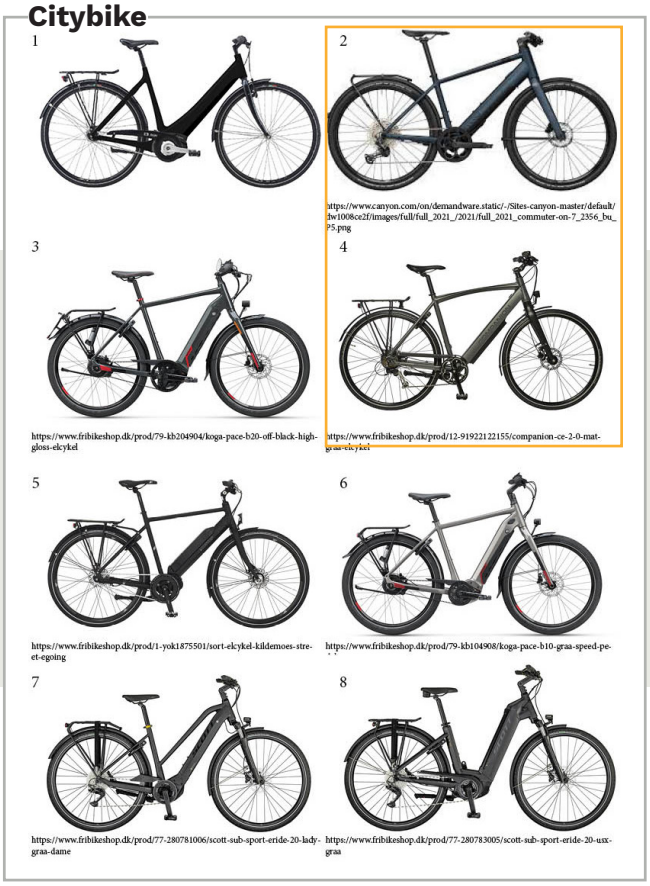
Ill. 85 User type test // MTB

The users of MTB liked gadgets and features such as the rear damper. Stability as well as lightweight looks is important for them alongside a sharp geometry and edges on the frame. A top tube is an essential part of the MTB as it symbolizes stability to the users. Lastly, space for extra equipment are important. The users prefer the 2nd MTB.



Ill. 86 User type test // Road

The users of road bikes associate thin frames with great bicycles. Alongside city bike users, simplicity is important, which means organic sharps without too many details. A key element for the users to associate tith the road bike was a top tube. The users prefer the 7th bicycle.



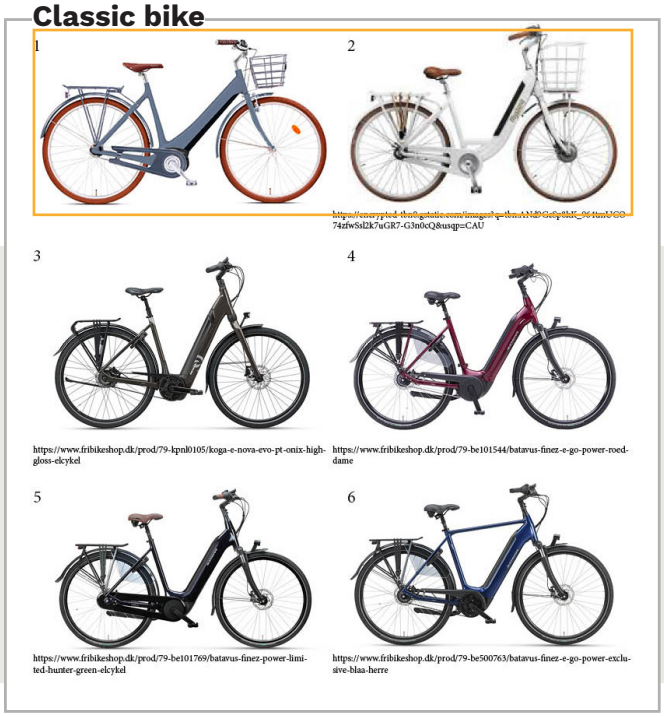
Ill. 87 User type test // Citybike

These users search for simplicity. Profiles should be as simple as possible and preferably without any sharp edges, bend etc. A thin, lightweight looking down tube and invisible battery has high priorities. The city bike should not have any bright details for example bright colors or be packed with gadgets. The users prefer the 1st and 4th bicycle.

Ill. 88 User type test // Hybrid

Users of hybrid bicycles does not look at the features but only aesthetic elements. It is important to have the visual from the MTB but not the features. Colors must be neutral and may not have accessories such as luggage carrier etc. The users prefer the 2nd bicycle.

Classic bike



Ill. 89 User type test // Classic

Users of classic bicycles tend to choose their bikes primarily for aesthetic reasons. Accessories as baskets, comfortable saddle and curvy handlebars are sort after. Coloring and easy excess on the bicycle equally important. Lastly, the users prefer a thin downtube and does not like if “the bicycle looks too clumsy” referring to the top of the down tube. The users prefer the 1st and 2nd bicycle.

Design requirements

MTB

- Space for equipments
- Drive in all terain
- Fast body posture
- Stickers
- Geometric frame

Road bike

- Look lightweigt (thin tubes)
- Simple frame (organic)
- Top tube
- Fast body posture

City bike

- Non gadget (Simple)
- Comfortable bodyposture
- Space for basket
- Round profiles

Hybrid

- Drive in terrain
- Simple frame
- Fast body posture

Classic

- Thin downtube
- Space for basket & luggage carrier
- Comfortable body posture
- Non pensioner wibe
- % Top tube

Recapulation/Quotes

City

”Looks like a woman bike without toptube”

”Looks lightweight”

”Like the simple profile”

Classic

”Looks comfortable”

”Like the basket”

”Easy to get on”

MTB

”Looks like a woman bike without toptube”

”Cool with spring”

”Nice color”

Road/Racing

”Looks like a woman bike without toptube”

”Small tubes, Looks lightweight”

Hybrid

”Looks like a woman bike without toptube”

”Like the color and stickers”

Ill. 90 User quotes

Conclusion

For a city and classic bike, the concept was in line with most of the user’s aesthetics requirements, but for road, hybrid and MTB some essential features were missing. The city, classic and road bike needs more simplicity and thin frames, users of MTB and hybrid wants sharp edges and geometry.

These elements need further work and feedback from users. Furthermore, a top tube is an essential part of the road bike, hybrid bike, and MTB users but not necessary for the city and classic bicycle users.

Top tube

Purpose

As shown in previous user feedback a top tube is an essential part of the identity of some bicycle types. It was therefore investigated of a solution with a removable top tube was possible.

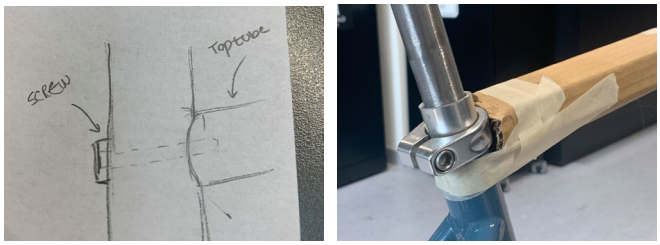
Investigation

The top tube needed to look like an integrated part of the frame while added, and not loom like it was missing when not on. As an inspiration of attachment, other bicycle equipment was investigated such as luggage carrier, bottle holder etc.

Ill. 91 Attachment points

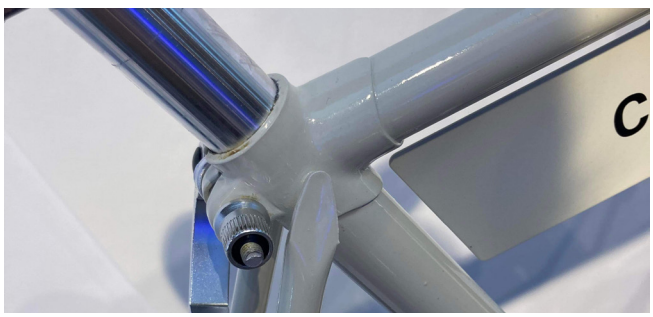
Most everyday bicycles has two insertion holes for equipment different locations on the frame which are used for attaching equipment such as luggage carrier, and has screws inserted when not in use.

A solution was sketched and tested in cardboard.

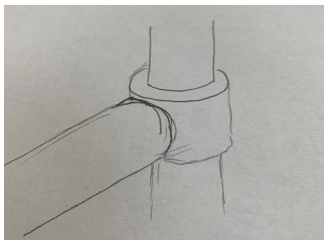


Ill. 92 Top tupe ideas

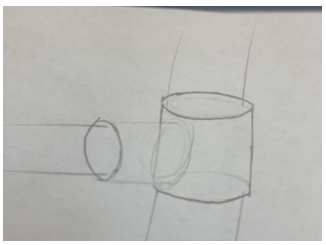
Another solution was investigated with inspiration from a bicycle from Copenhagen Bike Show (ill. 93) both solded and welded. This would be the cheapest solution but did not fit the frames design language.



Ill. 93 Existing attachment



Ill. 94 Top tube idea 1

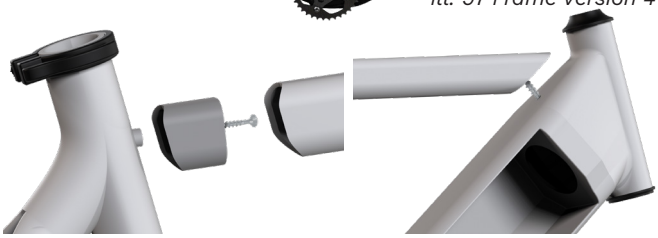


Ill. 95 Top tube idea 2

Ill. 96 Top tube first solution

The first solution was reviewed. By adding other insertion point at the top of the seat tube and top of the down tube the top tube could be attached to the frame by the same method as a luggage carrier. Thereby camouflaging the attachment point while the top tube is not attached. As attachment point to the down tube the top tube are screwed on from the inside. The benefit of a hollow down tube, was that it made it possible to attach the top tube from the inside of the down tube. This attachment method was tested with cardboard models.

Ill. 97 Frame version 4



Attachment to seat tube

Attachment to down tube

Ill. 98 Top tube attachment

Reflection

Another feedback round with users of the bicycle types should be conducted and evaluated if further detailing on the top tube was needed.

2.0 Battery interaction

Purpose

After adding a top tube to the bicycle, it was necessary to reevaluate if it still would be possible to access the battery from the top of the down tube or see if a solution with access from one side were preferred, and which side.

Battery access test

The battery access was tested with users that had to simulate turning a key to unlock and changing the battery on a cardboard muck-up, with access from the top and both sides.

Ill. 99 Bicycle muck-up for testing 2

Battery access top

Ill. 100 Battery access top.

Pros/cons:

- Top tube in the way

Battery access right side

Ill. 101 Battery access right side.

Pros/cons:

- Easy to access with one hand
- Easiest to do from opposite side
- Natural like unlocking a bike

Battery access left side

Ill. 102 Battery access bottom.

Pros/cons:

- Easy to access with one hand
- Easiest to do from opposite side

Conclusion

Due to the top tube being in the way the battery access was changed to be on the right side. The test showed this as the best solution as participants were able to turn the key with one hand and grab the battery with the other. The right side was chosen because this felt more natural with the key on the left side as for most bicycle locks.

Battery access on the right side

Might influence the strength and stiffness of the frame

Make the downtube thinner

Purpose

One of the user wishes (p 59) was to make the down tube look as thin as possible. Since the physical size of the downtube cannot change because it must be able to contain a Bosch battery, it was therefore investigated how the downtube visually could seem thinner.

Investigation

The fourth step in Formgiv, givform (Jaeger et al. 2022) is transitions and details which could make the frame seem thinner.
A 3D model of the frame was colored and divided in different ways to see what effect it would have. A parallel line through the down tube had the most potential but required more work.

Ill. 103 First color test

Ill. 104 Second color test

Ill. 105 Third color test

As the next step, pictures of the bicycle in perspective were printed and sketched upon in order to make quick ideations on ways to create a thinner down tube.

Ill. 106 Thinner down tube test 1

Ill. 107 Thinner down tube test 2

Conclusion

Illustration 106 had the greatest potential which let to integrating it into the 3D model. A new feedback round with users of the bicycle types should be conducted to evaluate further if the detailing made the down tube seem thinner.

Feedback on thickness of frame and top tube

Purpose

After changing the frame in relation to the 'user type test' requirements, a new feedback session was held. The purpose of this was mainly to receive feedback on the added top tube as well as feedback on the effort to make the down tube look thinner.

Investigation

The same user panel as on page 54 was used in the feedback session to commented on this projects bicycle in their respective bicycle type.

Ill. 109 MTB - Downtube & Toptube

MTB user comments

Some of the users seemed positive of the sharp edge on the down tube which made it look more robust. However, the users also said that the top tube seemed off at the connection point to the seat tube.

Ill. 111 Classic - Downtube & Toptube

Classic bike user comments

Users acknowledge that the down tube does not seem as heavy as the past bicycle but could not elaborate on what makes it look thinner.

Ill. 113 Hybrid - Downtube & Toptube

Hybrid bike user comments

The hybrid users agreed with the MTB users on both the down tube and the top tube.

Ill. 108 Frame - Downtube & Toptube

Ill. 110 Road - Downtube & Toptube

Road bike user comments

A couple of the user mentioned "It looks much more like a road bike with the top tube" but at the same time said that something seems wrong at the interaction point between the top tube and the seat tube.

Ill. 112 City - Downtube & Toptube

City bike user comments

As the classic bicycle users, thought that the down tube looked thinner than in the previous version. One user pointed out that "it may be because of the shift in color" that made this version thinner.

Conclusion

The effort of making the down tube seem thinner got great respond from most of the users across the bicycle types. None of the users mentioned the extra holes in the frame for the top tube. most of the user also commented on the interfaces from the top tube to the seat or down tube. Further research was needed to find out how the accessories from the different bicycle types can be attach to the platform.

Accessories

Purpose

Because the frame needs to be used for different bicycle types, it was investigated how the frame could enable connection of different types of accessories. This section highlights where they are located and what they are used for.

Investigation

Accessories as bottle holders, luggage carrier, bicycle locks, etc. attach to the frame with screws.

Ill. 114 Accesories

Two interaction points are at the outer side of the seat stays which are used for a luggage carrier. One is located between the seat stays and is used for a bicycle lock and the rear fender. Another two are located underneath the seat stays and are used for the bicycle lock as well. A bottle holder has two different locations to be placed with two interaction points each. Those interaction points are located at the mid of the down tube and mid of the seat tube.
Accessories as the basket, chain guard, repair kit bag, etc. is attach to either center of wheels, top/ bottom of the head tube or underneath the saddle.

Conclusion

To make room for as many possibilities as possible with the frame all interaction points from existing bicycles were added. Additionally, two new interaction points are placed on the frame for the insertion of the top tube. One at the top of the seat tube and one at the top of the down tube.

Derailleur vs hub gear

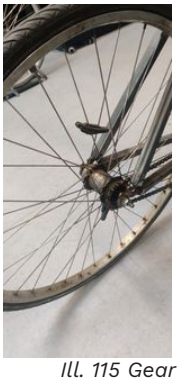
Purpose

Previous research (p.43) showed that it would be possible to make a frame that would be compatible with both hub and derailleur gear. This hypothesis had to be further tested.

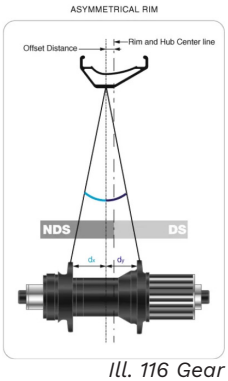
Investigation

Based on desktop research (p. 43) the thru axel length was determined to be 120 mm. The physical bicycle frame (see p. 52) was built accordingly to the desktop research and tested with both hub and derailleur gears (see ill. 115). Some wheels comes with spacings to fit the rear wheels to the frame and rear wheels with derailleur gear have asymmetric spokes. Left side have sloped spokes and right side are almost vertical (see ill. 116). Both wheels does not differentiate much in width and for frames that does not fit a specific wheel spacers can be used.

The Bosch motors are compatible with both derailleur and hub gears.



Ill. 115 Gear derailleur & hub test



Ill. 116 Gear

Conclusion

The prototype frame test shows it fits both an MTB and city bicycle wheel. Extra wheel types were not available at the test situation and was therefore not included in the test. but desktop research showed that bicycle wheels with a width between 120mm and 140 mm could be fittet with spacers.

01 Materials

Purpose

After finding the ideal bicycle geometry and design, it was investigated which materials the frame should be made of. This was done to get an understanding of which material it would make sense to produce the bicycle frame in.

The main criteria's for choosing a material was to achieve as light a frame as possible with thin profiles giving an expression of lightness and in a cheap material that was easy to process.

Materials

From desktop research, it was found out that the most common materials for bicycles are 7005 aluminium, 6061 aluminium, 4130 steel, and carbon fiber (Aliminum-guide, n.d.). Material properties for these materials were found (MakeItForm, n.d.).

	Tensile strenght, yield	Elongation at break	Weight	E-modul	Price
7005 aluminium alloy	124-290 MPa	25-40%	2.7 g/cm^3	70-80 GPa	Medium
6061 aluminium alloy	276 MPa	12%	2.7 g/cm^3	69 GPa	Cheap
4130 steel	460 MPa	28.2%	7.85 g/cm^3	190-210 GPa	Cheap
Carbon fiber	11820 MPa	1.6%	1.9 g/cm^3	183 GPa	Expensive

Ill. 117 Material specification

7005 aluminium alloy

7005 aluminium is one of the most common materials for bicycles due to its properties, availability and it is possible to weld. One of the disadvantages compared to 6061 aluminium is that it is difficult to form making the production more expensive (Bike-advisor, 2020). Additionally, aluminium frames are corrosion resistant and more rigid than steel, making them less comfortable for offroad but more sufficient for going fast on flat roads (wheretheroadforks).

6061 aluminium alloy

6061 aluminium is one of the most common materials for bicycles due to its properties, availability and it is possible to weld. Compared to 7005 aluminium, it has a lower yield strength but are often considered superior because it is easier to form, resulting in a cheaper production (Bike-advisor, 2020). Like 7005 aluminium, it is corrosion resistant and more rigid than steel (wheretheroadforks).

4130 steel

4130 steel is a durable material widely used in the bicycle industry. It has a high yield strength compared to aluminium, are easier to weld, and more flexible, making it more comfortable to ride on. The disadvantages of 4130 steel are that it results in a heavier frame compared to the other materials and it is not as corrosion resistant. A steel frame will therefore require surface treatment, and if any paint get scratched off it is likely to rust (wheretheroadforks).

Carbon fiber

Carbon fiber has a very high strength to weight ratio and can be finetuned for optimal material use by changing the carbon layup. This makes it an ideal material for specialized performance bicycles where a low weight is very important. Changing the carbon layup can also be used to control the stiffness of the bicycle. The disadvantages of carbon fiber are that is very expensive and not very durable in case of a crash (Theprocloset, n.d.).

Conclusion

4130 steel was chosen as a material for the frame despite being a heavier and less corrosion resistant material than steel. This was because the geometry with an open profile on the side of the down tube for battery access resulted in a thick profile for an aluminum frame. User response showed that a thin looking geometry was more important than the weight. Carbon fiber was not considered due to the price.

The frame will be produced in steel because a thin downtube is important for all the user groups.

04 Design brief

Based on some of 'detailing' phase. This design brief provides a summary of all the findings that the first part of 'detailing phase' has brought so far:

Summary

At the beginning of the 'detailing phase', different business strategies were investigated and which unique selling point the concept will accommodate.

It was found which character traits the different bicycle type users look for when buying bicycles. This resulted in some new requirements that the frame must be able to contain, which were investigated further.

Finally, it was investigated which materials bicycle frames are often made of and what are the advantages and disadvantages each.

The result of this is these results:

Important points

- Business strategy based on needs customization.
- Might influence the strength and stiffness of the frame
- In depth analysis of user decisions for choosing bike was needed.
- The project will be developed as a start-up.

All requirements:

Geometry requirements

- Slack angle = 72 - 73° (page 12)
- the chain stay length 458 mm (p. 34)
- seat tube inner diameter need to be 27.4 mm (p. 34)
- The thru axle length is 120 mm (p. 34)
- The down tube angle is 45 º (p. 34)
- The seat tube angle should be 73,5 degrees (p. 32)
- The reach length should be 440 – 455 mm. (p. 31)

Requirements

- To be electric (p. 16)
- Frame must not shield for retrofitted reflectors. (p. 15)
- Space for 2 independent brake systems (p. 15)
- Solution should be compatible with BOSCH eBike Systems (p.40)
- Battery access on the right side

Statusseminar 3

At the milestone it became clear that the user value of the concept still was not clear. The focus up to this point had been to make one frame that could be used for a city, classic , hybrid, mountain bike, and road bike The supervisors were not convinced this was the right focus, as the product would have to compete on the market with bicycles specialized for each category. An identified opportunity was to reframe the focus to take even more advantage of the modularity of the platform and distinguish the concept from specialized bicycles and focus on the everyday use. The modularity of the platform could be benefitting the users by letting them customize their bicycles as individuals and thus take even more advantage of the platform's modularity.
The downtube profile and material choices also had to be reevaluated to see if any better solutions were available. The bicycle company BIOMEGA was mentioned as possible inspiration for production methods.

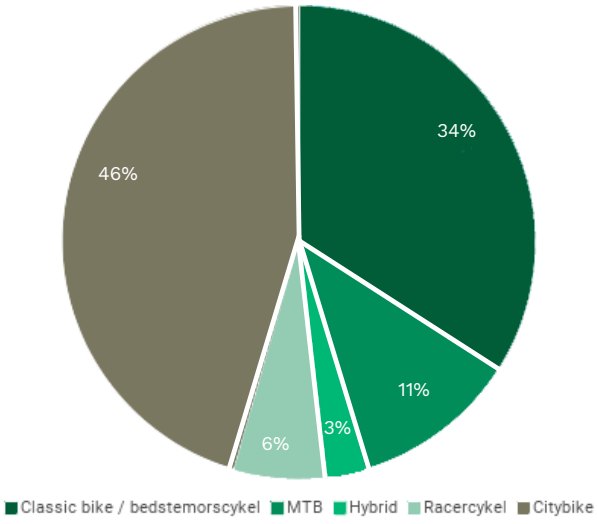
Customization experiences

Purpose

Based on the status seminar's questions about changing focus to create a frame where the user can change it as needed. It was investigated whether there is a real need for adaptation, or the user thinks that the six categories that exist now meets their needs.
To answer this question, a questionnaire was done.

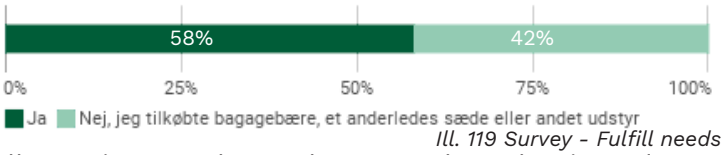
Materials

Based on a questionnaire shared on Facebook, 79 persons answered on various questions on their experiences of the purchase of bicycles (Appendix 17).
To identify which bicycles the participants of the survey initiated with the question:
What kind of bicycle do you have?



Ill. 118 Survey . kind of bicycle

Did the bicycle meet all your needs?.



Ill. 119 Survey - Fulfill needs

Illustration 118 shows that 80 % buy classic and city bicycle and 41 % of the bicycles bought did not fulfill the user's needs. Many user's mentioned accessories as baskets, luggage carriers, kickstand etc. but some user's changed equipment across bicycle types. For example, bought MTB or road bike wheels for a city bike because of the need to follow their children or drive in rough terrains like city parks.

Two participants added pictures of their bicycles with their story:

Person 1
Needed had modified citybike by adding a basket, another saddle and a different luggage carrier. She likes the functionality of the city bicycle with its forward-leaning siding position but would like the comfort and connivence of a classic bike by adding basket and a softer saddle.

Ill. 120 Person 1 bike

Person 2
Needed the ability to bring her dog with her. To do that she had to change the basket on her classic bike for a bigger basket.

Ill. 121 Person 2 bike

Person 3
Wanted a classic bike but with other wheel so she could accompany her children. But this combination was impossible to get.

Conclusion

In conclusion, **41 %** of the asked bicyclists modified their bicyclist or got one which did not fulfill their needs. The main accessories which were modified, were the adding/changing of baskets and luggage carriers. Whereas some changed major items as wheel or tires.

Customization interview - shops

Purpose

As an extension of the questionnaire, four different bicycle shops in Aalborg were interviewed if customers ask for customization of their new bicycles. All comments can be seen in appendix 18.

Investigation

Cykel20

They often meet customers who would like another saddle, handlebar etc. but not any major changes. He elaborated by saying ***"I am so tired of the bicycle world stereotypes because people are so individual and have different needs"*** and that is why he designed his own bicycle.

Munk Bicycles

At Munk bicycles, is it mainly the wheels customers would change. It was not often but sometimes users that want a road bicycle handlebar on for example city bicycles. ***"There is a type of customer that customize their bicycle and that is often done online or by themselves at home".***

FriBikeShop

"There are some people who want to change the bicycle and it is often the wheels, handlebars or the seat. On the contrary, it is nearly everybody that buys extra accessories like baskets, luggage carrier etc. But it is mainly female customers".

Vestbyens cykler

Vestbyens cykler do not experience those customers that modify bicycles except chain guards, kickstand, baskets etc. ***"It was normal to modify in the 1990´s but with the increasing numbers of bicycle types. Of course, you may not be able to meet all needs, but you can get very close". "About 10 percent changes handlebar and saddles and about 30 percent changes something if chain guard and kickstands are included".***

Conclusion

The experience of the employees in the bicycle shops are contrasted with the experience of the users in the previous section of the customization survey. People of the customization survey mentioned that 41 percent had to buy extra equipment or buy a bicycle that did not fit their needs because of the lack of other solutions. The employees mentioned that 10 percent changes the handlebar and saddle and probably 30 percent if chain guard and kickstands are included.

ReFraming

The interview at bicycle shops, the customization survey and personal experiences enlighted the need of customizing beyond the traditional bicycle types. For example the need of MTB tires on her city bike to driveon a bit rougher terrain. The possibility to customize a bicycle to the user's individual need without the equipment looking misplaced.

The project was therefore reframed to focus on making a bicycle as a white canvas where the user can design it as needed without it looking odd.

As a result of the reframing a new problem formulation was made:

Old problem definition

"How do we design a bicycle platform that simplifies the design and manufacturing process of everyday bicycles"

New problem definition

"How do we design a product platform for everyday E-bicycle as a canvas which enables user customization across bicycle types?"

Why is this important?

- Product development using a platform is generally faster, cheaper and less risky compared to creating each new product from scratch.
- Once tested, parts and assembly process due not have to be tested for each new product.
- Some users have needs that exceeds standard bicycle types.
- Trend is moving to more individual bicycles
- The users get more aware of the choices they make

First two points are elaborated on pa14. 3rd and 4th point was highlighted in the customization survey and is substantiated by the 5th point. Users keep getting more aware of choices they make in purchasing, environmental and socially aspects of their everyday lives and the personalization of products fitted the users' specific needs seems attractive to customers.

4P MODEL

Purpose

Based on the reframing, the 4p model (p. 23) had to be revised and constructed for the new focus to find out how the concept innovations is in accordance with the 4P model. (Sawhney et al., 2006).

Investigation

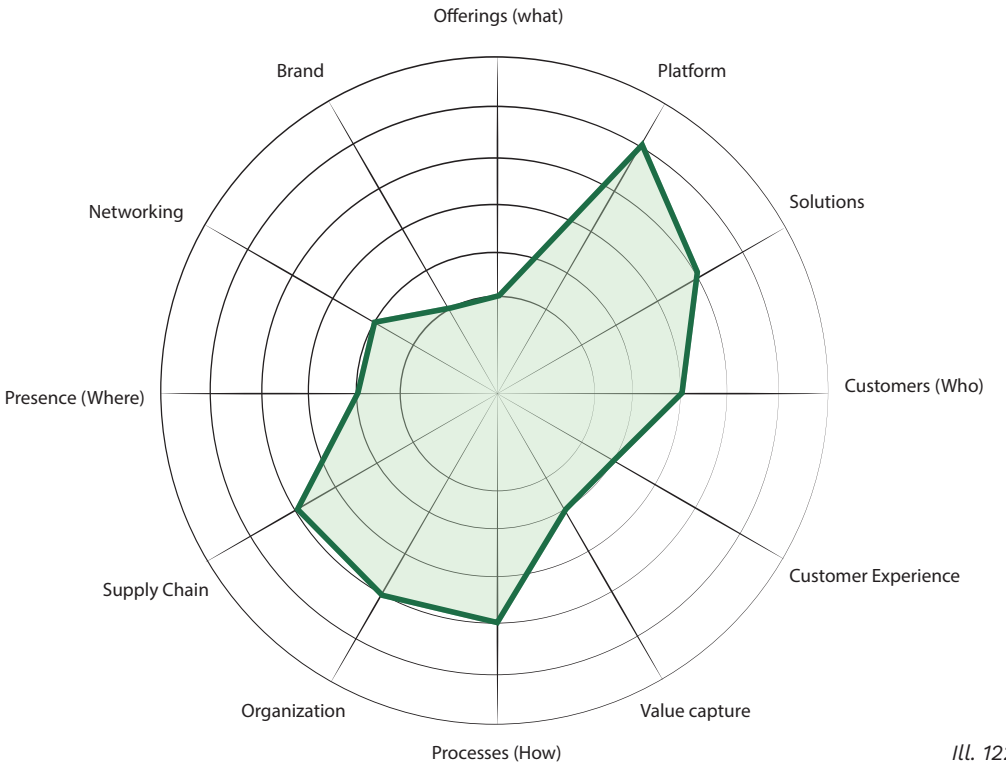
Platform
With a common set of components, the product platform will exploit the power of commonality. By utilizing the same components in construction of the frame, the platform creates a variety of opportunities for construction the bicycle to the individual customer needs. Furthermore, the user can exploit the industries standard components (handlebar, pedal etc.) to create the specific identity of the bicycle they want.

Solutions
As the solution of this project creates a variety of customized combinations to solve the customers problem, it innovates in the broadness of assortment of combinations.

Processes
By having the same frame bicycle types, the concept limits process complexity and gives the possibility to specialize within these.

Organization
Alongside processes, organizational partnerships would be strengthened by having less processes in production compared to companies with multiple bicycle frames.

Supply chain
In extension to processes and organization, the supply chain also minimizes by limiting the production processes. By having one exact method of producing and constructing the frame, the supply chain relationships could be strengthened.



Ill. 122 4P model revised

Conclusion

The concept innovates in one new way compared to the first 4P model (p. 23) which is solutions. By letting the customers customize their bicycle across and in between the traditional bicycle types, the concept innovate and stand out from the rest of the market.

Value vs cost

Purpose

After reframing the project and the design of the frame was at a satisfying point, it was necessary to evaluated it according to production methods based on value versus cost.

Investigation

The frame was divided into six separate components, down tube, head tube, top tube, seat tube, seat/chain stay and base. These components were split to evaluate the individual parts on what adds value to the user and to what cost.

Downtube

Three different profiles were compared by number of processes needed, unit price level and tooling price level: standard circular profile, flat oval profile and sheet metal.

	Process	Unit price	Tool price
Standard round profile	**Cut > hydroforming > drill**	Low	High
Flat oval profile	Cut > press > (laser cut)	Low	Low
Sheet metal	Laser cut > press braking > welding > press	Low/moderate	Low/moderate
	Stamping > welding	Low/moderate	High
	Metal injection molding	Low	High

Partial conclusion

Comments from the users on the down tube during the feedback session were that it looked more lightweight than other bicycles in the catalogs. Based on the importance of lightweight frames across all bicycle types the value to the customers were worth the cost of a hydroforming production method. This process reaches the level of detail sort after from the customers. An alternative method could be stamped and welded sheet metal, but hydroforming would have lower unit cost and better stiffness to the component. (“ABOUT THE HYDROFORMING PROCESS,” n.d.) (Thomson, n.d.).

Headtube

As the complexity of the head tube was low the production would be simple.

	Process	Unit price	Tool price
Standard round profile	**Cut**	Low	High

Partial conclusion

The customer had no comments to the head tube and the importance of it is low in the perspective of the customer. To keep the production cost low the head tube be cut from a flat oval profile (Thomson, n.d.).

Top tube

Two profile and four production methods was investigated as production methods.

	Process	Unit price	Tool price
Standard round profile	Cut	Low	Low
	Cut > swagging	Low	Low
	Cut > Hydroforming	High	High
Flat oval profile	**cut > weld**	Low	Low

Partial conclusion

As the aesthetic of the top tube were not important but the present of a top tube were, the cost should be low. The result was a flat oval profile cut in length after which 2 plates are welded on the ends to enable the attachment. (Thomson, n.d.).

Seat tube

To suit the saddle stem it was necessary to have a circular inner form but the connection between the seat tube and the base be dynamic by widening the profile.

	Process	Unit price	Tool price
Standard round profile	Cut	Low	Low
	Cut > bend	Low	Low
	Cut > swagging	Low/moderate	Low/moderate
	Cut > swagging > bend	Low/moderate	High
	Cut > hydroforming	High	High

Partial conclusion

Cutting and swagging were selected as production method because of the relatively low cost yet giving the seat tube a dynamic interface to the base. Adding another production method, as bending, would be too costly compared to the value it gives to the customer (Thomson, n.d.).

Seat-/Stay chain

Two profile and five different production methods have been investigated to fit value versus cost.

	Process	Unit price	Tool price
Standard round profile	Cut > hydroforming > weld	High	High
	Cut > hydroforming > weld	Low	Low
	Cut > bend > press > weld	Low	Low
Flat oval profile	**Cut > bend > press > weld**	Low	Low
	Cut > bend > weld	Low	Low

Partial conclusion

Cutting and swagging were selected as production method because of the relatively low cost yet giving the seat tube a dynamic interface to the base. Adding another production method, as bending, would be too costly compared to the value it gives to the customer (Thomson, n.d.).

Base

The base is the place where most components are connected to.

	Process	Unit price	Tool price
Standard round profile	Cut > hydroforming > weld	High	High
	Cut > hydroforming > weld	Low	Low
	Cut > bend > press > weld	Low	Low
Flat oval profile	**Cut > bend > press > weld**	Low	Low
	Cut > bend > weld	Low	Low

Partial conclusion

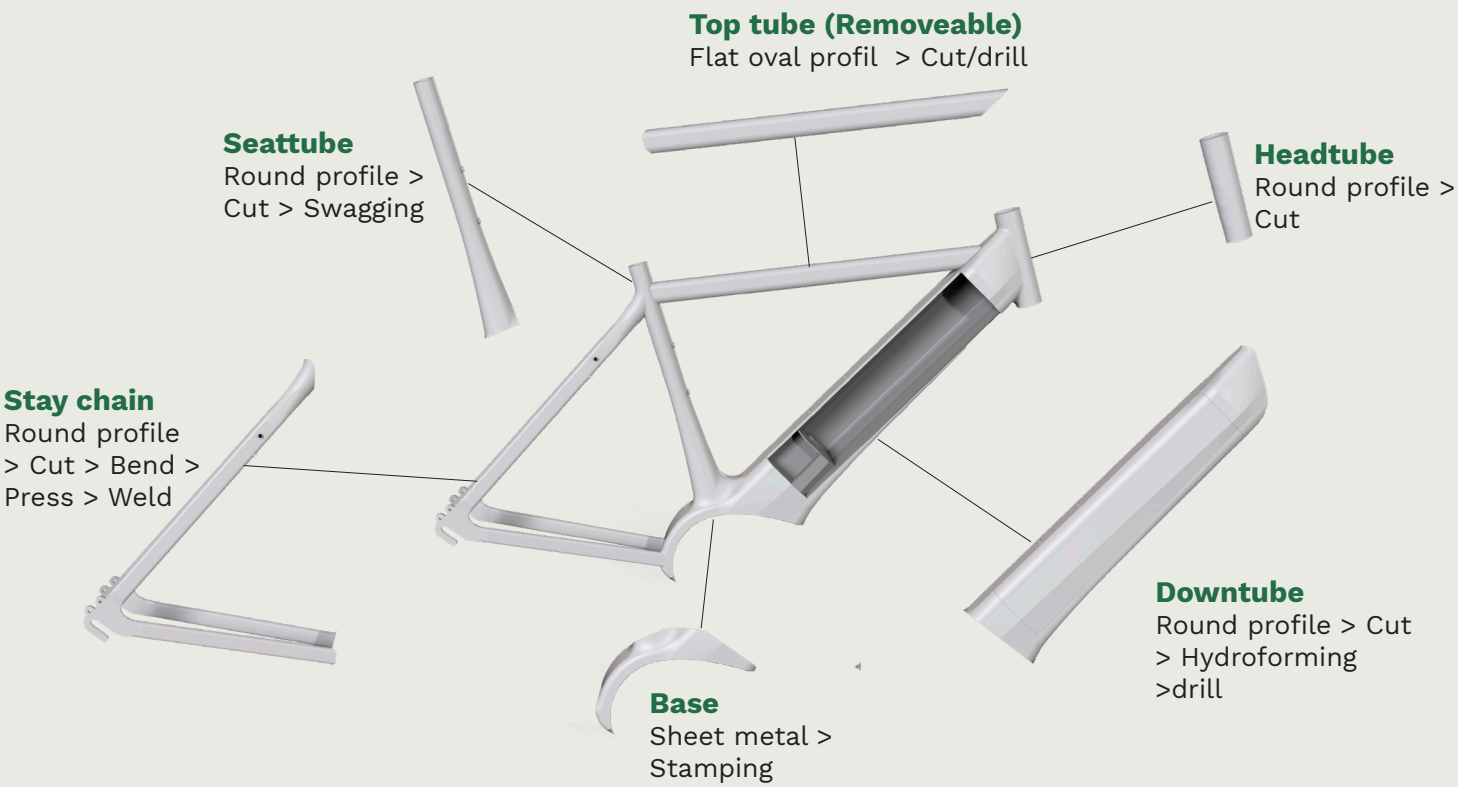
The motor connection will be metal stamped. This gives a relatively low unit price but the investment in tooling will be high compared to the other production methods (Thomson, n.d.).

Before

Ill. 123 Before investigation

After

Ill. 124 After investigation



Ill. 125 Exploded frame

Conclusion

The down tube will be cut and hydroformed, the head tube will be cut, the top tube will be cut, the seat tube will be cut and swagged, the seat/chain stay will be cut, bend, pressed and welded, and the base will be metal stamped.

All the parts except the top tube will be welded together. To make sure that the frame would be possible to make, as well as dimention the profiles, it was necessary to make a FEM analysis on the frame.

Load scenarios

Purpose

To be able to make FEM analysis of the bicycle frame and dimension the profiles, load scenarios had to be defined. Setting this up could also help reevaluate the downtube profile and material choice, based on stress and stiffness with the different materials.

Scenarios

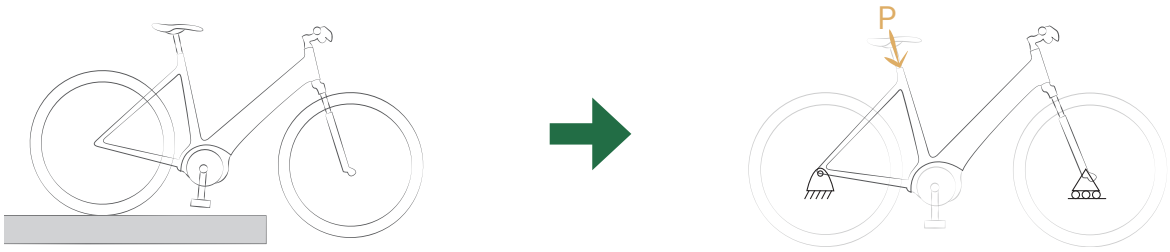
Four different static load scenarios were set up based on real life scenarios and standards from ISO 4210-6 (ISO, 2015) and TBIS 4210-6 (TBIS, 2019), to test the stresses and stiffness.

Scenario 1 - Road irregularity

Scenario 1 will occur when driving over a curb or over road irregularity that will send a force from the weight of the rider directly down onto the seat tube. The scenario corresponds to TBIS 2410-6 2.4 Frame and fork assembly – impact test' (TBIS, 2019).

The force P was calculated for a rider of 100kg and with a safety factor of 2,5 (Appendix 19).

P=2455N



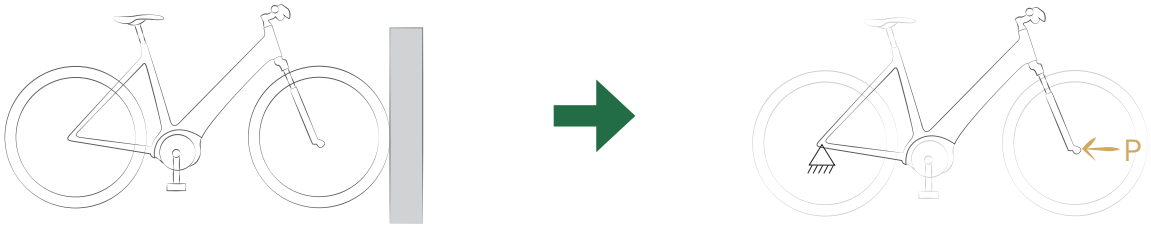
Ill. 126 Road irregularity

Scenario 2 – Frontal horizontal load

Scenario 2 is a frontal load affecting the fork horizontally that will occur when hitting a wall or barrier frontal with the front wheel.

The scenario corresponds 'TBIS 2410-6 4.1 Frame - impact test', with a force P of 1000N (TBIS, 2019).

P=1000N

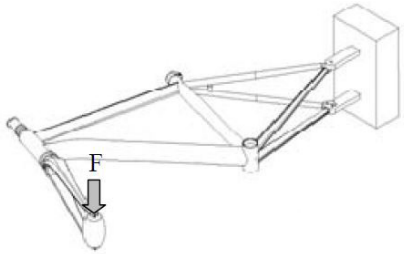


Ill. 127 Frontal horizontal load

Scenario 3 – stiffness with lateral force

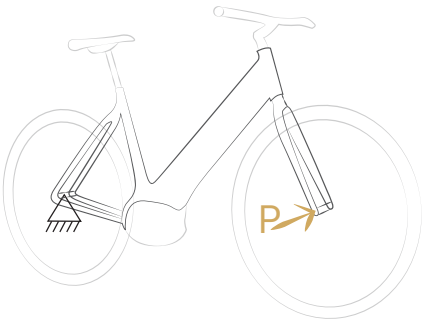
Scenario 3 is a lateral force applied sideways to the stiffness of the frame that will occur due to the twisting of the frame. This scenario is critical due to the geometry with an open profile on the side, that will be vulnerable to twisting.

The scenario is based on TBIS 4210-6 E3, with a force P of 300N (TBIS, 2019).



Illu. xx. TBIS 4210-6 E3,

P=300N



Ill. 128 Stiffness with lateral force

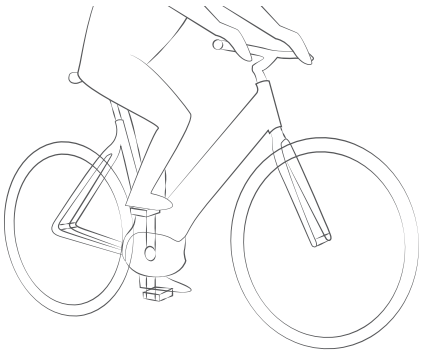
Scenario 4 – Stiffness when pedaling

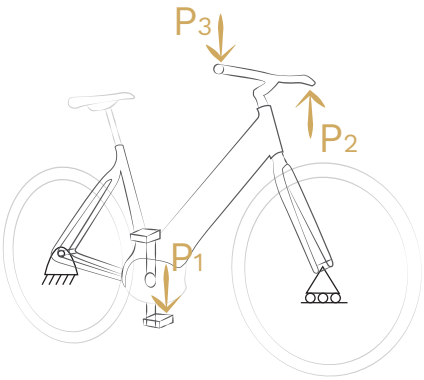
Scenario 4 is the most common scenario that will occur when riding the bicycle fast or uphill. The scenario is based on TBIS 4210-6 E2 (TBIS, 2019), and observations of behavior when riding a bicycle, where the rider pulls up in the handlebar in the same side as he pushes down the pedal with the leg and pushes the handlebar down on the opposite side with the hand.

P1 are based on TBIS 4210-6 E2 (TBIS, 2019), while P2 and P3 are estimated and calculated from a pulling weight of 4,5kg (Appendix 19).

P_1=800N

P_2 & P_3=44.19N





Ill. 129 Stiffness when pedaling

Down tube reevaluation

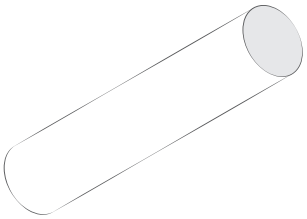
Purpose

After Status seminar 3 and a FEM analysis it became clear that the down tube profile had to be re-evaluated. Because of the battery the down tube had an open profile, making it less stiff in torsion, which resulted in a high material thickness to compensate. The possibility to use a closed profile was therefore explored.

Open vs closed profile

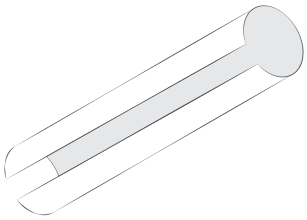
The torsional properties of closed profile are much stronger compared to an open profile. It was therefore important to avoid open profiles as much as possible for a construction like a bicycle frame, that will be affected by forces from different directions resulting in twisting (motivated, n.d.)

Good torsional properties



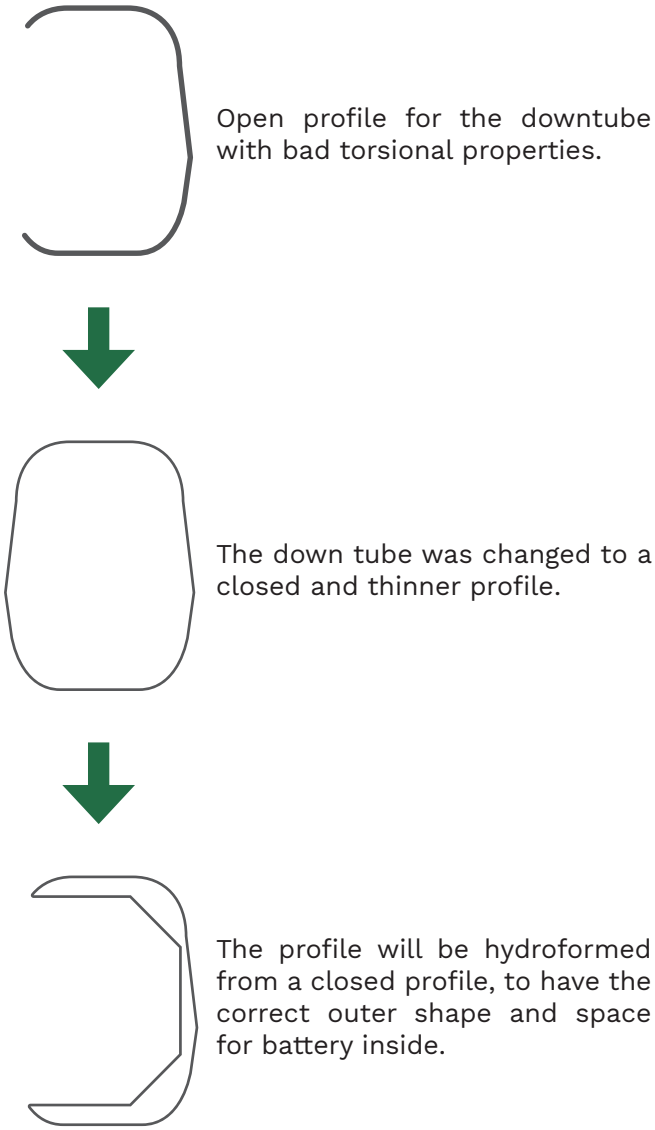
Ill. 130 Closed profile

Bad torsional properties



Ill. 131 Open profile

Change of downtube



Ill. 132 Profil developing

Conclusion

The down tube was changed to a closed profile that will be hydroformed to the right shape and with space for the battery. By changing to a closed profile stronger torsional properties were achieved, and it was necessary to make FEM analysis of the new geometry, to see how it influenced the strengths and stiffness of the frame.

The downtube was changed to a closed profile

FEM ANALYSIS

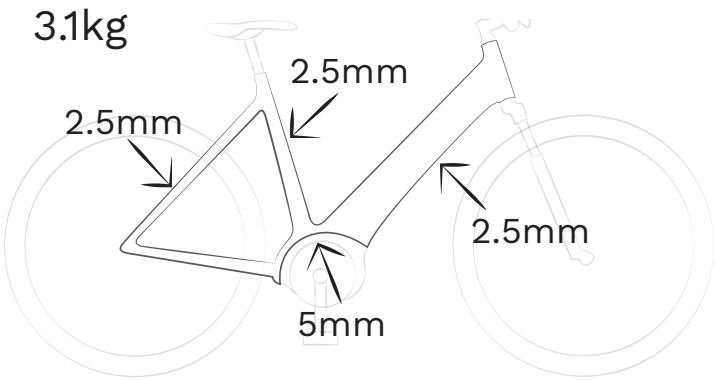
Purpose

To dimension the bicycle frame and profiles, as well as make qualified material and production choices, it was necessary to make FEM analysis of the frame's strength and stiffness. The purpose was to achieve a realistic construction with minimal material and weight, that would be safe and pleasant to ride on.

Investigation

Von mises stresses and displacements were found through FEM analysis, which were made according to the scenarios defined on page 72 ´Load scenarios ´. It was an iterative process where multiple FEM analysis was made for each scenario in 7005 aluminium, 6061 aluminium, and 4140 steel, which was carried out continuously with the detailing of the frame. This way the consequences to the geometry, weight, and profile thickness could be used to evaluate on material, production and design chooses. A detailed breakdown of the FEM process and calculations can be found in Appendix 19.

During the FEM analysis inaccuracy in the simulations and calculations were considered, and the results were not seen as true facts, but as a fair representation to compare the consequences of material choice. This resulted in changing the material to 6061 aluminium with the following profile thicknesses.



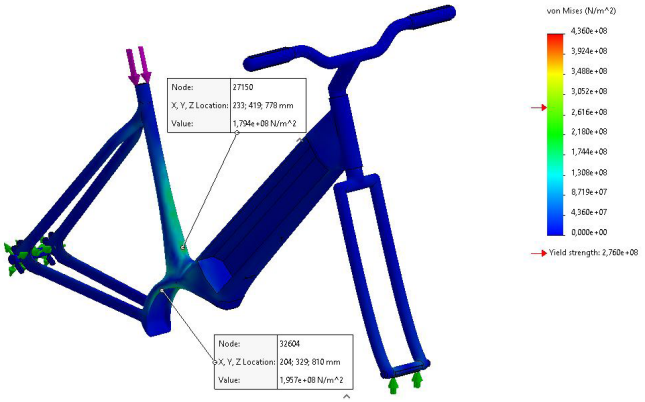
Ill. 133 Profile thickness

Conclusion

After changing the profile of the downtube it was assessed that it would be possible to make a frame in 6061 aluminium, that would be strong and stiff enough to be safe to ride on, without compromising too much on the aesthetics and dimensions of the frame. The simulations showed a weight at 3.1kg, which seems realistic when compared to similar bicycle frames, that typically weights between 2 and 3 kg.

Stresses

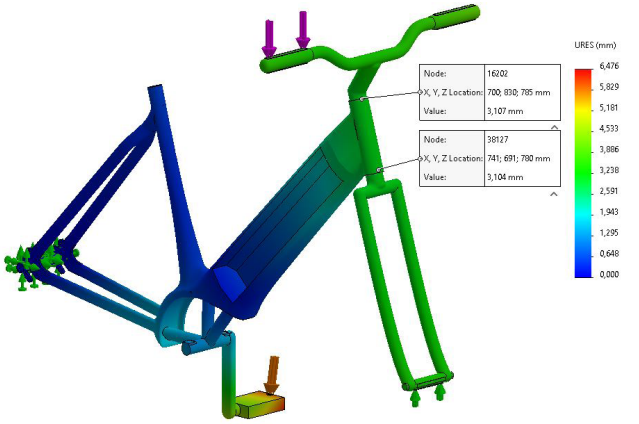
A maximum von mises stress of 195.7 MPa was found for scenario 1, at the base where the down tube and the seat tube meet. It was therefore concluded that the frame was strong enough, as this was below the yield strength of 6016 Aluminium alloy which are 276 MPa.



Ill. 134 Von mises stresses scenario 1

Stiffness

A maximum displacement of 2.6 mm at the head tube was found for scenario 4. As this scenario was based on peddling hard, while and pulling hard in the handlebar, it was concluded as an allowable displacement.



Ill. 135 Displacement scenario 5

The frame will be produced in 6061 aluminium

The weight will be approximately 3.1kg

Components

Purpose

Canvas is a product platform that relies heavily on external components chosen by the user in the customization proses. This means that the component list depends on the user's choice based on needs. However, a few components for connecting the battery and motor does not vary and was therefore specified.

External components

To connect the BOSCH PowerTubes the frame must be equipped with two mounting points which are standard components manufactured by BOSCH. Additionally, wires must be installed to connect the battery to the motor which also are standard components (Bosch, n.d.).

BOSCH Mounting Kit PowerTube - cable side

Ill. 136 Bosch Mounting Kit PowerTube - cable side

BOSCH Mounting Kit PowerTube - lock side

Ill. 137 Bosch Mounting Kit PowerTube - lock side

Bosch PowerTube cable

Ill. 138 Bosch PowerTube cable

Motor adaptor

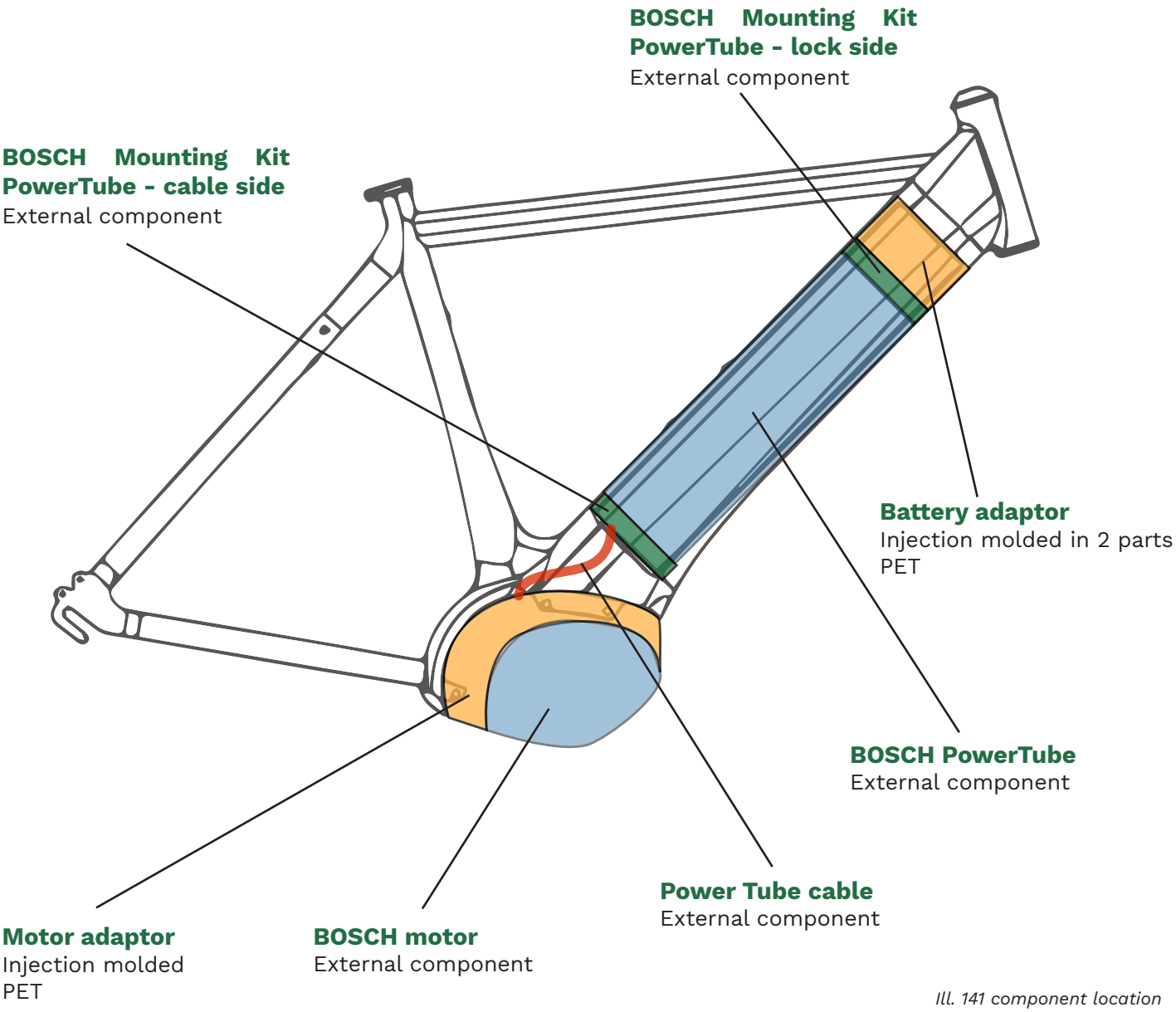
When analyzing the different BOSCH motors (p. 41) it became clear that a motor adaptor had to be developed to fit the Cargo line, Active line speed, and Performance line CX motor to the same platform as the other motors. The adaptor will be injection molded in HDPE which is a durable material that are used for other bicycle components such as mud guards (Plastindustrien, n.d). Due to not having the exact measurements for the interaction points of the motors, this component will have to be specified for realizing the product.

Ill. 139 Motor adaptor

Battery adaptor

A battery adaptor was also developed to make the PowerTube 400 and PowerTube 500 fit to the frame. A standard component for this exists, however the choice was made to develop one with a pocket for spare hoses or tools, to utilize the otherwise wasted space, and add value to the product. Like the motor adaptor the battery adaptor will be injection molded and due to the geometry, it will have to be molded as to parts.

Ill. 140 Battery adaptor



Ill. 141 component location

Conclusion

The solution must include BOSCH mounting kits and cable for connecting the batteries and motors to the frame. Additionally, two adaptors were developed, one for attaching different batteries and one for attaching different motors. Extra value were added by designing the battery adaptor to be utilized as extra storage space.

The solution should include BOSCH PowerTube mounting kits and cable

05 Design brief

Based on last part of the 'detailing' phase. This design brief provides a summary of all the findings that the last part of 'detailing' phase has brought:

Summary

At the end of the detail phase, two different user surveys were conducted to find out if there was a need for customization.

In addition, various bicycle shops were interviewed to hear their opinion on the bicycle world and the fact that it is divided into 5 categories.

A value vs. cost study was done to find out how the frame could be produced cheaper without removing value.

Finally, a FEM analysis was made to see if the frame can hold and what material it can potentially be made of.

The result of this is these results:

Problem definition

"How do we design a product platform for everyday E-bicycle as a canvas which enables user customization across bicycle types?"

Important points

- The downtube was changed to a closed profile
- The weight will be approximately 3.1kg
- The frame will be produced in 6061 aluminium

All requirements:

Geometry requirements

- Slack angle = 72 - 73° (page 12)
- the chain stay length 458 mm (p. 34)
- seat tube inner diameter need to be 27.4 mm (p. 34)
- The thru axle length is 120 mm (p. 34)
- The down tube angle is 45 º (p. 34)
- The seat tube angle should be 73,5 degrees (p. 32)
- The reach length should be 440 – 455 mm. (p. 31)

Requirements

- To be electric (p. 16)
- Frame must not shield for retrofitted reflectors. (p. 15)
  Space for 2 independent brake systems (p. 15)
- Solution should be compatible with BOSCH eBike Systems (p.40)
- Battery access on the right side

06 IMPLEMENTATION

The ‘fifth phase’ is the implementation phase. In this phase, it will be proposed how the product should be launched and the business strategy. In addition, the production cost will be calculated as well as when the product will hit the break-even. This phase will end with a reflection as well as a conclusion on the whole project.

Ill. 142 Implementaton

Startup

When starting a business within an industry with competitors such as Trek, Winther and Giant, it was necessary to distinguish in a new way and disrupt the industry. Canvas distinguishes in its core values and in the industries traditional values. The core values of Canvas would not fit any of the businesses within the industry which was the reason it was approached as a stratup.

Selling the concept to another company within the industry would not be suitable due to none of the companies having the same core values as Canvas. The industry designs bicycles specialized for individual purposes which does not align with users needs for customization. Canvas accommodate this by giving the user the ability to customize their bicycles for their individual needs. The core user value from Canvas is the ability to be customized across bicycle types and still withhold an aesthetic pleasing reference to each of the traditional bicycle types. Canvas distinguishes in terms of its platform-based approach. A platform with the possibility to customize your own bicycle within various categories such as motor, battery, gears etc. and thereby personalize their own bicycle.

Lastly, platforms as Kickstarter could be utilized for two reasons: Funding and publicity. To require funding to purchase production equipment without giving shares of the company to investors Kickstarter could be used as a reality check as well as funding. At the same time a Kickstarter campaign could generate publicity and increase interest globally without any investment in marketing campaigns. How the possibilities will be explored throughout in next chapter.

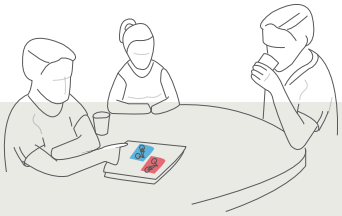
Business strategy

Purpose

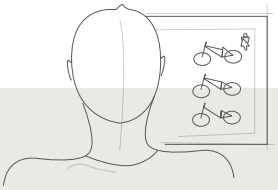
This section will highlight differences from the traditional bicycle industry and the Canvas business strategy. The traditional bicycle industry was descripted on page 45.

Value for company

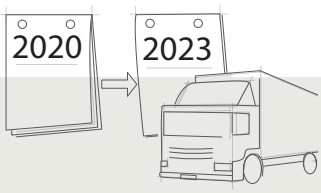
Canvas' business gives the start-up company less risk, because the frame can be assemble the bicycle according to the user's wishes and thus there will not be a residual stock of a type of bicycle. The production of canvas will primarily take place in Taiwan, while the assembly of the bicycle will take place in Denmark.



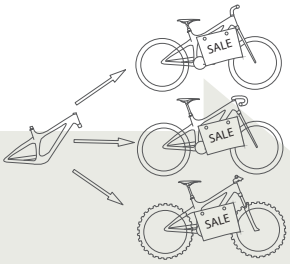
Design the new bicycles out from platform



Order bicycle frames



wait 1.5 to 2.5 years for delevering

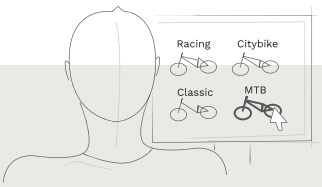


Design and sell according to market demand

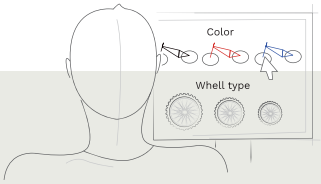
Ill. 143 Value for company

Value for user

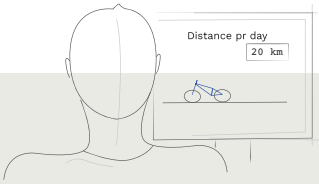
The business of Canvas invites the customers to design their own bicycles to their personality and needs. By having a clear canvas (the frame) to paint your own wishes and needs, Canvas lets the customers assemble their own bicycle and thereby gives the user a feeling of having created a product which is unique. By letting users assemble their product on their own, it could enhance the attachment towards the product and could thereby result in greater appreciation and make the users more likely to maintain the product (Vrist et al, 2021).



Select bike that fit your preference



Choose between x number of colors, wheels etc.



Enter your daily driving distance and the computer will suggest battery and motor type

Receive your bike and dride around

Ill. 144 Value for User

Launch plan

Purpose

The launch plan below is an estimate of what it takes before the product can be launched. Some of the steps will be funded until the company has equity by either investors or crowdfunding where- as other steps would be funded by the group. The launch plan takes an estimated 2 years – 2 years and 9 months.

Phase 1 // development // 3-4 month

User research and testing with users	Own
Optimizing compare based on production & DFA	Own
Prototyping of the product	Funds

Phase 2 // Validation //1-2 month

CE mark preperation	Funds
Instruction for use and risk	Own

Phase 3 // Preparation for production // 2-3 month

Tool making for production	Funds/investors
Marketing - Supply chain (global)	Funds/investors

Phase 4 // 1.5-2 year

First order - 1000 psc.	Funds/investors
Marketing - Supply chain (local) - Fairs / meating clients - Webside - Showroom	Funds/investors

DFA

Purpose

To find out how long it will take to assemble the bicycle in Denmark and become aware of where in the assembly process the most expensive solutions are.

Investigation

The method of Design for Assembly (Boothroyd, et.al, 2010) highlights elements which takes the longest time during fitting and if changed could influence the cost price of the bicycle.

Full version see app. xx:

Accessories components	No. Of components	Handling code	Handling time	Insertion code	Insertion Time	Total time Classic	Total time City	Total time MTB	Total time Road	Total time Hybrid
Bicycle front										
Handlebar	1	31	1,69	63	8	9,69	9,69	9,69	9,69	9,69
Grips	2	01	1,5	00.	1,5	6	6	6	6	6
Front brakes	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Bell	1	31	1,69	63	8	9,69	9,69	9,69	9,69	9,69
Light	1	31	1,69	63	8	9,69	9,69	9,69	9,69	9,69
Stem	1	31	1,69	63	8	9,69	9,69	9,69	9,69	9,69
Headset	1	31	1,69	64	10,5	12,19	12,19	12,19	12,19	12,19
Fork	1	01	1,5	64	10,5	12	12	12	12	12
Front wheel	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Disc brake	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Wires	3	01	1,5	64	10,5	36	36	36	36	36
Basket	1	31	1,69	63	8	9,69				
Fender	1	31	1,69	63	8	9,69	9,69	9,69	9,69	9,69
Motor Display	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Gear	1	01	1,5	63	8	9,5	9,5			
External gears	1	01	1,5	63	8			9,5	9,5	9,5
Bicycle mid										
Wires	4	01	1,5	64	10,5	48	48	48	48	48
Battery ends	2	03	1,95	63	8	19,9	19,9	19,9	19,9	19,9
Battery extension	1	03	1,95	63	8	9,95	9,95	9,95	9,95	9,95
Battery	1	39	3	60	5,5	8,5	8,5	8,5	8,5	8,5
Motor	1	39	3	64	10,5	13,5	13,5	13,5	13,5	13,5
Saddle	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Padels	2	01	1,5	03.	2	7	7	7	7	7
Chain screen	1	33	2,51	63	8	10,51	10,51			
Kickstand	1	01	1,5	73	9	10,5	10,5	10,5	10,5	10,5
Chain	1	31	2,06	63	8	10,06	10,06	10,06	10,06	10,06
Motor adaptor	1	03	1,95	74	11,5					
External gears	3	01	1,5	63	8			28,5	28,5	28,5
Saddle lock	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Gear shifter	1	01	1,5	63	8			9,5	9,5	9,5
Top Tube	1	03	1,95	80	6,5		8,45	8,45	8,45	8,45
Top tube insert	1	03	1,95	80	6,5		8,45	8,45	8,45	8,45
Bicycle back										
Luggage carrier	1	01	1,5	63	8	9,5	9,5			
Fender	1	31	2,06	63	8	10,06	10,06	10,06	10,06	10,06
Rear wheel	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Light	1	31	2,06	63	8	10,06	10,06	10,06	10,06	10,06
Disc brake	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
Gear	1	01	1,5	63	8	9,5	9,5			
External gears	7	01	1,5	63	8			66,5	66,5	66,5
Gear shifter	1	01	1,5	63	8			9,5	9,5	9,5
Bicycle lock	1	01	1,5	63	8	9,5	9,5	9,5	9,5	9,5
General										
Screws	8	01	1,5	0	1,5	24	24	24	24	24
Total time (minutes)						7,01	7,13	8,53	8,53	8,53

Ill. 145 DFA

Conclusion

Elements as wires (48 sec), motor adaptor (11,5 sec) or battery ends (19,9 sec) takes up a long-time during insertion. The fitting time could be limited by redesigning the items and benefit the total time of assembly by lowering the insertion time. The table can be found in appendix 20.

The most expensive total installation time is 8.53 min, which gives a cost of 35.5 DKK per. bicycle if the fitter receives 250 DKK per hour.

Unit cost guestimation & break-even

Purpose

As the last step, an estimate was made of production costs, as well as finding out when the company will have break-even. The estimation was only made for a frame without components.

To estimate production cost and the overall cost of the frame, a few production companies were contacted for an estimated price. The companies could not predict a price because of unpredictable aspect within the production prices as of global tendences in the supply chains.

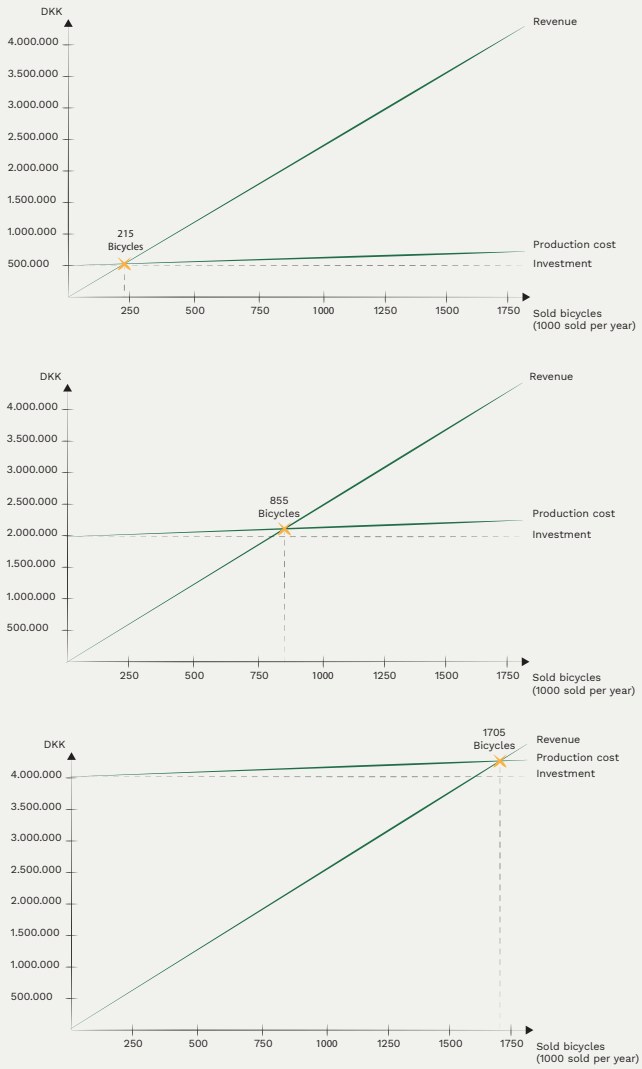
As a result of this, three production price guestimations were conducted. Guestimations of hydroforming, bending, stamping and swagging production prices assumed the base of these calculations.

From an interview with Henrik Christiansen (appendix 21), the CEO of H.F. Christiansen, 20 % of the cost price of a bicycle is based on the frame. Based on the price of Bosch motors and battery the frame of a e-bicycle was guestimated to 10 % of the cost price. Based on the same interview are the earnings of a bicycle guestimated to 35 % of the cost price.

The point of Break-Even varies in the three production prices which influence the risk of investment that must be done before realizing the business. The point of Break-Even raises as the production costs raises. On the other hand, it will be a one-time investment in tools which does not need to be bought every year but renovated occasionally and thereby are paid off overtime.

Tooling equipment	No of tools	Price	Units of bicycle sold	frame price	Sales price	Total Production price	Total Sales price	Sales price of complete bike	% of the bike frame	Earnings	Material price per bicycle
			Break even point								
Hydroforming	1	333.333,33	215,00	150,00	2.500,00	532.250,00	537.500,00	25000	10,00%	135,00%	150
Bending	1	66.666,67									
Stamping	1	33.333,33						Materials price	Tooling price Investment		Amount of bicycles
Swagging	1	66.666,67						32.250,00	500.000,00		
								150,00			215
Tooling equipment	No of tools	Price	Units of bicycle sold	frame price	Sales price			Sales price of complete bike	% of the bike frame	Earnings	Material price per bicycle
			Break even point								
Hydroforming	1	1.000.000,00	855,00	150,00	2.500,0	2.128.250,00	2.137.500,00	25000	10,00%	135,00%	150
Bending	1	400.000,00									
Stamping	1	200.000,00						Materials price	Tooling price Investment		Amount of bicycles
Swagging	1	400.000,00						128.250,00	2.000.000,00		
								150,00			855
Tooling equipment	No of tools	Price	Units of bicycle sold	frame price	Sales price			Sales price of complete bike	% of the bike frame	Earnings	Material price per bicycle
			Break even point								
Hydroforming	1	2.000.000,00	1705,00	150,00	2.500,0	4.255.750,00	4.262.500,00	25000	10,00%	135,00%	150
Bending	1	800.000,00									
Stamping	1	400.000,00						Materials price	Tooling price Investment		Amount of bicycles
Swagging	1	800.000,00						255.750,00	4.000.000,00		
								150,00			1705

Ill. 146 Cost estimation



Ill. 147 Break -even

The illustration shows three different price points on tooling equipment which is the varying factor of the calculation. Based on the interview with Henrik Christiansen (appendix 21) were the precents of the sales price located in the bicycle frame guestimated to 10 %, the material price was estimated based on material prices on Alibaba (Alibaba, 2022) which resulted in 150 DKK and at these calculations were the sales price at 25.000 DKK.

Conclusion

Due to the lack of concrete tooling prices, the point of Break-Even were made for three diferent price scenarios. The main variating price are on tooling and thereby a one-time investment which could be used through multiple batch's and paid off overtime. On the other hand, it was difficult to estimate if the Break-Even point is too far into the future to withstand a business or if the sales prices exceed the price point of which customers would purchase the product. As the cost price on a frame were guestimated to 150 DKK and the sale price at 2.500 DKK. As the sales price are much higher than the cost price it would be possible to decrease the sales price to lower the total sales price of a completed bicycle. This would influence the Break-Even point which is at 855 bicycles for the middle point of tooling guestimation.

PRICE SETTING

Based on the platform business model and the individual customization done by the users the price point of the sold bicycles will vary. The price setting was done based on market research (Appendix 22) which primarily investigated components and the level of quality of these. With the use of approximately same list of components as e-bicycles on the market, the concept will be ranged from 20.000 to 30.000 DKK depending on the level of components on the individual bicycle.

Ill. 148 Sales price

Conclusion

The project started with the primary objective of creating a bicycle platform that would simplify the production and design process of bicycles. The intention was to achieve this by designing one frame that could be used for city bikes, classic bikes, mountain bikes, hybrid bikes and road bikes, and thereby increase the number of shared components across these bicycle types. One of the main advantages of this platform approach was that this would remove the time consuming and expensive process of designing and testing a new frame for each bicycle. During the design process it became clear that only focusing on designing for the manufactures benefit, not necessary would result in a good product. This was because the product for the end user would have to compete with highly specialized bicycles for each category, on a very saturated market. Therefore, the framing of the product was changed to focus on individual user needs.

It was identified that there was a gap in the market for electric bicycles where most bicycles are designed to either fit into one of the existing bicycle categories or to appeal to a very specific target group. There was no easy way to get a city bike with off-road tires or a mountain bike with a luggage carrier and basket, without having to modify the bicycle after purchase. This was possible to do with the platform approach, that originally was developed from a production perspective. Canvas is therefore a product platform-based bicycle, that exists of a frame which to a limited degree can be modified by the user through component choice to fit their needs at purchase. This gives Canvas a unique market position that goes hand in hand with the trend of individuality with more awareness of individual needs, while keeping the production simple.

One of the big challenges of the project was to design one bicycle frame that aesthetically would work with the different components. Especially the form language of the fork varied a lot just from city bikes to mountain bikes. The solution to this was to keep the overall geometry and design of the frame simple, and close to the iconic double diamond shape that most bicycles have. Instead of trying to fit in to one specific design language, the frame became a white “canvas” as the name suggests, where the styling and expression comes from the other components.

A big part of the project was to find the best size, dimensions, and angles for the bicycle frame, to make it pleasant to drive on with different components and for people of most sizes. Based on research of bicycle geometry and physical testing, Canvas is made in one size that fits users between 160 cm and 195 cm in height. This gives a range that would hit around 80% of adults.

An important feature of Canvas that makes it stand out on the market, is the removable top tube. The bicycle market is to a large degree separated into men and women bicycles, where men’s bicycles often have a top tube while women’s does not. From a practical perspective most men do not want the top tube as it is not needed and just in the way. This has resulted in most electric bicycles being designed without a top tube to be more unisex. However, most people associate it with a woman’s bicycle if it does not have a top tube, and the top tube is therefore critical for some users to identify themselves with the bicycle. Therefore, Canvas is designed with an attachable top tube that are not part of the structural integrity of the bicycle and can be attached to the frame if desired. This way the user gets to choose if they want the top tube or not, without affecting the production of the main frame.

Reflection

Product reflection

Platform
Canvas has been developed as a product platform with great focus on the advantages in development and testing of using the same frame for multiple bicycles. Creating one platform that are compatible with wide range of components is a comprehensive and expensive process, compared to creating a frame for specific components. However, in the long term a platform will be cheaper as only one design process are required for multiple bicycles. When making a platform it is important to know that it also leads to some disadvantages, as it limits the products and innovation to what is possible within the platforms limit. External components such as motor might be outdated meaning that the platform eventually will be outdated and must be redesigned. The motor was assessed as most likely to change in the future, which only will result in small changes to the platforms interface at the base to update the platform.

Motor and battery dimensions
During the process it was not possible to acquire the exact dimensions and interaction points for the motors and batteries, before the very end. This resulted in the interaction points on the frame being based on measurements from reference pictures, and therefore not being accurate. If the project would be further developed these interaction points would therefore be important to update to fit the motors and batteries.

Is one size fit all possible?
As the research, experiment and interviews showed through the process, a one-size fits all frame seemed possible on paper and practice. The approach of a one size fits all goes against the common mindset of the bicycle industry that has different sizes of most of their frames. Selling a one size fit all, would therefore require a change of mindset, for users to accept and believe that this is possible. Having a showroom where costumers could try the bicycles could therefore be necessary to gain the users acceptance as well as approval to the concept. It will be a major paradigmatic shift in a controversial industry where new frames have specifications which the users cannot fell but they are used as selling point anyway. On the other hand, many customers are being so well-informed that they can make their own choice based on Google searches.

User feedback
Through the process various users was interviewed and used for testing. Most of the design decisions were to a large degree based on user feedback, which might vary depending on the users asked. To accommodate for this there has been great focus on getting feedback from many different users by for example including experts such as bicycle mechanics. Including a large user group could also give some disadvantages, because compared to using the same small user group every time. Different users has different opinions which could have caused confusion in decision making situations within the group.

Business/price
In terms of the unit cost guestimation and the final bicycle price could have been investigated further. A few production companies were contacted to estimate the production cost, but none were able to help with a price estimation. More bicycle companies could have been contacted to estimate the cost, as well as the tooling price. The final guestimation have many sources of error and are leading towards a discussion rather than a conclusion.

Product reflection
In relation to the product the down and top tube could have been challenged further. For example only one group member were tasked with making the down tube seem thinner which could have limited the result. Furthermore, the top tube should be reviewed for further development. The top tube had two design rounds and are not fully integrated into the design language which also were stated by the users.

Process reflection

Throughout the process the project was reframed multiple times as more information was gathered. When reframing, the process could have benefitted from being better at taking a step back and look at former findings to see if something went missing. This could have let to misplacing of knowledge, something not being integrated in the new framing or a reframing that did not fit some aspects of the product. It would also have helped making sure no rushed reframing decisions were made at any point in the process.

During this project Morten Mogensen from Butchers & Bicycles was used as an external supervisor giving feedback on the concept, the process and giving subjects to investigate or take into consideration. This have led to a realistic view on the development process as well as an inside view into the industry of bicycles. On the other hand, the group could have been more critical of the knowledge giving by Morten. Working within the industry for several years could have giving him a narrow perspective based on his company and business. there might also be something he could not say because of legal reasons. Being more critical after each feedback session with Morten could therefore have led the process in another direction.

Lastly, the process of working with a product which influences multiple users with a variety of perspectives has given the group the experience of analyzing and structure a great amount of data points. These mapping tasks and continuously presenting the data to share knowledge through the process sharpened communication skills as well as gave the group possibility to brainstorm on for example quotes during the analysis of the feedback sessions.

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Ill. 116 Gear-https://l.facebook.com/l.php?u=https%3A%2F%2Fblackjackwheels.com%2Fasymmetric-rim-main-advantages%2F%3Ffbclid%3DIwAR2oFJhGQ7YyEGIdESu-hCGOG1-Ztch6eYU4nNiFuryFp6RJjz3OY3aPNRA&h=AT0TzyF08EpPkJzAtGjxdbDWDEpliEcDpCgpWhaFSysMwCG17w6ARqWuFcyAwtjYElvjJ1RTyzCG015DJ3fr4uI9aM67XB2eG3HIgWlfIdCvylF8ihEq__-RF7U9f7GtT9Uv3AUb

Ill. 136 Bosch Mounting Kit PowerTube - cable side - *https:// - www.bike-discount.de/en/bosch-powertube-mounting-kit-cable-side*

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Ill. 138 Bosch PowerTube cable - *https://cykelshoppen.dk/elkomponenter/bosch-powerpack-frame-cable-310mm?gclid=Cj0KCQjwvqeUBhCBARIsAOdt45b-8JWMX9bko6MrsSbzNDad5KsVDEA7fCiREwPNvByd4xiNl8GlV5MaAnisEALw_wcB*

CANVAS

PRODUCT REPORT

MSC04- ID1 JUNE 2022

Kristian Vrist Hansen, Martin Fyhn Kristensen & Mette Bjørn Lind

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Aalborg University

Master Thesis in Industrial Design

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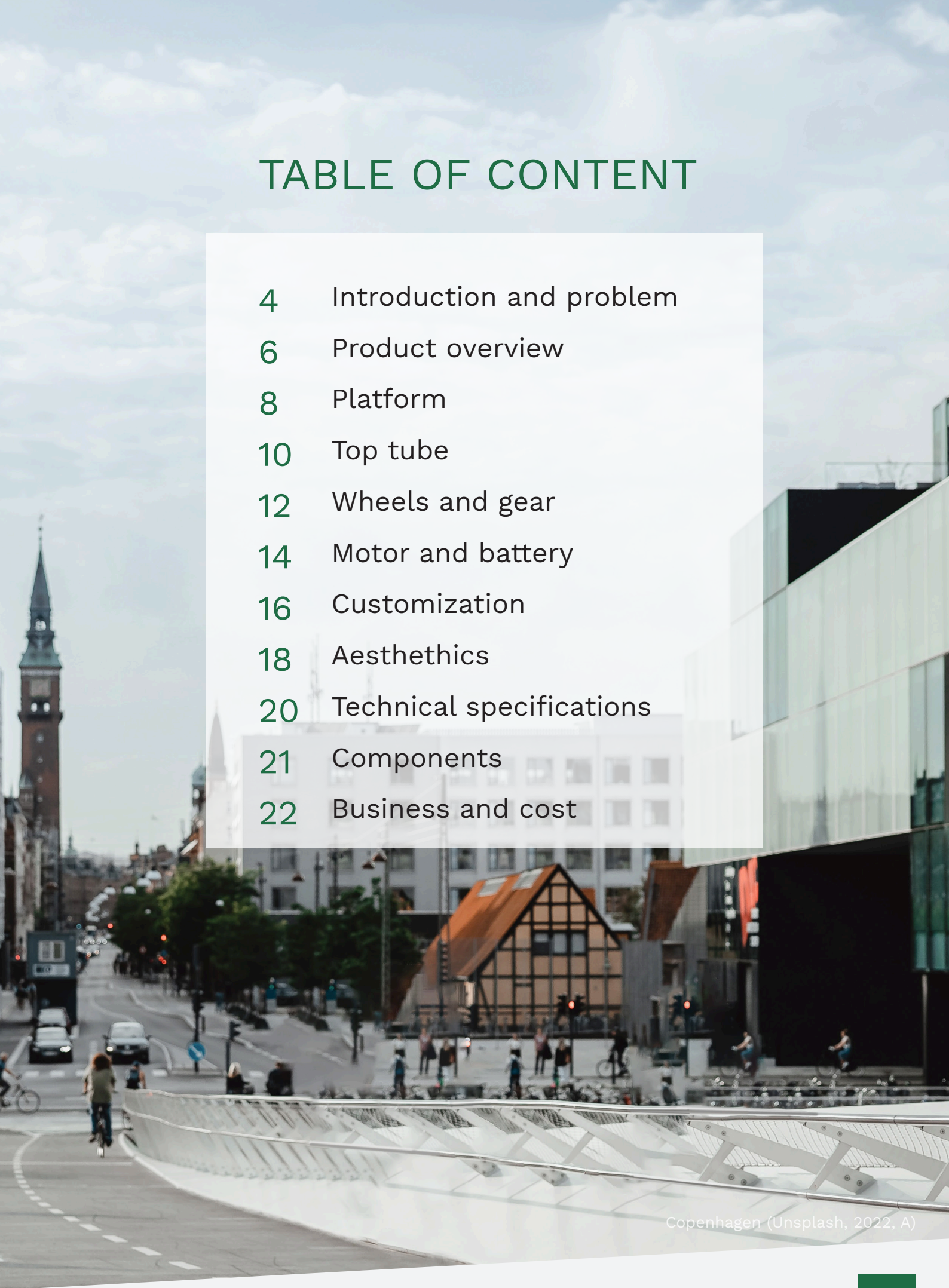
TABLE OF CONTENT



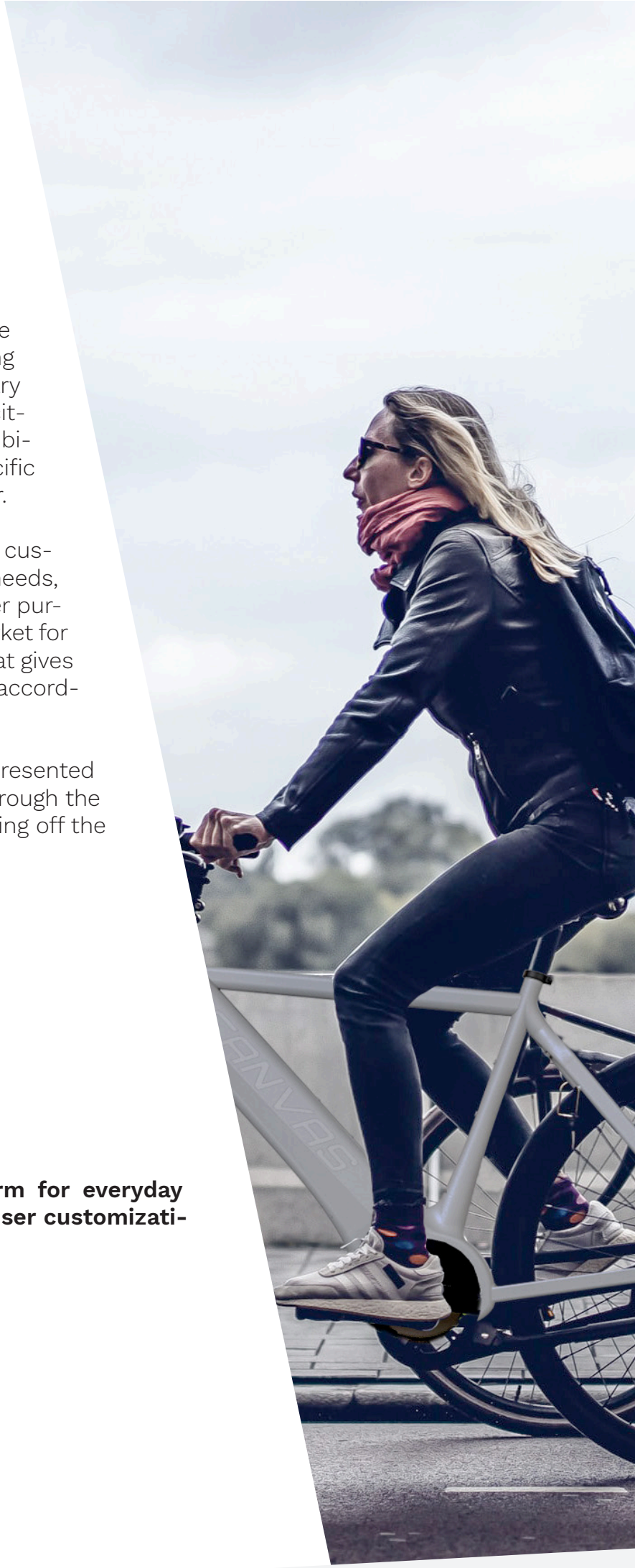
Copenhagen (Unsplash, 2022, A)

INTRODUCTION

With the rise of electric bikes and climate change awareness, bicycles are becoming a greater part of everyday life as a primary means of transport from A to B within cities. People are more dependent on their bicycles and customizing bicycles for specific user needs are more and more sort after.

Currently there are no easy solutions for customizing electric bicycles to specific needs, without having to modify the bicycle after purchase. There is therefore a gap in the market for an electric bicycle built on a platform, that gives the costumers the ability to customize according to their needs.

The product proposal Canvas will be presented in this report, that will take the reader through the proposed buying experience, while showing off the possibilities and features of Canvas.



PROBLEM

How do we design a product platform for everyday E-bicycle as a canvas which enables user customization across bicycle

Bicycles (Unisplash, 2022, B)

CANVAS

CREATE YOUR BICYCLE


CANVAS


CANVAS


CANVAS
SCHWALBE
SCHWALBE


CANVAS

PLATFORM

Design your own bicycle that fits your needs in everyday life. Canvas is an electric bicycle built as a platform that opens for endless possibilities to customize bicycles in any configuration you would like.

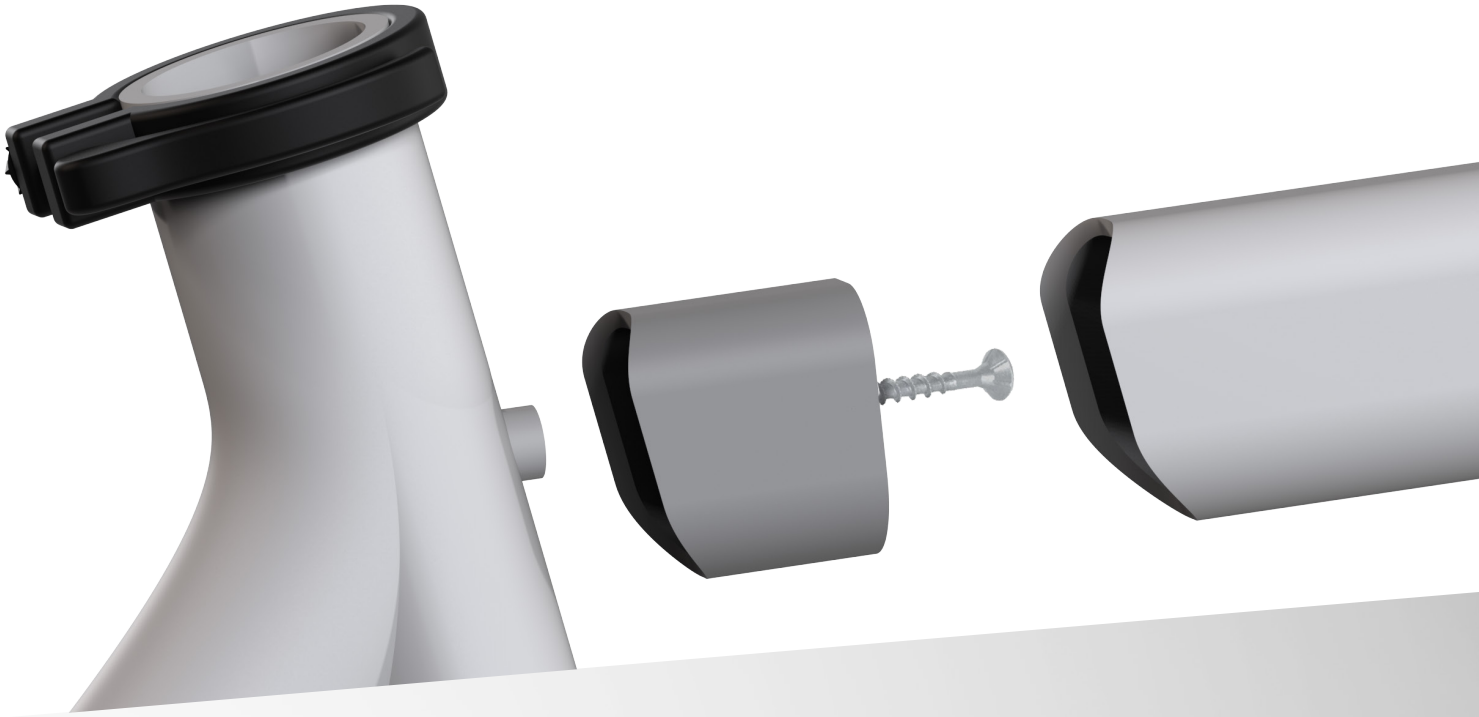
The costumer experience starts with choosing between four different bicycles, that then can be customized further to their needs.


CANVAS
KENDA
CANVAS

TOP TUBE

With top tube

Without top tube



While configurating your new bicycle you will have the opportunity to add a top tube.

The top tube joins the design of the bicycle beautiful together with the help of two bolts, that are screwed in different directions and secures the top tube tight to the frame. The top tube is removeable at any time with the right tools.

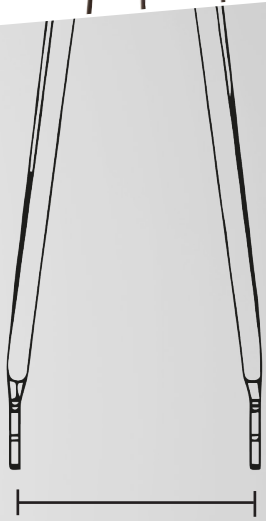
WHEELS AND GEAR

Hub gear & slim tires

Derailleur gear & fat dires

What are your needs? Are you mainly riding on paved, flat roads or do you like rougher wheel and a great number of gears? Those choices are yours to make.

A 120 mm distance between the stays makes it possible to choose between hub and de-railleur gears as well as multiple wheels.



MOTOR AND BATTERY

Are you going far? Are you going fast? Do you want a sporty acceleration? Canvas provides you with it all!

Six different motors are available for either hub or derailleur gears and an adaptor gives the possibility of added both sizes of motor and thereby enhances the possibility of customization.

Three different batteries are available ranging from 400 Wh to 625 Wh. If PowerTube 400 or PowerTube 500 are chosen a 70mm storage box will be installed to make the shorter batteries fit. This storage box is perfect for bringing an extra hose or repair kits.

Active Line

Active Line Plus

Cargo Line

Performance Line

Performance Line Speed

Performance Line CX

PowerTube 400

PowerTube 500

PowerTube 625

Motors and batteries (Bosch, 2022)

CUSTOMIZATION

Finish the bicycle by choosing the seat and handlebar that fits your needs, as well as desired colors and accessories such as a basket. The frame is designed with multiple attachment points and this step is what truly makes the bicycle special and opens for endless possibilities.

Saddle

Saddles (Bike24, 2022)

Handlebar

Handlebars (Cykelpartner, 2022)

Accessories

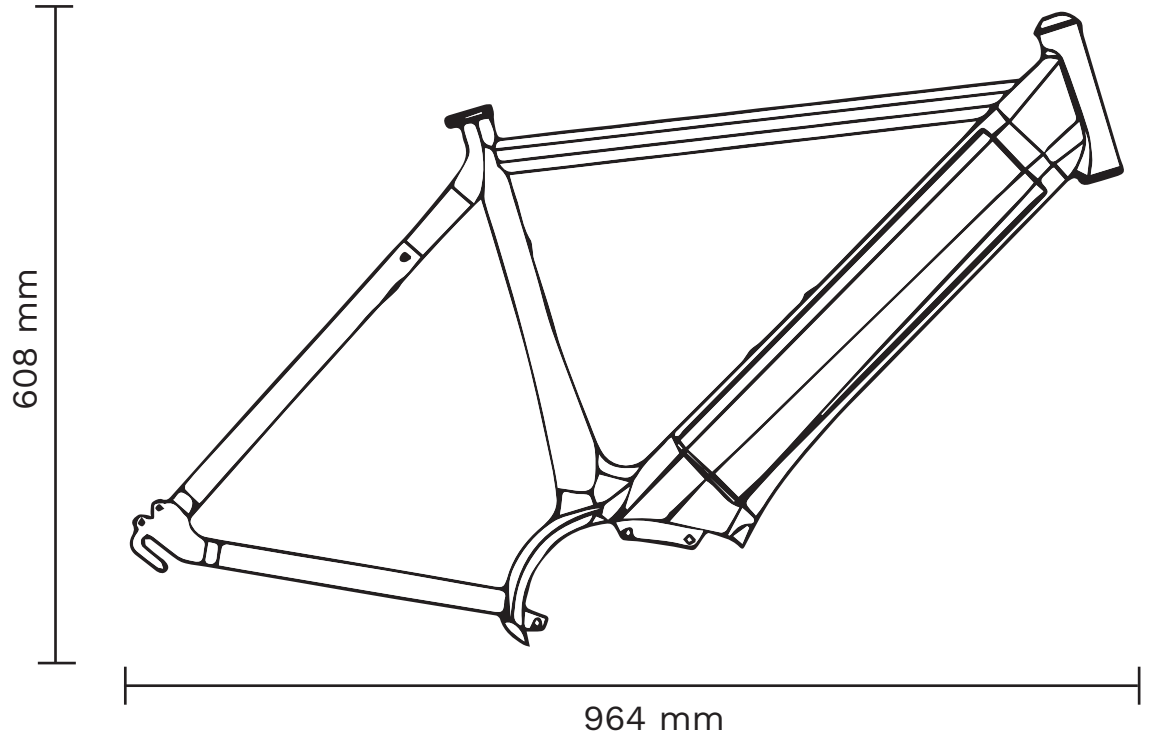
assesories (Cykelpartner, 2022)

AESTHETICS

The frame of Canvas has a simple and elegant design that follows the common diamond geometry that are seen on most bicycles. The simplicity makes it seamlessly blend in with varying components, where the frame becomes a canvas and the components the paint and focus points that completes the bicycle.

Small details such as the transition from seat stay to seat tube and from seat tube to the base, as well as the sharp line on the down tube, gives the frame a sense of quality. An overall light expression are also achieved through the line on the down tube.

TECHNICAL SPECIFICATIONS



WEIGHT
3.1kg

MATERIAL
6061 Aluminium

SIZE
608 x 964 mm

HIGHT RANGE
160-195cm

MOTOR
BOSCH eBike Systems
40-85Nm max torque

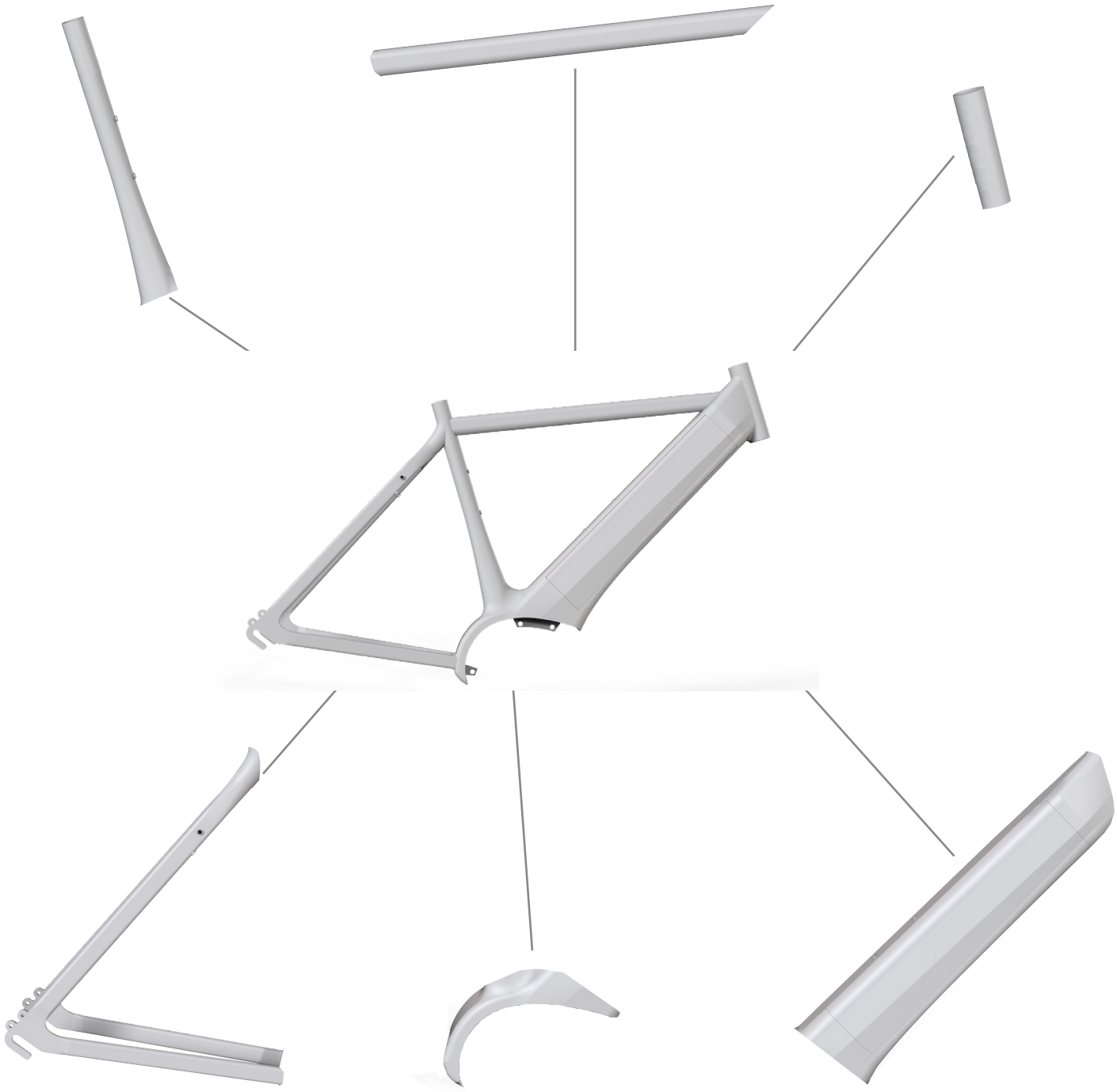
BATTERY
BOSCH PowerTube
400-625 Wh

COMPONENTS

SEAT TUBE
Round profile 2.5mm
Cut > Swagging

TOP TUBE
Oval profile 2.5mm
Cut

HEAD TUBE
Round profile 2.5mm
Cut



CHAIN & SEAT STAY
Round profile 2.5mm
Cut > Bend > Press > Weld

CRANK BASE
Sheet metal 5mm
Stamping

DOWN RUBE
Round profile 2.5mm
Cut > Hydroforming

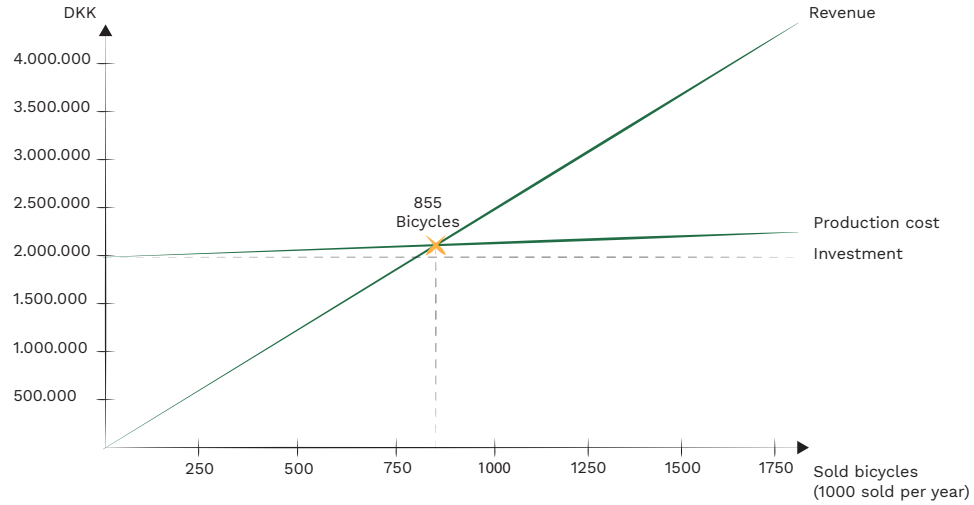
BUSINESS AND COST

Canvas is a revolutionary bicycle that will be sold online through a website, where the configuration of the bicycles as well as placing an order would take place. An addition to the website, showrooms will be in strategic locations in the biggest cities throughout Denmark. These showrooms' purpose is to give customers the opportunity to test ride 10 - 15 premade configurations and interact with sales staff regarding any questions on the bicycles.

The price setting of the bicycles depends on the level of components added to the individual configuration but would vary from 20.000 to 30.000 DKK.

BREAK-EVEN

The point of Break-Even is calculated only for the frame with no components. With the investment of 2.000.000 DKK on tooling equipment and a material price for each frame of 150 DKK will the Break-Even point be at 855 sold frames with the sales price of 2.500 DKK for each frame.



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Bike shop (Pixels, 2022)

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