Developing the e-Kick for Swapfiets

Graduation project Sjoerd Koudijs

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Preface

Before you lies my thesis ‘Developing the e-Kick for Swapfiets’. It is the documentation of my graduation project for the master Integrated Product Design at the TU Delft. Designing a new electric kick-scooter model for the company Swapfiets which will be implemented in big European cities.

This project was commissioned by the company Swapfiets and supervised by my chair Jos Oberdorf and my coach Caroline Kroon.

I would like to thank my supervisors for their input and advice throughout the timeline of this project. Many thanks to Team Product of Swapfiets who took me in as one of their own and gave me experience of the working operations. Especially many thanks to Luuk de Leeuw who was my coach from Swapfiets. He showed me the ins and outs of product development inside a big company which is a very useful experience to have.

Thanks to my roommates for helping me with tests and photoshoots. Thanks to my friends for the study sessions which boosted by productivity . Thanks to the employees of the PMB who helped me in any possible way with my prototypes.

And lastly a big thanks to my dad who told me just a while ago:
“Afstuderen is niet het einde, het is het begin!”

Sjoerd Koudijs, Delft 10/02/2021

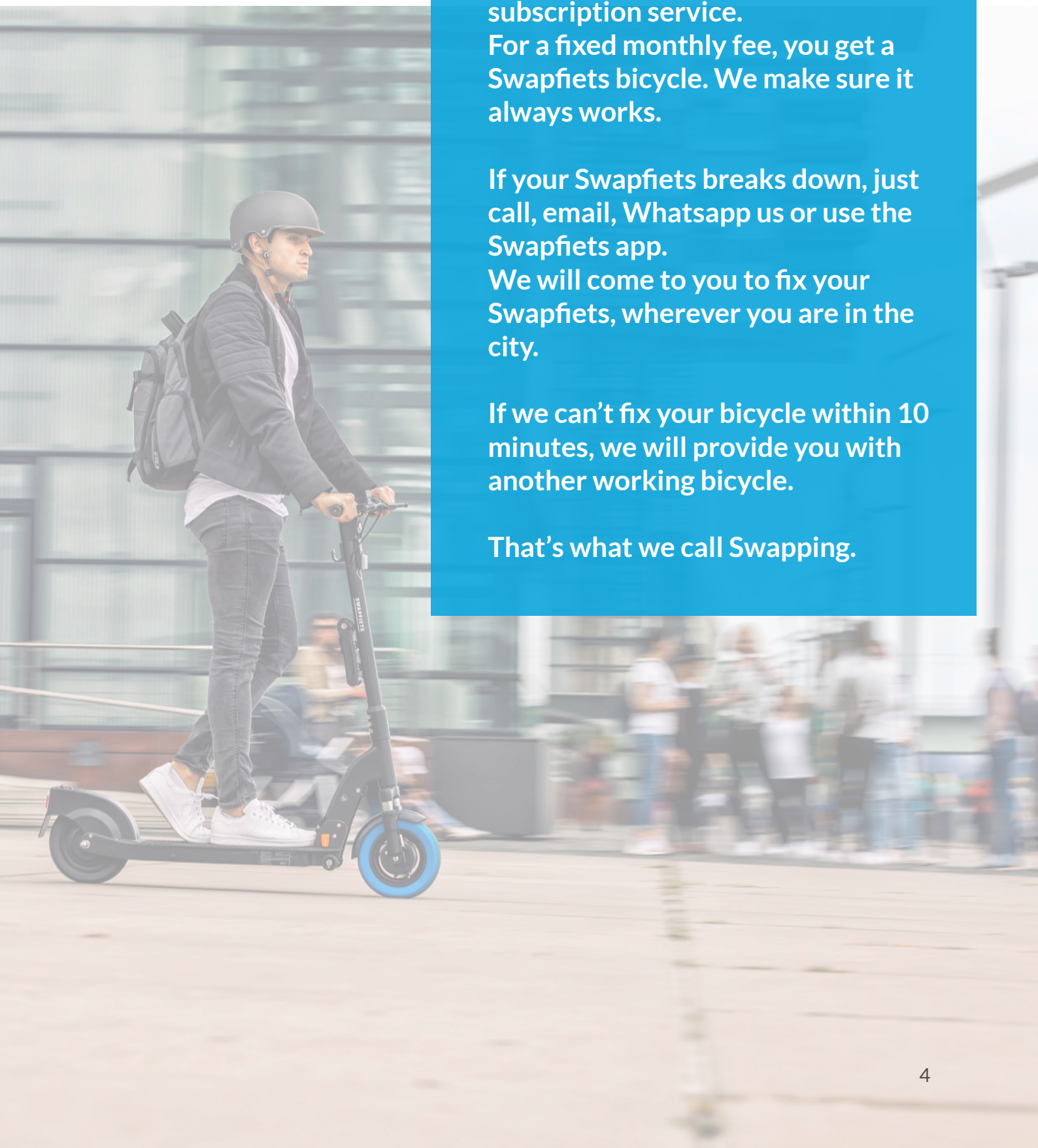
Introduction

Swapfiets is the world's first bicycle subscription service.
For a fixed monthly fee, you get a Swapfiets bicycle. We make sure it always works.

If your Swapfiets breaks down, just call, email, Whatsapp us or use the Swapfiets app.
We will come to you to fix your Swapfiets, wherever you are in the city.

If we can't fix your bicycle within 10 minutes, we will provide you with another working bicycle.

That's what we call Swapping.



Original1
Single speed clasic Dutch bike

Deluxe7
Luxurous bike with 7 gears

Power7
e-Bike with 7 gears

e-Scoot
Electric scooter with a maximum speed of 45km/h

e-Kick
Foldable electric kick-scooter with a maximum speed of 20km/h

Swapfiets started their business in the Netherlands, originally in Delft. But they have already expanded to 7 european countries in the past 2 years. With this exponential growth new products are added to Swapfiets' portfolio. The current products they have are shown above.

In this report the new design for the electric kick-scooter for Swapfiets, the e-Kick is documented. The research about the users, mechanics and other stakeholders lead to demand and requirements for a new model. This new e-Kick 2.0 model will be in operation next year. So if you get a chance to get the Swapfiets e-Kick, next year you will probably see my contribution driving around the streets.

Why this project?

The company Swapfiets is currently experimenting in a new mobility market, the so-called 'Light Electric Vehicle' market. Swapfiets mechanics, retail employees and product team are experienced on the workflow with multiple bike types but not with an electric kick-scooter.

With the two pilots of kick-scooters released in 5 different cities, Swapfiets mainly focuses on rapidly placing the product on the street and gathering data fast instead of thoroughly analysing this new subscription based market for electric kick-scooters.
The current 'White label' kick-scooter model is not intentionally designed focussing on the needs of the stakeholders. The main stakeholders consist of three types of people: The end user of the electric kick-scooter, the Swapfiets employee repairing and delivering the scooter and the manufacturer of this electric vehicle.

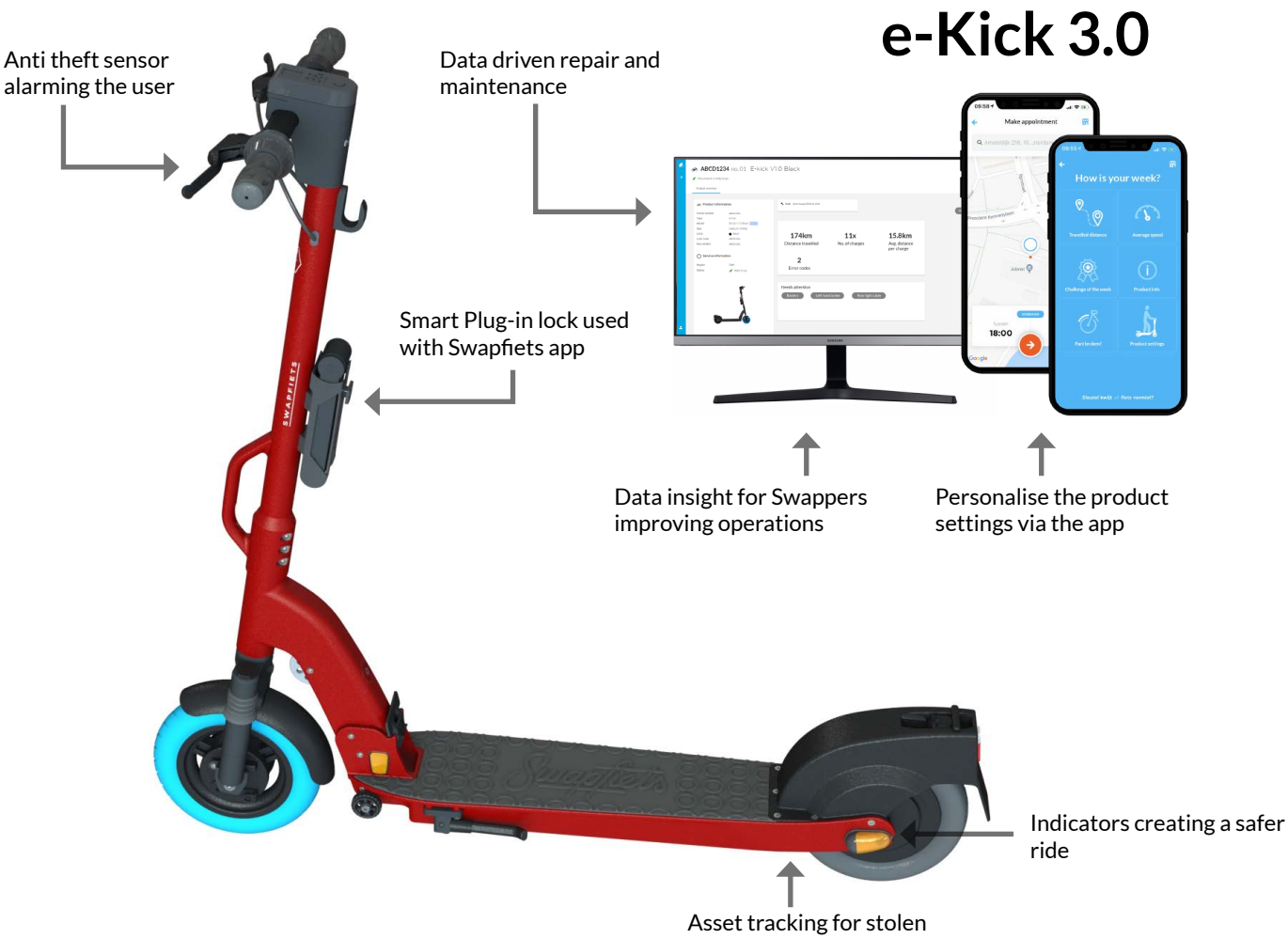
Summary

The design of Swapfiets' first electric kick-scooter, the e-Kick 1.0, is not specified on the Swapfiets user and Swapfiets operations.
Therefore the new e-Kick model needs to to comply with the lifestyle of the end user and improve his daily routines.
For the Swapfiets mechanics the solidity and repairability is an important objective.
The kick-scooter manufacturer must be able to make it, delivering high quality products.
Looking at the timeframe of the project, the aim for the launch of the new e-Kick design is around Q1 2022.

The target user lives in a big city using the e-Kick in combination with other transportation. He wants the e-Kick to be safe, carryable and reliable.
For the mechanic multiple bad quality parts need upgrading and the steering console is repair unfriendly. Next to that, the waterproofing of the e-Kick is not according to standards.

Shown below is the new e-Kick 2.0 design ready to be ordered at the manufacturer. On the next page the e-Kick 3.0 is shown which is the next generation e-Kick design with future possibilities for Swapfiets operations.

The realization of the new design into Swapfiets operations is spread out over a time frame of 3 years. In the roadmap below the implementation plan for the e-Kick 2.0 and 3.0 is shown.



Content

Problem statement

The design of Swapfiets' first electric kick-scooter, the e-Kick 1.0, is not specified on the Swapfiets user and Swapfiets operations.

What are the objectives?

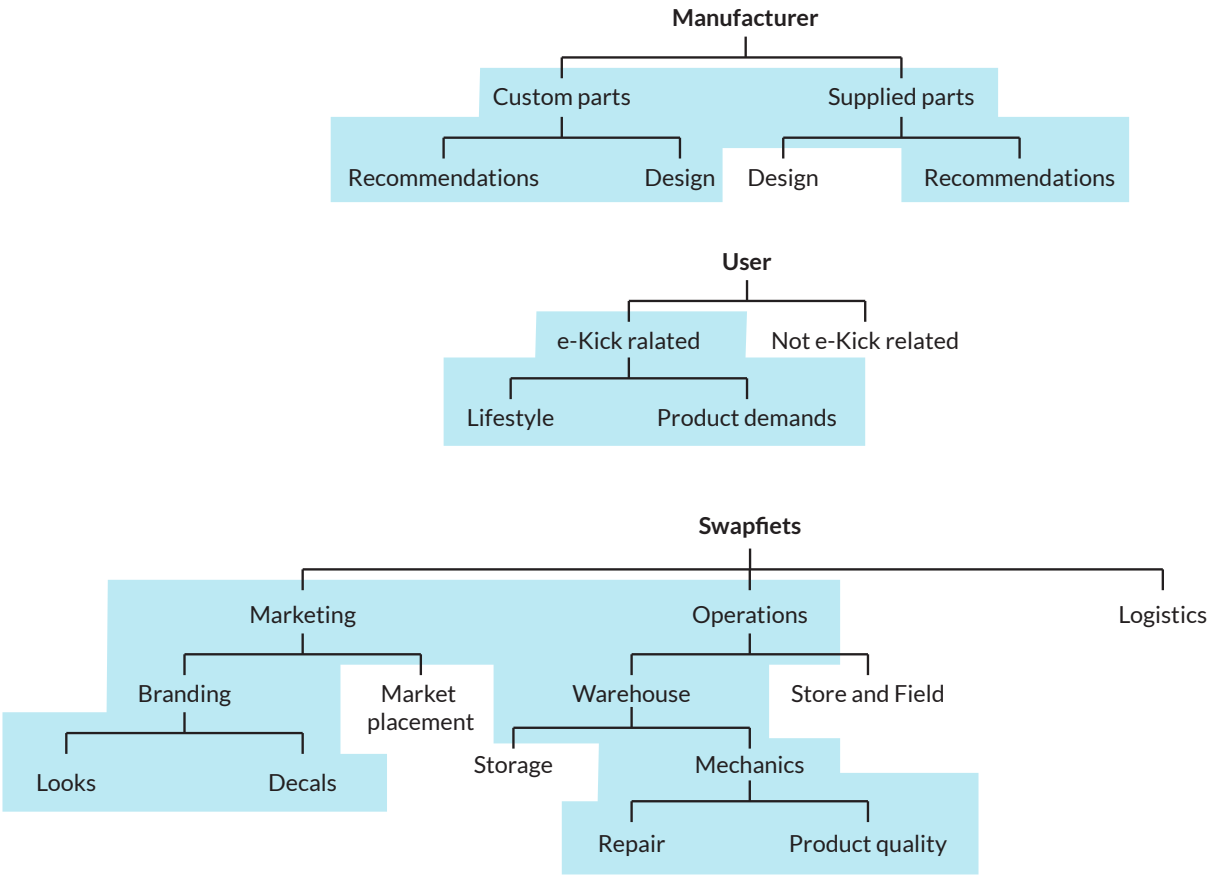
The issues that are addressed to come up with a solution for this problem are based on the three types of stakeholders.

- The e-Kick design needs to to comply with the lifestyle of the end user and improve his daily routines.
- For the Swapfiets mechanics the solidity and repairability is an important objective.
- The kick-scooter manufacturer must be able to make it, delivering high quality products.

Looking at the timeframe of the project, the aim for the launch of the new e-Kick design is around Q1 2022.

Design scope

In the figure below the scope for this project is shown. Within the whole process and operations around the e-Kick the project scope will only focus on the aspects inside the framework. The main focus will be on the new e-Kick design that can be delivered in Q1 of 2022, the so called e-Kick 2.0. Next to that, the e-Kick 3.0 will also be focussed on, a design for the e-Kick that shows Swapfiets an indication of possibilities for a next generation e-Kick. The ratio between the development of the e-Kick 2.0 and 3.0 is approximately 4:1.



Project goal

As you can read in the project brief in appendix 10, the goal is the development of an ‘off the shelf’ Swapfiets kick-scooter to a specially made Swapfiets kick-scooter. This newly developed product suits Swapfiets customer needs, improves Swapfiets intern workflow and is designed to last.

In the project brief it was also mentioned that the design is delivered in a fully working and detailed prototype made by the Swapfiets’ kick-scooter manufacturer.
This was not a realistic statement because of two main reasons.

1. The time management for ordering a prototype looking at manufacturing time and transport would not fit in the project planning
2. Because for the e-Kick 2.0 no major design changes were made to the frame, a new prototype made by the manufacturer is overkilling the prototype. It can also be tested on the an adapted version of the e-Kick 1.0

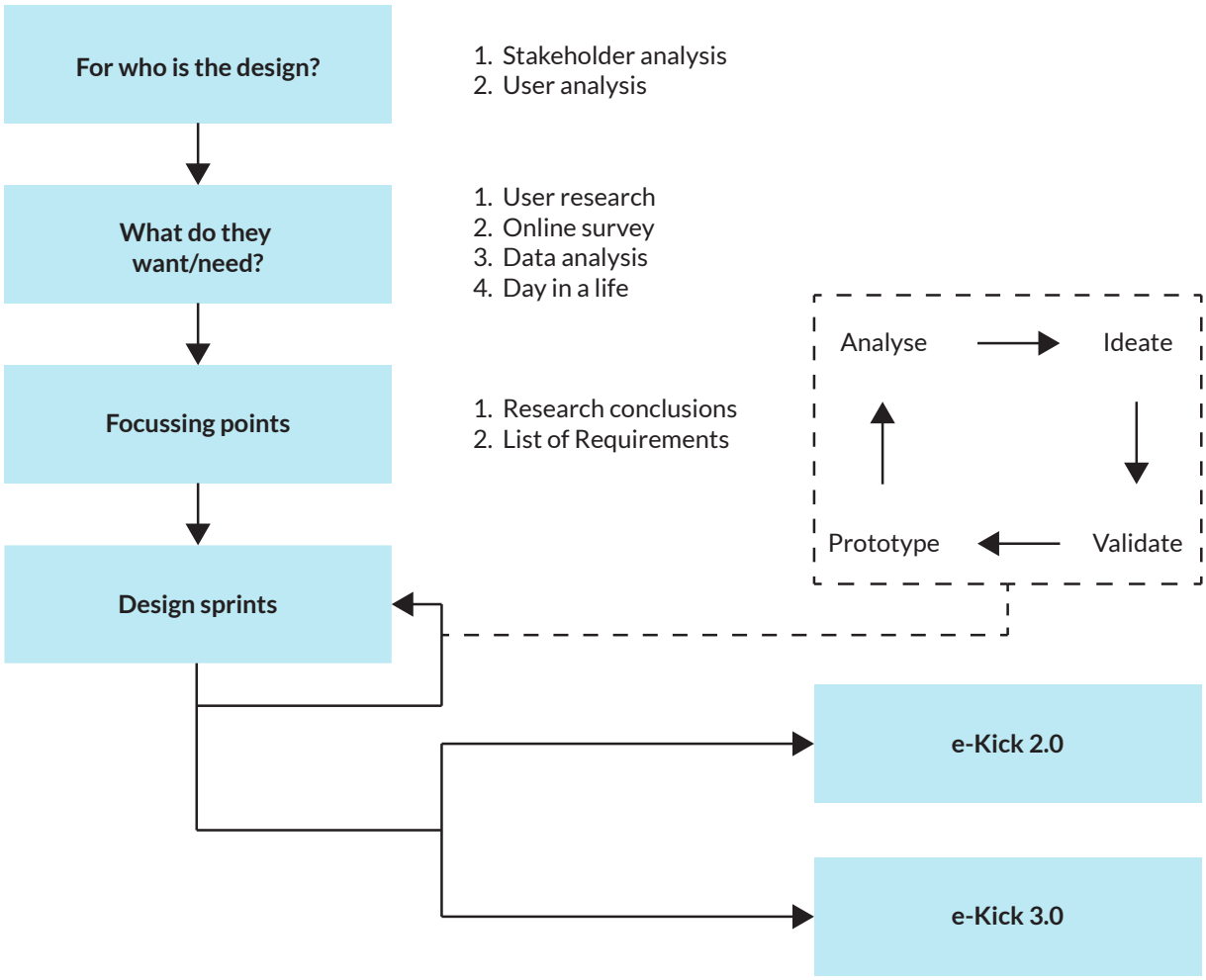
This part of the project goal is therefore not achieved in this graduation project but instead all design changes are prototyped and tested with the adapted e-Kick 1.0 version.

Approach

The global approach for this graduation project is shown in the figure below. In this figure you can see the split between the research and the development/validation phase. In the research part the main focus is on all stakeholders and what they want regarding the new e-Kick model. Based on the outcome of this research, the focussing points for the development phase are determined. With this, a more detailed list of requirements is created containing all insights from mechanics and users, government regulations and design boundaries.

For the development/validation phase the iterative method of design sprints is used. For all predefined focussing points a design sprint is carried out and documented in appendix 11 to 21. These design sprints have the classic loop of Analyse-Ideate-Prototype-Validate.

All conclusions out of the design sprints were then combined into 2 different e-Kick designs.
The first design is the e-Kick 2.0 which has realistic design changes which are discussed with the manufacturer and will be part of the new e-Kick model of Swapfiets in the coming year.
The second design is the e-Kick 3.0, a design less limited by part availability and production time and more focussed on future possibilities.



Research questions

For the research phase of this project the main focus is on the user and the mechanic. The first part of this graduation project is to answer the questions below.

Stakeholders
- Who are the stakeholers for a new e-Kick design?
- What do these stakeholders want?

User
- Who is the user of the e-Kick and what is their lifestyle?
- What do they want in an electric kick-scooter?

Mechanic
- Which parts will break down fast?
- What problems will occur during repair and how can we improve it?

Stakeholder analysis

A lot of stakeholders have influence in the design of the new e-Kick model. Apart from the final user perspective and desires, the new e-Kick needs to fit all Swapfiets' operations, is designed to conform government regulations and must of course be manufactured.
In appendix 7 all stakeholders are all discussed in depth about who they are, what motivates them and how they will benefit from the project. In this chapter the main takeaways are documented.

Swapfiets

The company Swapfiets has a very unique business model for the mobility market. They are the first bicycle subscription service. This model of taking ownership away and providing the service of transport is a circular improvement to society. Swapfiets want to show the world that this is the way for the mobility market.
A Swapfiets product is successful and profitable when the Swaps/Customer/Year is as low as possible. This means that the user benefits a long time from a working product and Swapfiets has a manageable amount of repairs coming in. Therefore it is important that the quality and lifetime of the product is high.

Mechanic

For the mechanic it is important that the repair can be executed smoothly. The defects are easy to find and all parts can be easily replaced. Avoid permanent fixations and the product needs to be repaired with the standard toolkit of the mechanic.

Government

For the regulations of the new e-Kick model, the German regulations are taken as a starting point. These are the most strict across Europe, so if the e-Kick conforms to these regulations, it will be legal in almost all other countries. This will not limit Swapfiets' expansion across Europe.

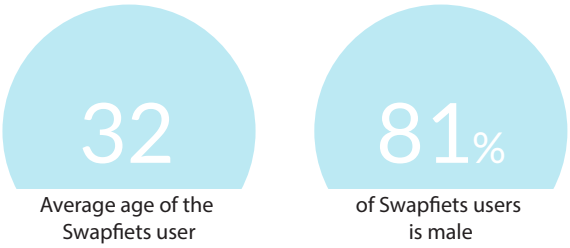
Manufacturer

The manufacturer is a Chinese company that designs and manufactures bikes and electric kick-scooters. They have an intern engineering team to implement all customers' demands into their products. This means that small design problems can be outsourced to the manufacturer instead of solving the problem ourselves.
The new design for the e-Kick must be discussed thoroughly with this stakeholder to make clear what the result must be. Communication is a tough challenge with this stakeholder.

User analysis

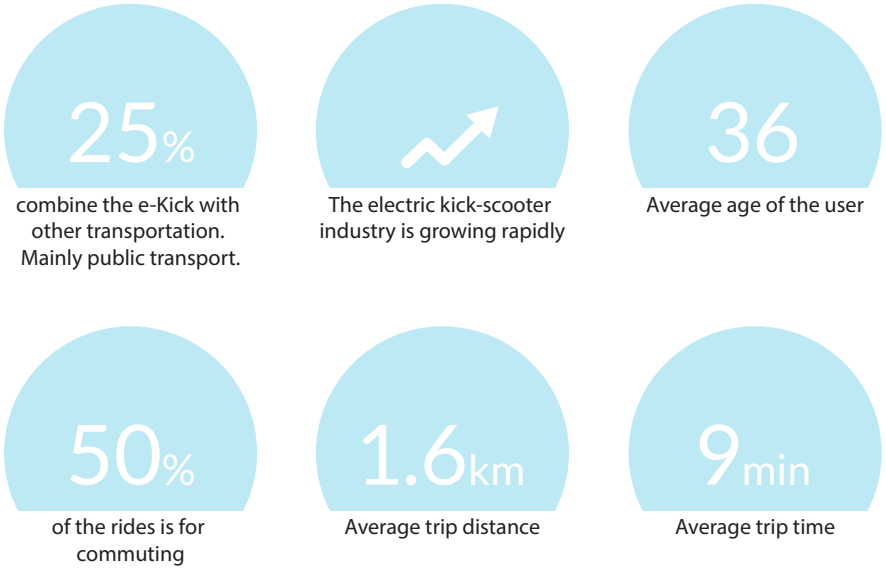
The e-Kick 1.0 is already a couple of months in operation in multiple cities across Europe. Next to two different electric kick-scooter types, the e-Kick is being used by Swapfiets members. Because it is currently evolving from a small scale pilot to a large scale product launch, the current user analysis can not only be based on the members Swapfiets has. Instead next to the existing member analysis, a member prediction will be made focussing on the competitors in the mobility sector of electric kick-scooters.

The Swapfiets members using the e-Kick are mainly located in Berlin. Looking at the Swapfiets customer data, the average age of the e-Kick user between 25 and 34 years old. Next to that is 81% of the users male. Based on this information and the insights from employees of Swapfiets Berlin (See appendix 4 and 5) a not very accurate persona was created. This persona can be found in appendix 8 where also is mentioned why it will not represent the future e-Kick user.



For now it is important to predict who will be the future e-Kick users when the 'Innovators' and the 'Early adopters' will change to the 'Early majority'
For this it is good to look at the customers of the big sharing companies like Lime, Tier and Bird. The adaptation of this product goes faster because the customer does not need to make an investment before riding an electric kick-scooter but simply pays per minute.

In appendix 6 a more detailed explanation about the market analysis is shown. The main takeaways for the average kick-scooter user are shown below.



Personas

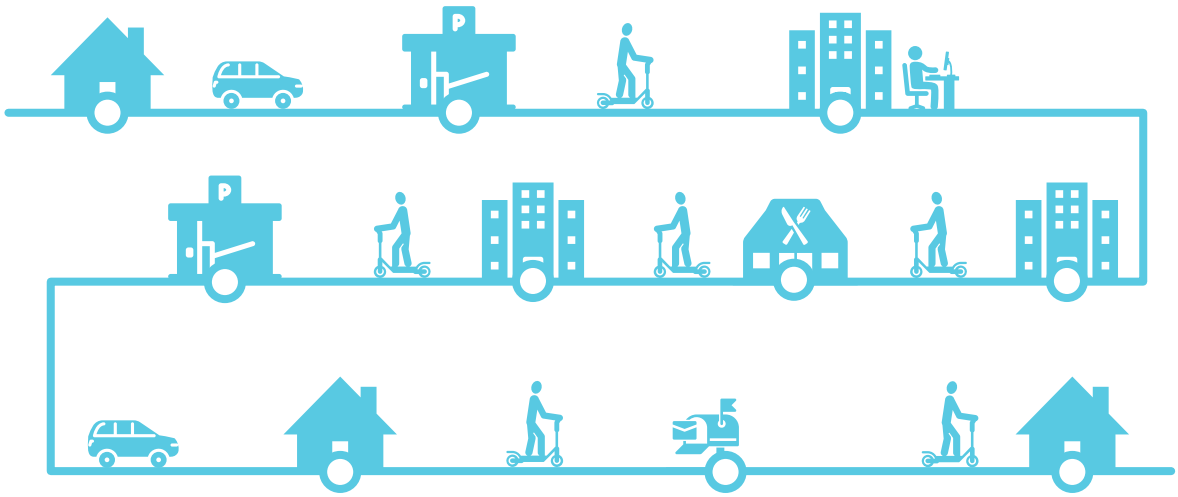
Based on the insights from the Swapfiets data and the market analysis the following two personas were created. These two personas give an indication of the future target group for the e-Kick 2.0.

SIMON

Gender:	Male
Age:	32 y/o
Profession:	Small business consultant
Personality:	Family man Has ritm in life Car user Lives outside city
Values:	Reliability Fast travel Safety

Average driving distance per day

12km



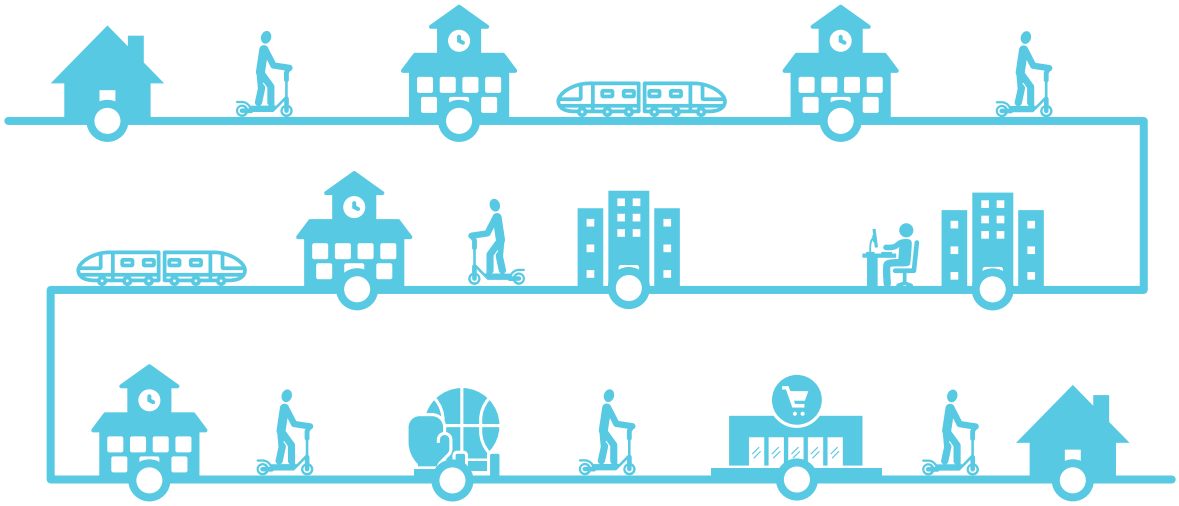
Simon saves a lot of money by parking his car at a free parking garage at the edge of the citycentre and uses the e-Kick for the last 3 kilometers to the office. With this clever combination he is less time in busy traffic and therefore home early. Next to that, he likes the ability to go to a nice place for lunch in just 5 minutes. However, safety first!

JOSEPH

Gender:	Male
Age:	35 y/o
Profession:	Shop owner
Personality:	Outgoing Interested in people Loves going to a bar Lives in a apartment inside city center
Values:	Flexibility Honesty No limits

Average driving distance per day

15km



Joseph uses his e-Kick in combination with public transport. He takes the train and goes the last couple of kilometers with the e-Kick, saving a lot of time using the bus or metro. He loves the freedom of going anywhere close by at any time. Groceries shopping and going to the gym is now not depending on 3 different metro connections or busy traffic.

Customer journey

In a customer journey every step in a daily routine where the product is involved is highlighted. These simple events are then analysed for potential problems or customer pain points. Based on this analysis every event has requirements that are linked to the e-Kick. To see the complete List of Requirements see appendix 9.

START OF THE DAY

UNPLUG CHARGER

- The e-Kick must be fully charged overnight.
- Indicator must show it is charged.

WALK DOWN STAIRS

- The e-Kick is not too heavy.
- Can be carried with one arm.
- Has a place to grab with hand.

RIDE THE EKICK

- Resistant to hot and cold temeratures
- Resistant to bad weather
- Pleasant riding experience.

TURN IT ON

- e-Kick must always turn on if charged.
- Feedback if the e-Kick is on.

UNFOLD THE E-KICK

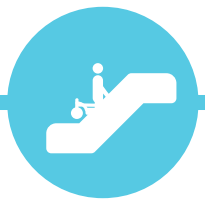
- It must be clear how to fold.
- Feedback if folded correctly.

PARTICIPATE IN TRAFFIC

- The e-Kick has bright lights.
- The e-Kick is safe to use on the road.
- You can show the traffic where you are going.
- The e-Kick drives not too fast.

FOLD THE EKICK

- The e-Kick can only fold if the user wants it.
- The e-Kick can be folded within 5 seconds.



WALK TO STATION

- You can walk 100m carrying the e-Kick.
- You can access public areas with the e-Kick.
- You can take the e-Kick onto an elevator or escalator.

PARK THE EKICK INSIDE

- The e-Kick must not claim a lot of space while stored.
- The e-Kick must fit in a closet.
- Hanging the e-Kick is an option.

CHARGE THE EKICK

- After a day driving the e-Kick can be charged again if the battery is almost empty.
- The battery can be charged if percentage is still high.
- The charger fits a regular EU plug.

END OF THE DAY

WALK UP THE STAIRS

- The e-Kick must not be extreamly dirty after riding throug bad weather.
- The e-Kick must not fold open while carrying it.

RIDE THE EKICK WITH GROCERIES

- The e-Kick is safely drivable with some luggage.

LOCK THE EKICK

- The e-Kick can be locked.
- The e-Kick can not be easily stolen.
- The e-Kick must be attached to something.

ENTER TRAIN/TRAM

- You are ollowed to take the e-Kick with you in the public transport.
- The e-Kick fits through the public transport doors.

RIDE WITH TRAIN/TRAM

- The e-Kick can be stored inside the public tranport.
- The e-Kick does not impede other travellers.

RIDE TO THE STORE

- The user can navigate to the location.

User research

To get more insight in the wishes and demands of the e-Kick user, multiple user researches were carried out. An e-Kick test day was organised to observe and hear first impressions of new electric kick-scooter users. An online survey was conducted to create insight in their product experience. And a Swapfiets helpdesk analysis showed insight in the customer Swap history which shows what are common issues.

In appendix 1 to 3 all details about each individual research can be found. The main insights which are relevant for the new e-Kick design are documented in this chapter.

Cruise control

The constant force on the throttle with the thumb is not very pleasing. Adding a cruise control will improve the comfort and will make each ride smoother.

Hand brakes

The ergonomics of the hand brakes are not optimal. They are not in perfect reach which does not improve the safety and comfort of the e-Kick.
The double hand brakes are a good thing. Compared with a single brake they feel more safe.

Rear axle nut

On the rear axle the nut is pointing outwards. This resulted in some small injuries at the ankles of users. All pointy parts must be out of the way of the users foot when making the kick movement backwards.

Range

The range of the kick-scooters is too short according to some users. The user is never satisfied with the range of the e-Kick. Even when they used a kick-scooter with a range of 65km they wanted more. So for the new model we do not increase the battery capacity to increase the range. However, we have to keep track of the performance of the battery over time. The minimum range must stay at the current level of the e-Kick 1.0 and not become worse.

Lock

The current lock is not a good design. Users want an electronic lock or a more ergonomic one. They don't like the bending down was mentioned 7 times of which 4 referred to an electronic lock.
Another main problem was the lock holder that broke off or came loose. This means that the current lock attachment needs a redesign.

Indicators
As an outcome of the test day and the online survey, indicating your direction in traffic is not easy with the e-Kick. Because of the small wheels the steer is not safe to hold with one hand. Adding indicators to the rear of the e-Kick which can be operated with a controller on the steer solves this problem and creates a safer product.

Flat tire
The majority of electric kick-scooter types Swapfiets currently uses is the Segway model. This model has pneumatic tires which give the user a comfortable ride and more grip in bad weather. The main disadvantage is that these run flat. Looking at the data, a big percentage of the kick-scooters coming back is because of the flat tires. This means that the new e-Kick tires which are airless, have a big impact on the broken ratio of the e-Kick.

Display
A lot of broken e-Kicks were caused by error codes. This means that the kick-scooter has an internal error which blocks it from driving. A potential cause is water damage. Therefore the overall water and dirt protection of the e-Kick needs an upgrade.

Battery
Some users complain about the quality of the battery. The range is too short or it does not charge properly. The manufacturer claims the e-Kick has a range of 30 km but this is under ideal circumstances. The customer is probably wrongly informed about the ‘real’ range which could lead to a reason for swapping the e-Kick. Therefore it is important for the battery to always charge and for Swapfiets to explain to their customers that always using the sport mode, will drain the battery fast.

Mechanic research

The Swapfiets mechanics who have experience working with the e-Kick and other types of electric kick-scooters gave a lot of useful information about the e-Kick 1.0. Documented below are the main improvement points for the new model e-Kick. All details and other small mechanical issues can be found in appendix 4 and 5.

Kickstand

The Kickstand is of bad quality. The plastic part wears out and results in malfunctioning shown in the picture. At Circ (a kick-scooter sharing company) they had a lot of broken kickstands of the same model.

Repairability of the steering console

If something needs replacement on the steer or in the steering console the whole steer needs to be disassembled. Because of the low quality and small cables inside, repairing the steer takes a lot of effort and time. This needs improvement.

Charger cover and plug

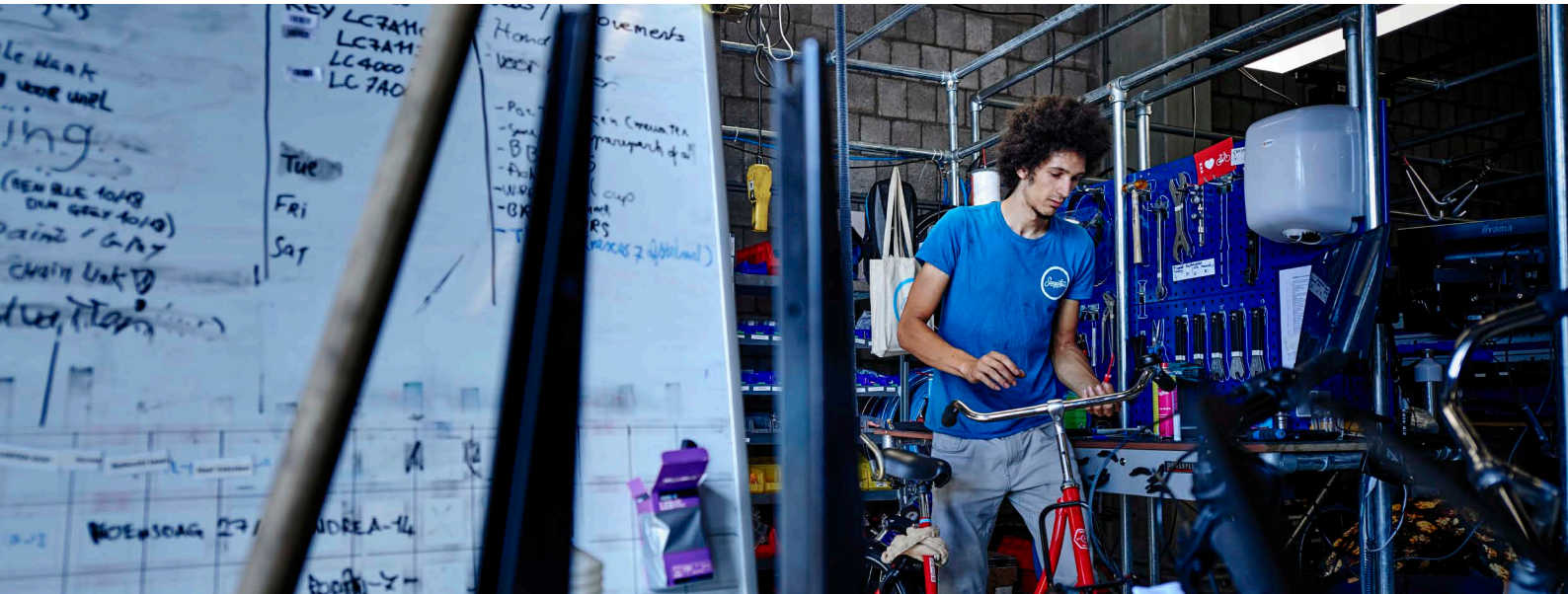
The plug cover for the charging port is of bad quality and falls off easily resulting in letting the charger port exposed to water and dirt.

Water damage

There are a lot of issues caused by water damage. This causes corrosion at connectors or shortcuts the whole system. All connectors must be protected against water. This also applies to the battery and charger plug.

Bolts and nuts

All bolts in the e-Kick are not tight enough. This must be solved not by over tightening them but by using a thread locking adhesive.



Research conclusion

The research questions mentioned earlier in this report are leading to focussing points for the development phase of the project. The stakeholder and user analysis and the user and mechanic research resulted in thorough analysis of options for a new e-Kick design.
Stated below are the most important takeaways from the research phase which will be used as a start for the development and validation phase. All the insights from the research done together with all regulations set by the German government are combined into a list of requirements which can be found in appendix 9. This list will be used as a guideline for the design of the new e-Kick model.

User

- The e-Kick is easy to carry
- It can be used in public transport
- It gives feedback while charging
- The hand brakes are safe and comfortable
- The e-Kick can be locked easy

Mechanic

- Improve the kickstand
- Don't let bolts fall off
- Make it resistant to water and dirt
- Improve the repairability of the steering console

Swapfiets operations

- Low Swaps/Customer/Year
- Show the customer Swapfiets' circular goals
- Comply to all German government regulations

Design result

In this second part of the report the result from the development and validation phase is documented. Here the designs for the new e-Kick models are shown and explained. The whole process of the development and validation is done in multiple design sprints which are documented in appendix 11 to 21.

e-Kick 1.0 vs. e-Kick 2.0 vs. e-Kick 3.0

First the original e-Kick 1.0 is shortly shown including its specifications and performance. This is the e-Kick model from the Chinese manufacturer that is currently in operation of Swapfiets.

Next up the e-Kick 2.0 is shown. This model is designed for fast implementation into Swapfiets operations. All design aspects discussed are validated with the user, mechanic and manufacturer to be ordered for the next year. Some design changes are already in a further stadium and will be delivered at the end of march 2021. Because of the fast realisation time of the e-Kick 2.0, it does not include radical design changes. Moulds for the frame parts can not be changed, limiting the design freedom for the e-Kick 2.0.

The e-Kick 3.0 is the 'beyond' version designed for Swapfiets. This is a next generation model which is not limited by any fast realisation demands. This means more advanced technologies are used and design limits regarding the frame are more flexible. The e-Kick 3.0 is therefore not worked out to detail but is kept in the concept phase. The e-Kick 3.0 has the pospuse to be an inspiration for Swapfiets to get an indication of where their product can go after the launch of the e-Kick 2.0.

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e-Kick 1.0

On this page the current e-Kick 1.0 is shown with all its specifications. This gives insight in the current model which is the base for the new design of the e-Kick 2.0 and 3.0.

	Item	P1
Dimensions	Length x Width x Height	121x51x111 (CM)
weight	Net weight	17.8 kg
Rider	Max. Payload	220 lbs (100 kg)
	age application	14+
	Applicable height	3' 11"—6' 6" (120—200 cm)
Machine Parameters	Maximum speed	20 km/h
	Mileage	30 km
	Max. Slope	12°
	Applicable terrain	asphalt/flat pavement; obstacles < 0.4 in (1 cm); gaps < 1.2 in (3 cm)
Battery	Battery type	21700 lithium battery
	Battery core quantity	20
Motor	Maximum power (W)	350W
Charger	Charge limiting voltage	42V
	Charging time	About 6 hours.

Solid blue front tire

Kickstand on the side

Rear wheel motor 350W

Folding mechanism

- 2 handbrakes
- 2 Mechanical front drum brakes
- Electrical rear brake

LED display
- Battery indicator
- Speed indicator

e-Kick 2.0

The e-Kick 2.0 is the e-Kick version for Swapfiets following up the first version 1.0. This new version is designed to be released at the end of 2021 and therefore are all new design features validated and discussed with the manufacturer.
The development of the e-Kick 2.0 is mainly focussed on 3 target groups. Of course the user of the e-Kick is very important to keep in mind. Next to that is the repairability of the e-Kick of high importance so the mechanics are an important target group. And lastly the company Swapfiets as a whole is also influencing the design of the e-Kick with their vision and demand.

The User

The Swapfiets members who are going to use the new e-Kick model are being explored in chapter User analysis. Combining these personas with the user research done, the following aspects for the e-Kick improvement are based on the user.

Vision

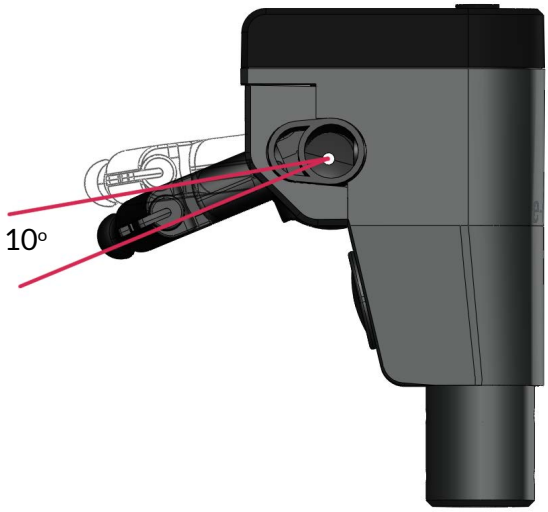
The e-Kick 2.0 is for the user a transportation type that does not limit their daily life but enhances it. By focussing on safety we ensure the user of reaching the destination. Next to that is the user feedback guiding for creating new features and improvements.

Safety

The e-Kick needs to be safe to operate and gives the user a safe experience driving. This is guaranteed by multiple design iterations implemented in the new e-Kick 2.0 model.

Hand brake angle

The current hand brake angle is pointing too much upwards. Firstly, this is not ergonomically pleasing and does not feel comfortable holding the brakes while driving. Secondly, reaching for the handbrake at this weird angle, needs extra attention which prevents the user from brake reflexes. This makes the position of the hand brake unsafe.
In Appendix 11 the whole development process of the handbrake angle adjustment is explained. The final result is that the handbrake is tilted downwards 10 degrees which improves the reachability and safety of the e-Kick.
This is achieved by machining the slots for the hand brakes inside the steer at a different angle.



Steer rotation limit

One of the biggest causes for injuries with electric kick-scooters are potholes (Ma et al., 2021). Driving into these holes in the road often causes a crash. Driving into a pothole impacts the steering and in many cases the steer rotates over 90 degrees causing the driver to flip over the steer. This flipping can be prevented by limiting the rotation angle of the steer. This will decrease the chance for the driver to flip over the steer when hitting a pothole.
The current rotation limit on the steer is 180 degrees to prevent the cables inside the steering shaft from entangling but this is not safe. The new rotation limit is at 150 degrees decreasing the risk of the e-Kick to crash when hitting a pothole and increasing the risk of the e-Kick to keep driving.

User friendly

Next to the safety improvements, the use of the e-Kick 2.0 has to contribute to the life of the user and not add extra hackles to their daily routines. Therefore, based on their input shown in appendix 1-3 and on other aspects of the user research, the following design aspects are added to the new e-Kick model.

Carrying

To carry the original version of the e-Kick, the steering pole with a diameter of 42mm can be gripped. This is possible but not pleasing, especially not to the user with small hands. In appendix 11 the whole design process for improving the carrying of the e-Kick is explained. This design process resulted in adding a grip to the steering pole right above the centre of gravity of the kick-scooter. This hand grip is made of the same material as the frame, aluminium, and is welded to the steering pole. The new grip which is ergonomically shaped and has a diameter of 26mm, is a more comfortable grip and makes the carrying easier. Carrying the e-Kick to your apartment or using it in public transport is now way easier.

Lock location

On the e-Kick 1.0 a foldable lock inside a holder is attached to the frame to lock the e-Kick with. This lock is high quality and represents the value of the e-Kick. However the location to loop the lock through is through the front wheel suspension. Multiple requests from users came in to improve this locking location (appendix 2). In appendix 14 the whole process for a new lock design is explored which resulted for the e-Kick 2.0 in a new locking location for the foldable lock. Because the new grip is welded to the frame and the spacing between the grip and the frame is big enough for the lock, the new locking location is raised 35cm compared with the old location.

Cruise control

Looking at the response from the user analysis shown in appendix 21, a couple of participants mentioned the lack of a cruise control. Especially when driving long straight roads, a cruise control improves the driving experience and takes away the constant pressure on the thumb for using the throttle. In the software of the main computer inside the new e-Kick 2.0 a cruise control is added. This software update keeps the e-Kick driving at a constant speed when enabled. If the e-Kick drives at a constant speed for 5 seconds the cruise control will turn on automatically and will be turned off by braking or using the throttle. With that, audio feedback of a beep is used when turning on.
With this new feature the driving experience of the e-Kick 2.0 will be more comfortable and therefore the user more pleased.

Charger feedback

While charging the e-Kick, feedback is desired to indicate the charging status. This gives the user an indication about the time left for charging and the rate of it. In the current model the display is off and there is no feedback to the user about the charging status.
In the software of the new e-Kick 2.0 the charging status is added. Now, when plugged into the net, the display shows the battery status and charging progress. It contains 5 bars which will be blinking on the display if being charged.
This implementation improves the feedback to the user who has now more information about the charging status and time.

The Mechanic

The second stakeholder having a big influence on the new e-Kick design are the mechanics of Swapfiets. They repair all broken products by replacing or repairing parts. Improving the repairability of the new e-Kick 2.0 and preventing the product from breaking down is playing a big role in the new design. From the mechanic perspective two main focussing points are key: the breakdown prevention and the easy replacement.

Vision

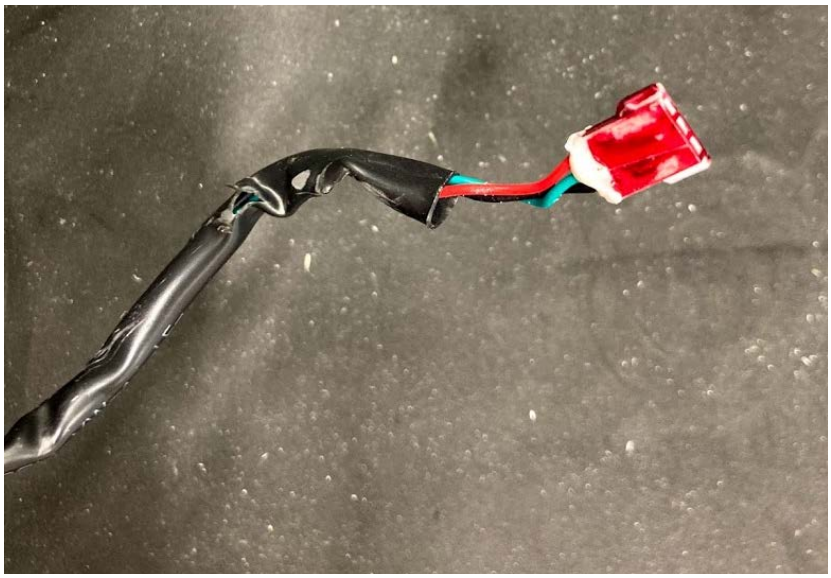
The new e-Kick 2.0 design consists of high quality parts which do not break down frequent. When a part is broken it can be easily reached, taken out and replaced by a regular bike mechanic. This makes the product durable and time efficient.

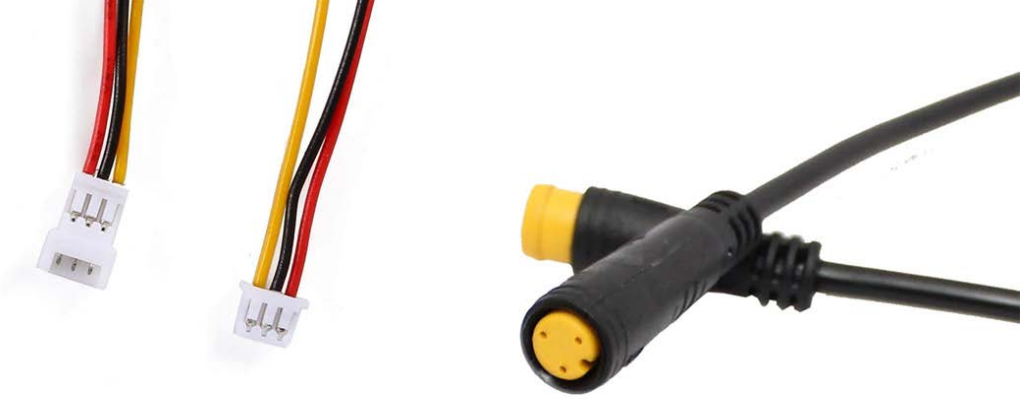
Prevent breakdown

Swapfiets wants to keep their products on the road as long as possible. They track their product performance by Swaps/Customer/Year. By satisfying the customer and preventing the product from breaking down, this KPI can be reduced. The following design changes are made to the e-Kick 2.0 to prevent possible future product failure.

Cable protection

The cables inside the steering console running from the hand brakes and throttle to the display are not up to the quality standards. The 3 pin cables are covered with heat shrink instead of regular cable protection. Repair and movement in the steering console impacts these cables which will lead to water shortcuts or bended cables. Replacing these cables with cables with normal flexible cable protection will prevent this from happening.
Keeping the quality of the cables up to standard will benefit the mechanics. The product will break down less often and the cables are more flexible to work with.





Cable connectors

The connectors inside the steering console connecting the handbrakes and the throttle to the display are not up to the IP56 standards. They are simple 3 pin connectors covered up with heat shrink. This heat shrink makes it more resistant to water and dust but also requires a mechanics expertise. When replacing a hand brake or throttle, the part replacing process takes a big effort removing and re-applying heat shrink.
The new connectors are according to the IP56 standards and do not require heat shrink. It is just plug and play. The main challenge however is the size of the new connectors, this issue is discussed further on at the cable management section.

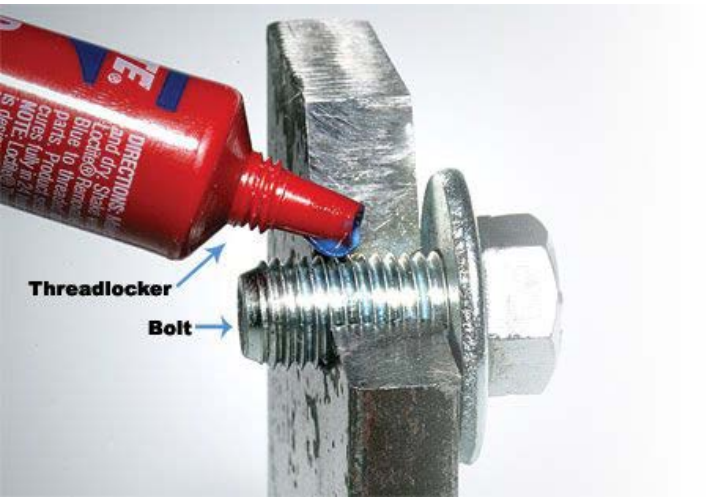


Image source: popularmechanics.com

Loctite

According to a lot of users, some parts or bolts fall off while riding the e-Kick. This means that a lot of bolts and nuts are not resistant to the vibrations that come with riding the e-Kick. To assure the safety of the user and the reliability of the product these bolts must be resistant to these vibrations. Simply tightening them is not the solution but using a thread locking adhesive is. Almost all bolts and nuts used in the e-Kick 2.0 will be applied with Loctite, one of the best thread locking adhesives on the market. This addition will prevent parts from falling off the e-Kick increasing the users safety and reducing the mechanics work.

Kickstand

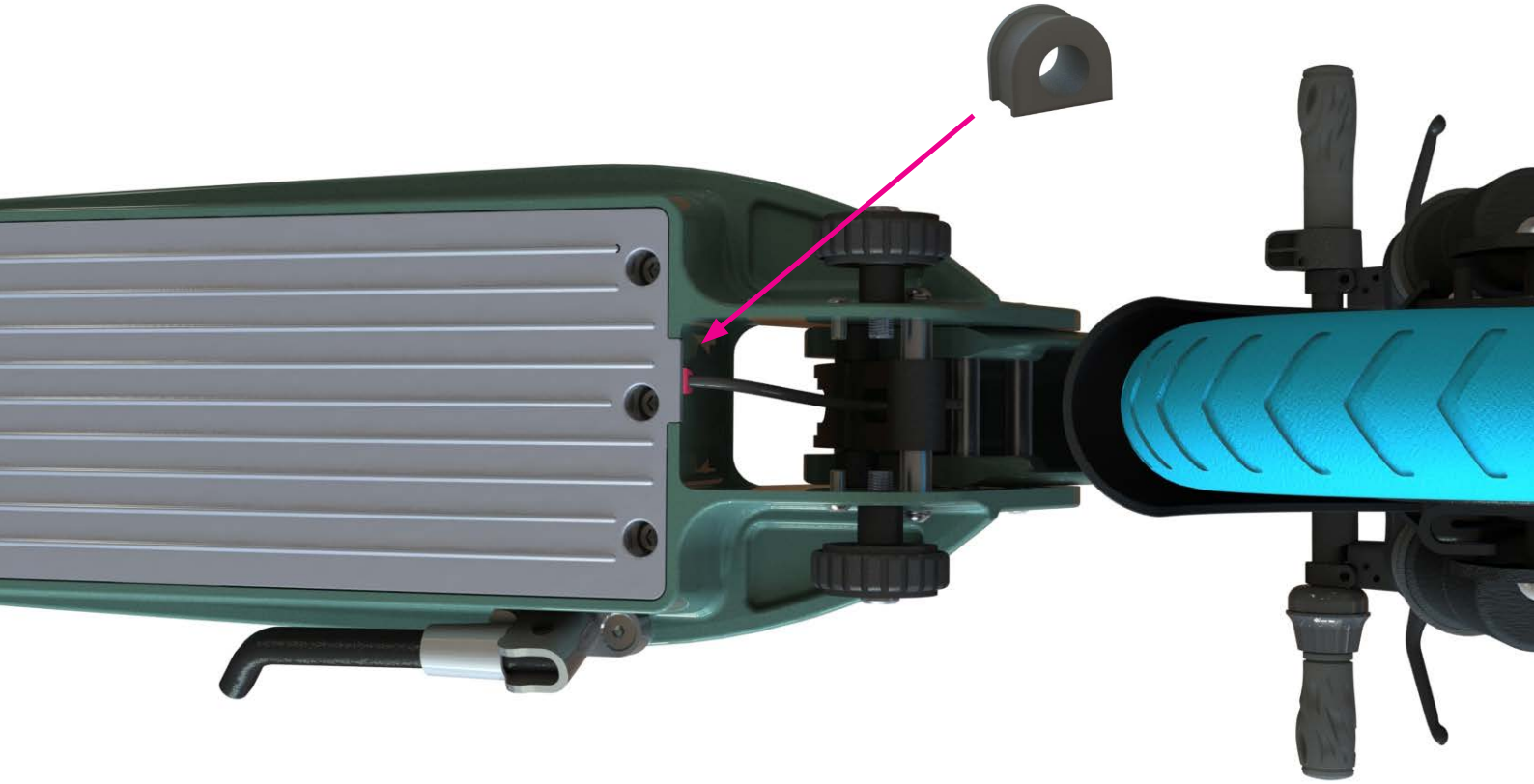
The kickstand on the first e-Kick version has issues with the hinge shown in the image tot the right. The hinge rotates too far out causing the kickstand to break resulting in a broken e-Kick. This is prevented by using a new kickstand type, found by one of the suppliers of the Chinese manufacturer. This will keep the e-Kick 2.0 on the street longer without the issue of a broken kickstand. For a more detailed development process, see appendix 15.

Easy replacement

All failure is impossible to prevent and part eventually will break down. When this happens it is important that the mechanics can change this easily. This means no permanent fixations and only a standard bike mechanics tool set available for repairs. The following design changes are improving the repairability of the new e-Kick model.

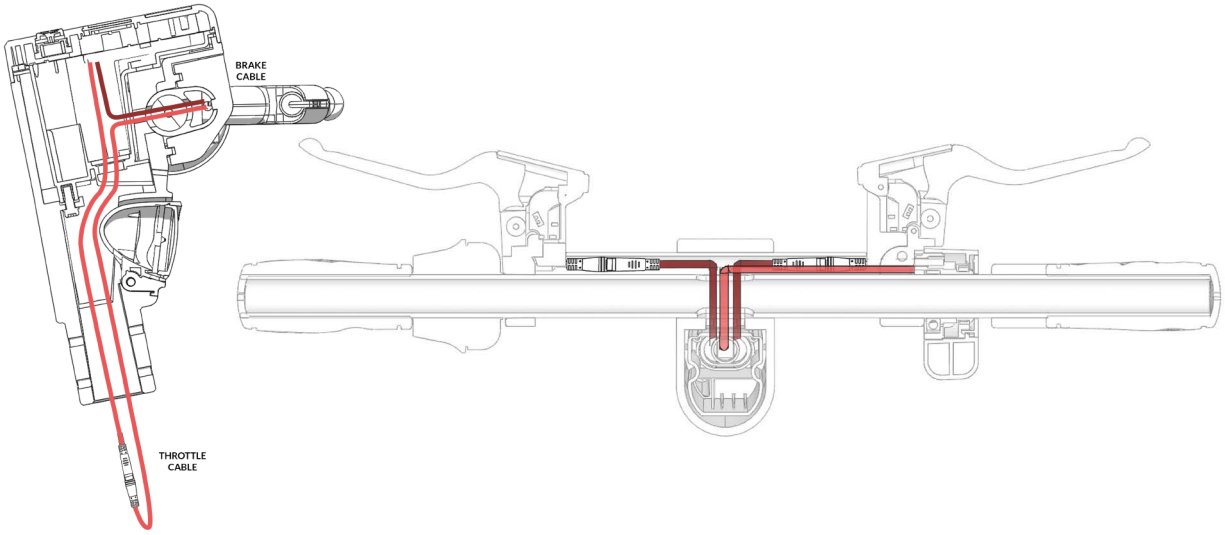
Rubber cable entries

The cables running to the main computer next to the battery in the main body of the frame enter at the front and rear. This entry needs to block water and dirt from entering the battery compartment. Currently this is solved with hotglue. This solution is not the best option because this hotglue is not reusable when the battery compartment is opened up for repair. The new e-Kick 2.0 has instead of hotglue, rubber cable grommets are used to seal the gap around the cable entry.
This new method will eliminate the hotglue tool from the mechanic toolbox and reduce the work impact of opening up the battery compartment.



Cable management

Due to the new cable connectors inside the steering column, space is an issue now. Where the connectors first ran parallel, a different layout is needed. This must not impact the improved repairability achieved by the previous iterations of increasing the hole in the steer and the use of high quality connectors. In appendix 13 the whole design process can be looked into. The final result is a new cable route inside the steering column that gives every connector more individual space for the mechanic to reach. In the image below the new cable route is shown which will give the mechanic a better reach for repair and supports the bigger size cable connectors.



Hole inside steer

Inside the steering console, cables run from the hand brakes and throttle to the display. These cables need to be guided through the steer when reinstalled or repaired. The hole inside the steer is very small and the mechanics can not work with this (Appendix 5). By increasing the hole inside, the mechanic gets more space to work in and has a better reach and view on the cables. This steer is still strong enough to withstand the use of an electric scooter and still passes all safety regulations (NEN, 2017) This improves the reliability of all components in the steering console.

Swapfiets

The company Swapfiets wants to lead the movement to more livable cities. Therefore their products must fit their users and cities and these products must show how that Swapfiets is working on these livable cities. This means for the new e-Kick 2.0 that the branding and the looks needs to fit the vision of knowing your customers and its surroundings and showing your sustainable development.

Vision

The e-Kick 2.0 has a branding that fits the target audience and its surroundings. It has a professional look and shows the circular values of Swapfiets.

Branding

In a brainstorm for branding with the Graphic design and Marketing department from Swapfiets, we concluded that the target audience for the Swapfiets product Power 1, a single speed electric bike, has a lot of similarities with the target user of the e-Kick 2.0. The reliability and non-frill design are key qualities for both groups. Because of the similarities the branding aspects of the colour palette of the Power 1 bike will be copied for the e-Kick 2.0.

New colours

Based on the colour palette of the Power 1 bike design the same looks will be added to the e-Kick frame. Not only is the colour applied to the steering pole, as the e-Kick 1.0, but also to all main frame parts. Now the colour aspect to the e-Kick is not only a ‘random’ part, but creates a whole.

Matte
Magic Black 001

Matte
Blue Granite 890

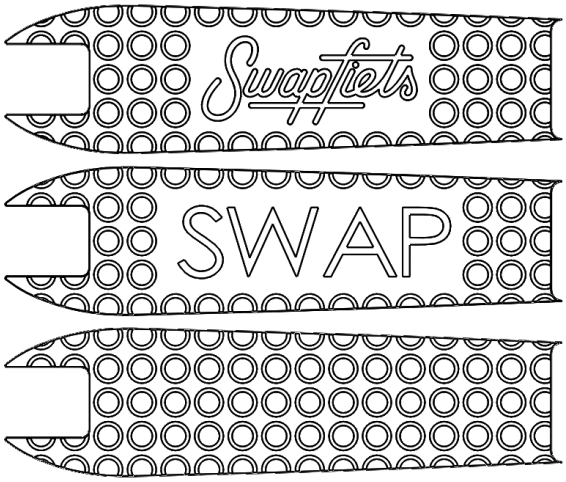
Matte
Blackberry Whine

Matte
Hunter Green 674

Gloss
Off White

Foot board

Swapfiets wants to spread their name all across Europe. The key marketing strategy is having an iconic recognisable product with the blue front tire. This recognisability will be increased if other parts of the e-Kick give subtle hints to the company behind this vehicle. By customizing the footboard and adding the Swapfiets logo, name or, more subtle, wheel to the deck, not only the user will know the product is from Swapfiets, but also a lot of other people passing by.

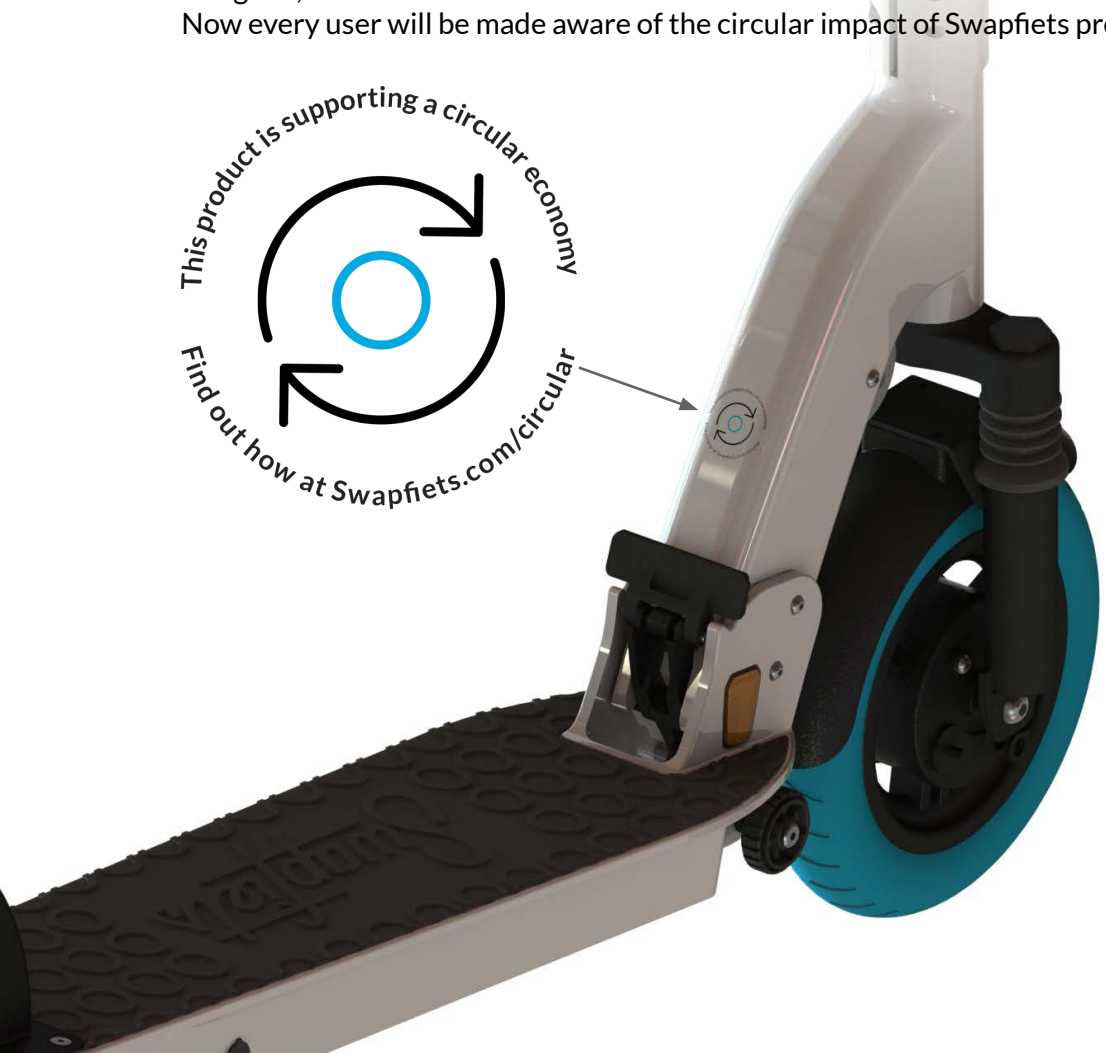


Circular business model

The business model of Swapfiets, Product as a Service is a version of a circular business model. By keeping the ownership of the product at Swapfiets, the vehicles will always return after use to Swapfiets and linked to a new user.

Next to the circular business model, Swapfiets aims to close the circular loop of their products. By increasing the lifespan, repair broken parts and recycle when it has no purpose. Swapfiets works with a percentage scale for each product. For example the Deluxe 7 is 88% circular because 88% of all bike parts are kept in the loop of reuse, recycle and remanufacture.

These two circular aspects about Swapfiets need to be exposed. Not by only using the media but by labeling their products. In cooperation with the marketing team the following sticker is designed, added to the decals of the new e-Kick 2.0.
Now every user will be made aware of the circular impact of Swapfiets products.



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e-Kick 3.0

The e-Kick 3.0 is the next generation e-Kick for Swapfiets. All designs discussed in this chapter are triggers for Swapfiets what the possibilities are for a future (1 or 2 years) design. Just like the e-Kick 2.0, the 3.0 is also focussing on the same three target groups. The user, the mechanic and Swapfiets as a company. All these three stakeholders are taken into account and benefit from the e-Kick 3.0.

The User

The user of the e-Kick 3.0 will demand a product that lives up to the comparable products in the market. This means Swapfiets need to keep innovating. The new e-Kick 3.0 will benefit the user by making it connected to them personal and giving the ability to customize. Next to that, will extra features improve safety and give the user a safer feeling about the product.

Vision

The e-Kick 3.0 is an electric kick-scooter for Swapfiets that is known by the user for its reliability, ease of use and connectivity. By giving the user the power of customization and a safe experience, the e-Kick will be the product the user desires.

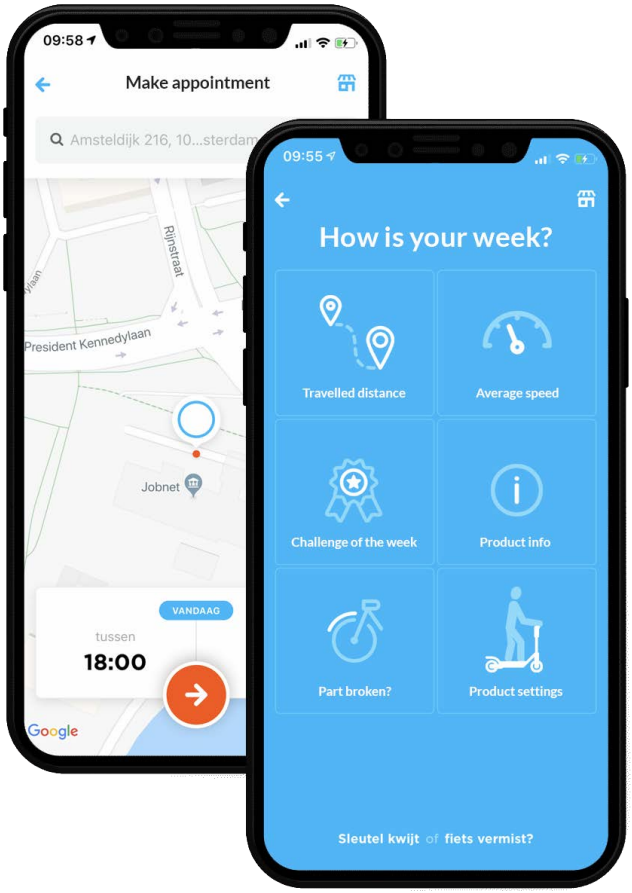
Connectivity

In collaboration with the Tech team of Swapfiets, options about implementing the smart technology available by the Chinese manufacturer for the e-Kick into the current Swapfiets digital products were discussed. This smart technology would give the following options:

- Track the location of the e-Kick
- Connect the e-Kick to a mobile device via Bluetooth
- Lock and unlock the e-Kick wireless
- Collect usage data of the e-Kick (driven km, charge freq, driving time, avg speed, error codes)
- Modify e-Kick settings like cruise control and speed

Personal product

The Tech team from Swapfiets is currently improving their mobile app with the goal of making the app ‘the friend you always have in your pocket’. This means that it guides the user with their product use and makes the process of a repair request as easy as possible. They also aim to give the user more information about their own Swapfiets product, by for example showing fun facts or Strava challenges.
By linking the e-Kick 3.0 to the Swapfiets app the user can use this product page to view all data about his product. Here he sees the driven distance and time, battery indication and charging time, etc. All this information makes the user more connected to the product which increases the user experience. Next to that, software adjustments can be controlled via the app. The cruise control can be switched on and off based on the users demand. The maximum speed can be adjusted for each driving mode (eco/drive/sport).



Smart locking

The connectivity between the e-Kick and the user via the mobile app also creates the opportunity to use a smart lock which can be locked and unlocked with the phone or with a tag. For the e-Kick to be parked safely, a cable lock is still required. Adding a smart plugin cable lock is not adding extra value to the product because the cable lock still needs to be stored on the e-Kick and the user needs to do the same handlings.

Safety
For the e-Kick 2.0 some features to make the product safer were not yet possible because of a supply shortage or a government not approved version. For the e-Kick 3.0 these limitations are not taken into account. Next to making the product safer, the user will experience a safer environment for their e-Kick.

Hidden rear nut
Resulting from the user research in appendix 3, the nuts on the rear axle can injure the ankle of the user when making a kick movement backwards. This could not be solved for the e-Kick 2.0 because of the design limitations for the frame. For the e-Kick 3.0 these nuts need to be sunken into the frame so nothing sticks out to the side.

Indicators
Because of the small wheels and the narrow steer, all electric kick-scooters are not as balanced as a bike. Driving with only one hand is dangerous which prevents the driver from indicating direction in traffic with their arm. Adding indicators on the e-Kick 3.0 will make the vehicle predictable for other traffic and therefore safer for the user.
These new indicators are located at the rear of the e-Kick and are operated with a switch on the steer which can be controlled with the left hand.

Anti theft function

With the option to add the connectivity to the e-Kick, sending notifications to the users mobile phone is made possible. Now the option of adding an anti theft function is providing a more secure feeling to the user. If the e-Kick is locked and at the same time moved or tilted, the user will get a notification on their smartphone alerting them of a possible theft. The main goal here is to give the user the feeling of total control over their product.

The Mechanic

The new e-Kick 3.0 will give the mechanic also a lot of benefits. From failure based repair the shaft can be made to data driven repair. With the possibility of data generation from the e-Kick, repairs can be predicted more accurately.

Vision

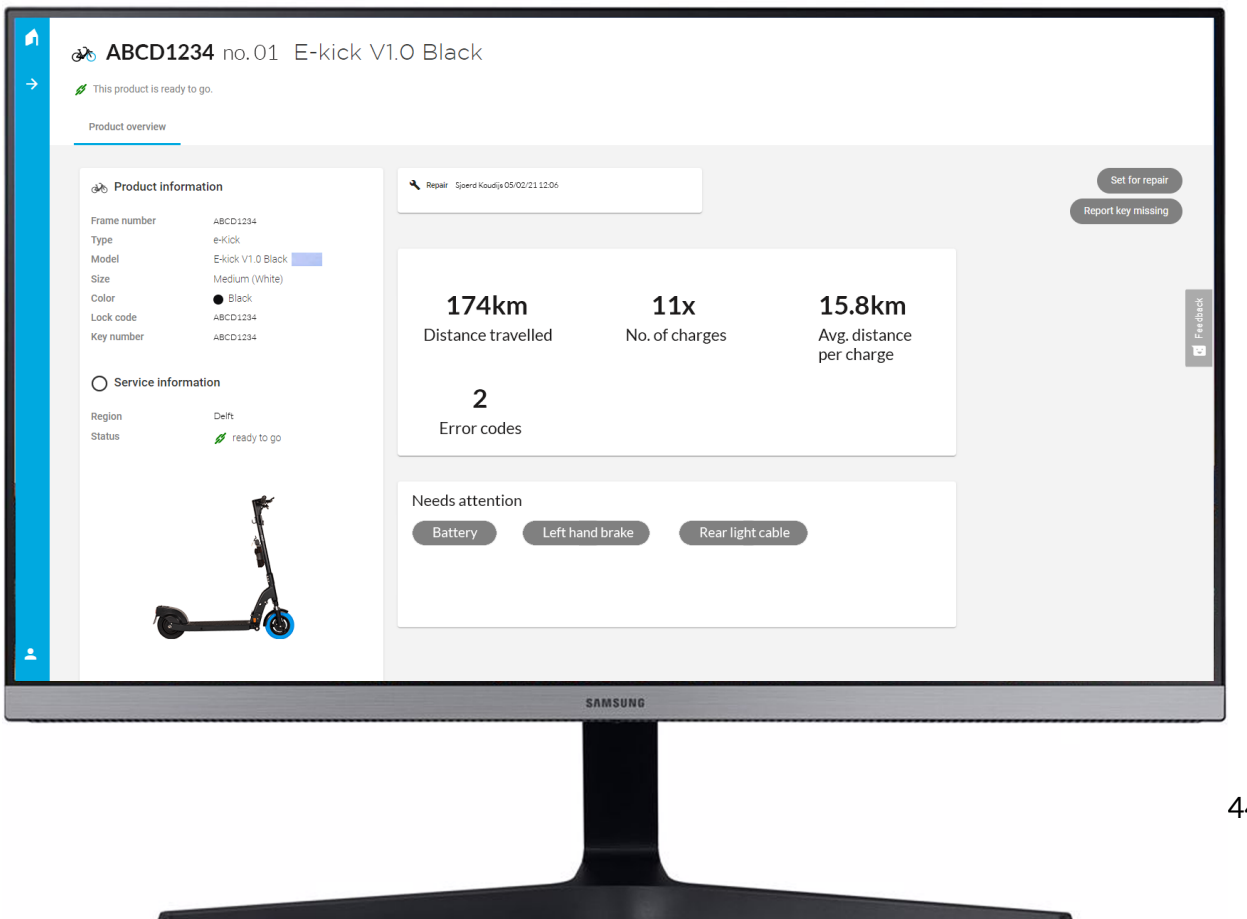
The e-Kick 3.0 is a data driven product. By live monitoring the product status and performance, failure preventing repairs can extend the lifetime of the product and give accurate insights for future design changes.

Data driven repair prediction

By monitoring the driven distance, amount of charges, average distance per change, average speed, frequency of use, time of in use and many more features, the behaviour of the e-Kick can be predicted. After analysing the breakdown ratio of all parts, during a repair, the mechanic receives repair advice based on this data.
For example, the mechanic pointed out that the average distance per battery charge is only 5km. So he gives the battery an extra check to see if this was due to the bad battery quality or due to the users habit of changing.

Problem interception

Also users can be contacted if their product will reach a high failure risk. This can lead to a simple check-up which provides the user of trust in the company and prevents the mechanic from totally worn out products.



Swapfiets

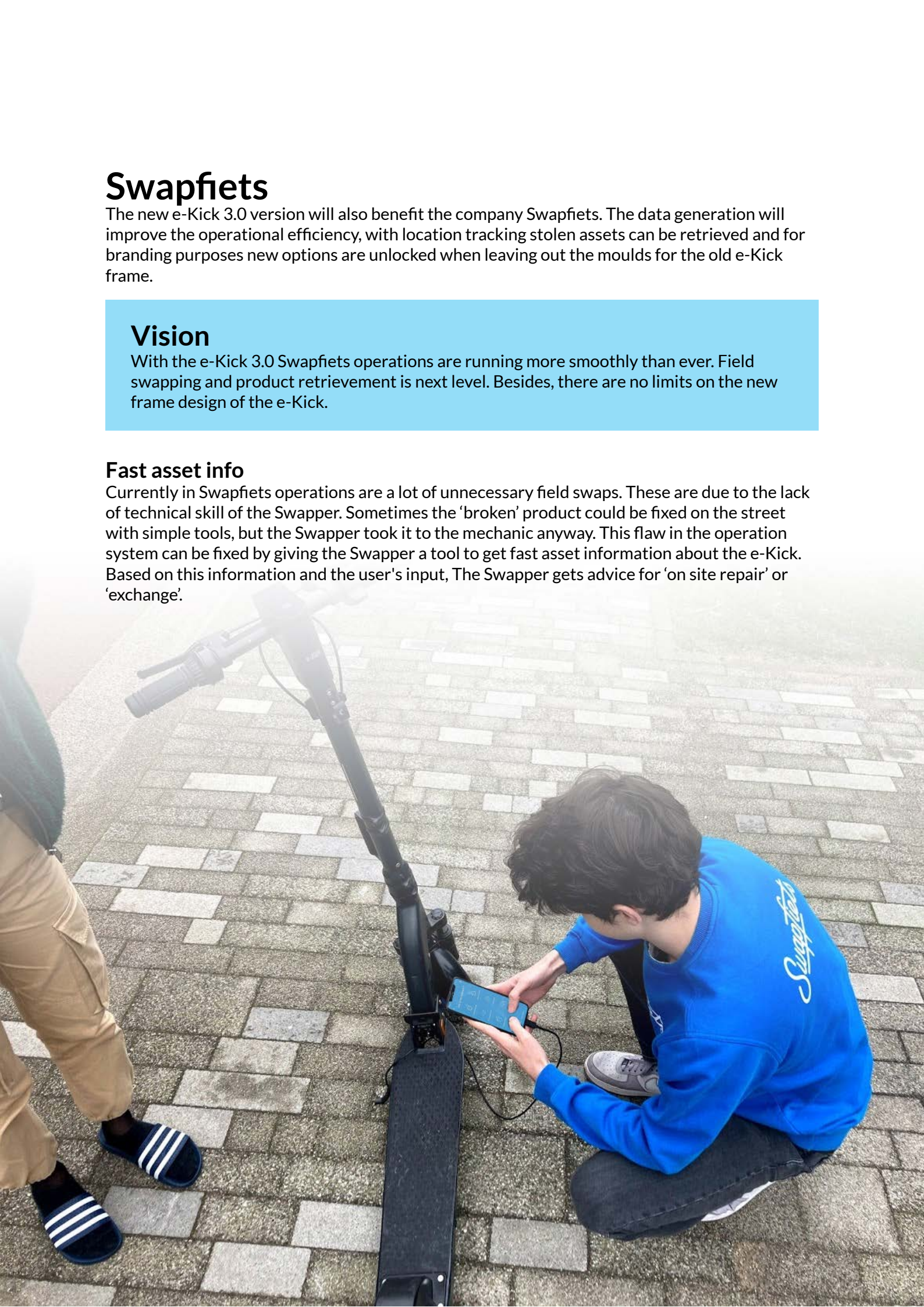
The new e-Kick 3.0 version will also benefit the company Swapfiets. The data generation will improve the operational efficiency, with location tracking stolen assets can be retrieved and for branding purposes new options are unlocked when leaving out the moulds for the old e-Kick frame.

Vision

With the e-Kick 3.0 Swapfiets operations are running more smoothly than ever. Field swapping and product retrievement is next level. Besides, there are no limits on the new frame design of the e-Kick.

Fast asset info

Currently in Swapfiets operations are a lot of unnecessary field swaps. These are due to the lack of technical skill of the Swapper. Sometimes the ‘broken’ product could be fixed on the street with simple tools, but the Swapper took it to the mechanic anyway. This flaw in the operation system can be fixed by giving the Swapper a tool to get fast asset information about the e-Kick. Based on this information and the user's input, The Swapper gets advice for ‘on site repair’ or ‘exchange’.

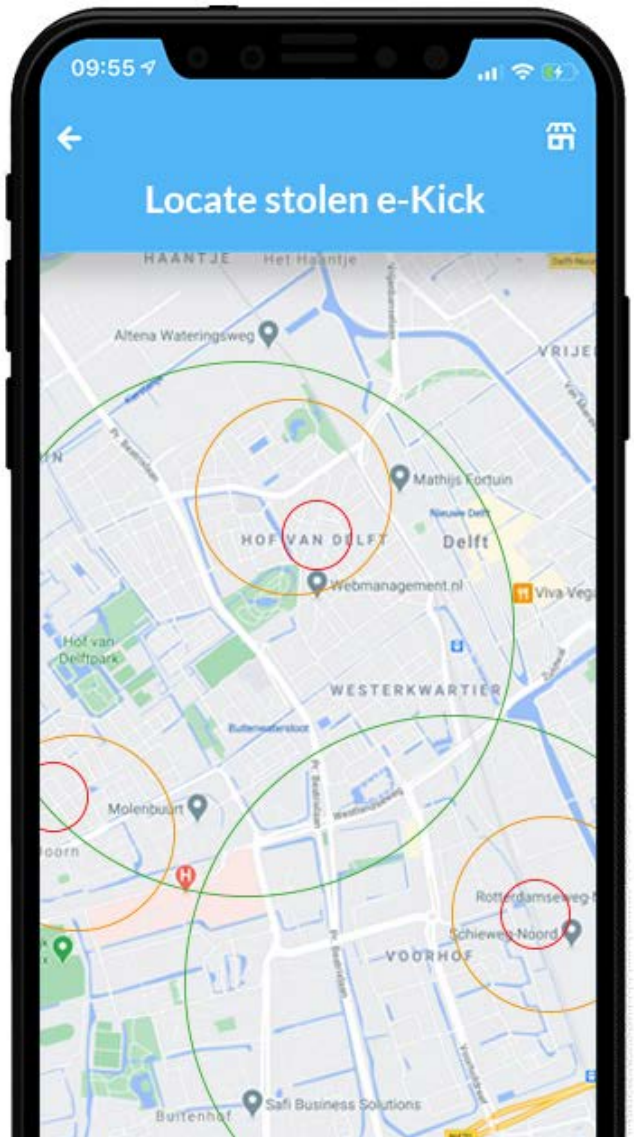


Stolen product retrievement

Just like the VanMoofs campaign #sorrythieves, being able to track the location of the asset after it is stolen saves the company a lot of money by retrieving these assets. But the most important thing is that the user is insured for getting a new e-Kick. By emphasising the anti theft features on the e-kick 3.0, thieves will think twice before stealing an e-Kick and users can park their vehicle with a confident feeling.

Ensure user payment

A occurring problem with all e-products of Swapfiets is the payment of the user. A lot of them just do not pay. The Tech team is currently working on this problem. In association with them the use of a smart system inside an e-product could be an option. With this it is possible to make the product useless from out of the HQ. By simply disconnecting the user from the vehicle he is not able to use it anymore. So now Swapfiets has the powerful weapon of 'You don't pay, you can't ride'

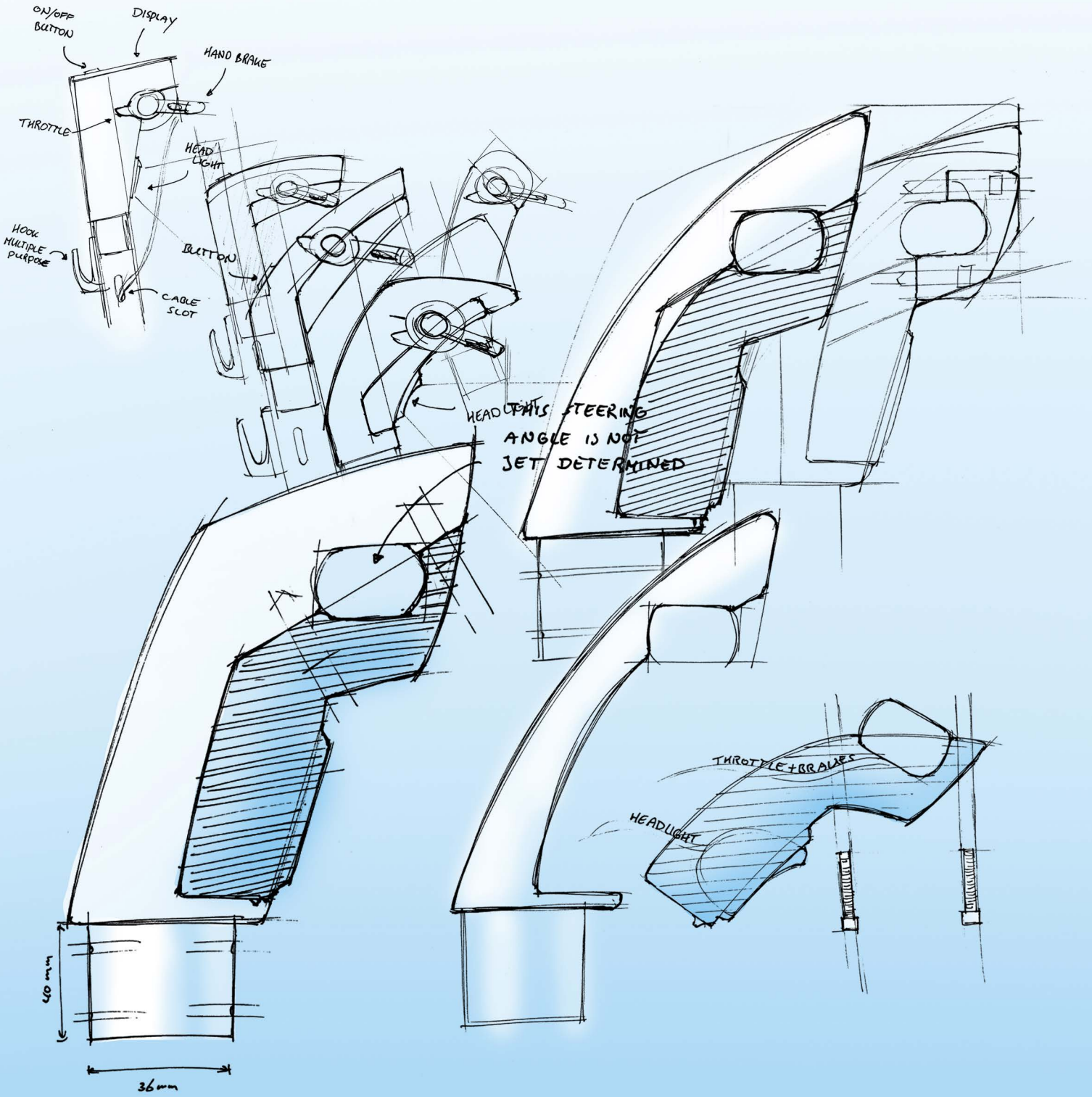


Branding

For the e-Kick 2.0 design, all moulds for the main frame parts are the same as the e-Kick 1.0. This design limitation was mainly because of the high investment cost for a new mould. For the e-Kick 3.0 this limitation is not taken into account which gives the freedom to redesign new main frame parts.

Steering column

A lot of extra parts and features are added to the e-Kick 2.0 and 3.0 which require more space inside the steering column. The new cable connectors, the indicator switch, the smart 4G and Bluetooth connection and the possibly a smart lock. In the current part there is some extra space left for some of these extra parts. Fitting it all inside is not the only problem, reaching it for assembly and repair is as important. For the design of a new steering column some design sketches were drawn pointing out the problem and possible solution. The detailing is not in a stadium for production but more a guideline for a potential future design.



Conclusion

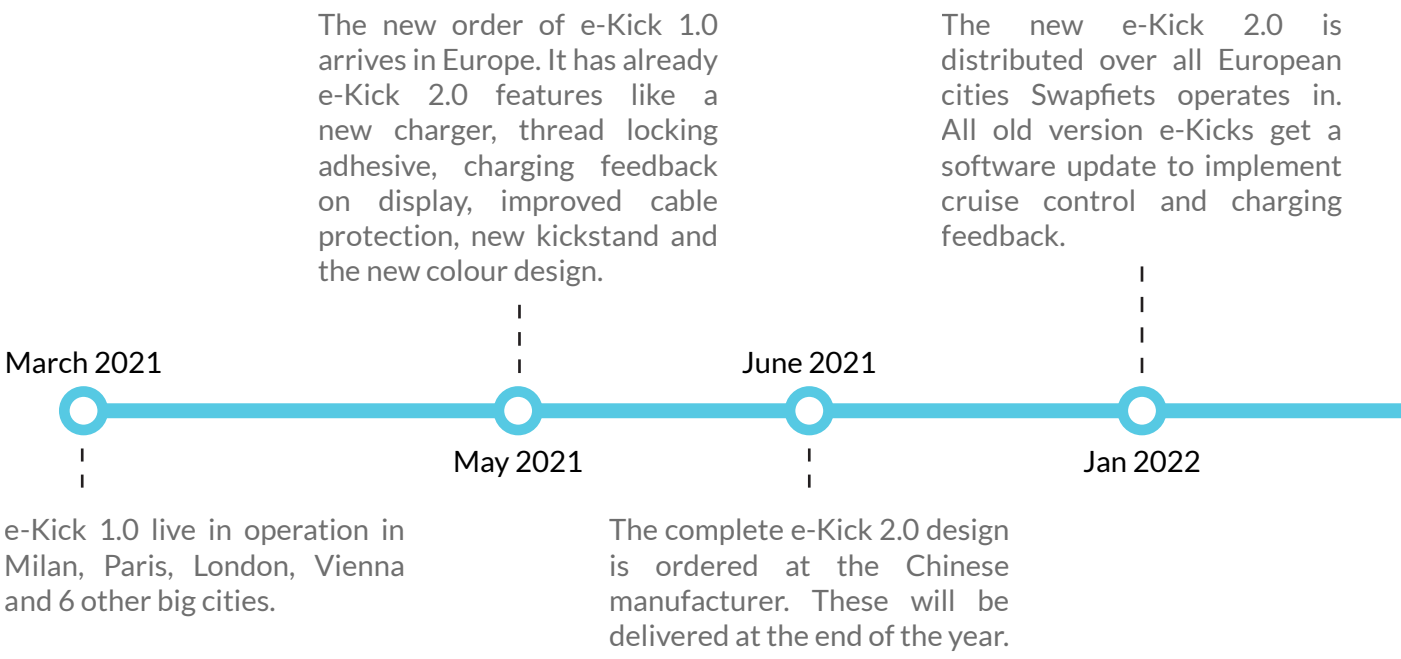
In June this year the first newly ordered e-Kicks will enter operations in Europe! This new version already has a lot of features implemented form the e-Kick 2.0 design. For example the new charger port and the charging feedback will be in the next model. The final e-Kick 2.0 will be delivered next year and will contain all new design improvements.
The main design changes in comparison with the current e-Kick 1.0 type are documented below.

- The added grip for easier carrying and locking purposes
- A better repairable steering column
- More resistant to water and dirt
- Added cruise control
- New colours design

Some of the features are already implemented in the new design of the manufacturer. This is the last stadium of the design implementation. However, not all design changes are discussed in detail with the manufacturer. In the design process the limitations of this stakeholder is taken into account but there still needs to be some work done.

The e-Kick 3.0 is the next generation model which is a visionary product for Swapfiets operations in 2 years. This new design contains new features for a smart product. This gives the following new possibilities.

- Enhanced relation between product and customer
- Data driven product repair and maintenance
- Fast accessible product data for Swappers



Next to the smart part, the product is not limited by moulding investments which gives the opportunity to add extra safety features like indicators and create more space inside the steering column for new technology.

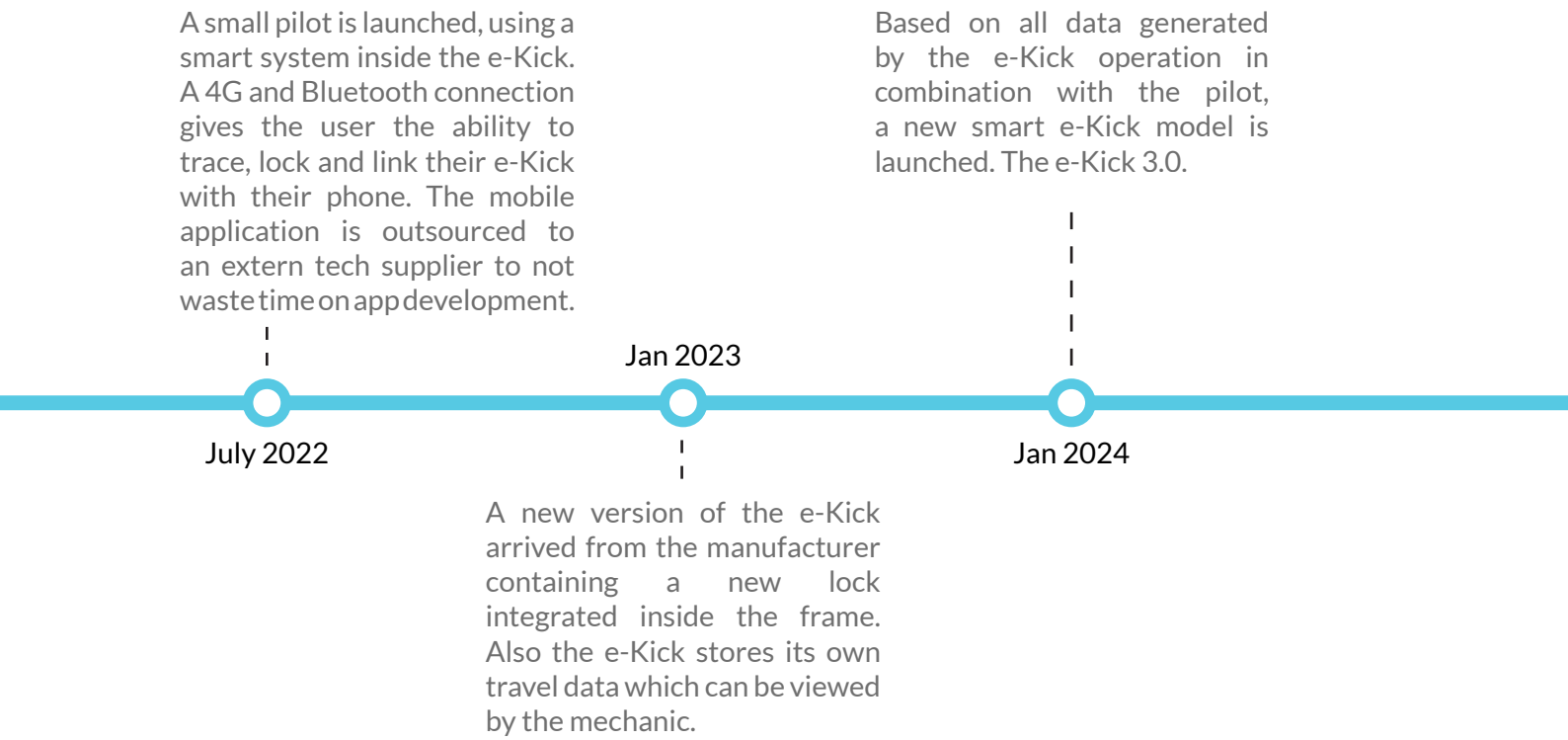
Recommendations for Swapfiets

All design aspects of the e-Kick 2.0 needs to be discussed with the Chinese manufacturer. They need to be convinced of the design and know it into detail before implementing it. You can expect some small design changes made by the manufacturers engineers. For example the welding tolerances of the grip are not taken into account in the 3D model.

Next to that needs the new cable route inside the steering column extra validation. This new method shown in appendix 13 is prototyped and individually tested, however the Swapfiets mechanic did not test it yet. Therefore it needs some extra testing before final implementation in the e-Kick 2.0.

The design of the e-Kick 3.0 is recommended to use as an inspiration for a new generation model. Implementing all in one go is impossible. Take small steps in iterating and testing all smart aspects. Start with simple data generation inside the e-Kick, not wireless available for validating if this data improves the Swapfiets operation workflow.
Next to that is the e-Kick compared with other Swapfiets products, a small scale product. This means that it is a perfect candidate for the testing of new data driven features which then can be implemented on a large scale on other Swapfiets products.

Shown below is a roadmap for the next three years of the e-Kick development for Swapfiets. This is up to the launch of the e-Kick 2.0 accurate, after january 2022 the roadmap is an indication of how the future may evolve including the e-Kick 3.0.



Reflection

In this chapter a personal reflection about my graduation project is split up into 4 parts. Each part is reflected on out of my own perspective.

Situation

At the start of my graduation in september 2020 the situation was promising. The TU was open for students, I was welcome at Swapfiets HQ for three times a week and I was part of Team Product. Working from home was also a regular workflow which was in combination with TU and HQ visits a fine way of week planning.
For me the TU Delft workshop was available. With the engineering experts walking around with a lot of prototype and machine experience they were a valuable asset to the project.
Within Swapfiets I was part of the company and had access to all general files and everybody within the company was open for a talk, brainstorm or shared insights.
Weekly meetings with Team Product, Luuk and Jos were organized to keep each other updated.
Within Team Products the way of product development is by quick data driven iterations.
Place a product in the market and see if it works is a fast approach compared with thorough market analysis and small scale pilots. For the e-Kick the same approach was used. An off the shelf kick-scooter was placed in two European cities and based on the customer response new measurements were taken.

Task

My task was to design the next version of the e-Kick for Swapfiets which would be launched in multiple European cities. With the data of the pilots and the first e-Kicks in the workflow as a resource for product improvement, the new e-Kick would be an improvement for the user, the mechanic and the manufacturer.
So the following tasks were expected in my graduation project:

- Analyse existing Swapfiets data
- Research the existing users
- Analyse Swapfiets operations
- Design new e-Kick
- Prototype the new design
- Validate with validation team existing of users, mechanics and swappers
- Order new model at Chinese manufacturer

Action

What I actually ended up doing was almost the whole list of tasks documented above. However, not all of them were really specified and could be interpreted in multiple ways. Therefore the actions I actually did are documented below more specifically.
Analyse e-Kick stakeholders and determine their influence and demands.
Review Swapfiets pilot data and indicate product failures and users demands.
Online user survey for user demands and product iterations
Swapfiets mechanics and operation analysis for product repairability and implementation
Combine all insights from research into focussing points for new e-Kick version
Design solutions for each individual focussing point using agile design sprints involving Swapfiets employees for their expertise or using valuable connections with other companies for their input.

- Discuss the new design aspects with the Chinese manufacturer and determine if the realisation process is outsourced to them or done by us.

- Prototype each design solution independently in the TU Delft workshop
- Validate the new design aspect with the prototype. Validation is done with Swapfiets mechanics or TU Delft students.
- Combine the validated design solutions into one new e-Kick model, the 2.0 or 3.0.
- Create a detailed 3D model of the e-Kick 2.0 including tall new design solutions.

Result

All these actions resulted in a new design for the e-Kick 2.0 and 3.0. From Swapfiets the e-Kick 2.0 was expected to be realistic and implemented fast. Manufacturing limitations and new complex technologies who need a long implementation and testing time in Swapfiets operations don't have priority over product optimization.
Therefore the e-Kick 2.0 design is based on the e-Kick 1.0 design with a lot of small changes made to different parts. This makes it feasible for fast implementation.
However more disruptive designs for the e-Kick automatically lead to a longer implementation time and therefore less desired by the fast implementation way of working of Swapfiets.
The e-Kick 3.0 is the result of combining the more disruptive designs into one new e-Kick model. This model shows my ability to take one step further than just product optimization.

Reflection

Reflecting on the whole process of my project I had three main challenges to tackle:
The fast implementation desire of Swapfiets limiting the design freedom
The difference in expected result between the TU and Swapfiets
Less interaction with stakeholders, users, coaches, and Swapfiets employees due to the Covid lockdown.

At the start of the project I had in mind to design a complete new e-scooter model. Because of the fast implementation desire Swapfiets had, I was enthusiastic about a fast walkthrough through the complete design process from start to finish, ideation to manufacturing.
In my TU Delft career I got some experience with the feasibility of a product. But going this far to upto ordering at the manufacturer was new for me. Developing a design to this stadium for implementation limits the design freedom. Moulds were kept the same and technologies which cannot be implemented in Swapfiets operations within a small time frame were off the hook. It took some time before I realised the boundaries for this e-Kick model. I think this was mainly because at the start of my project I had amore concept driven design vision without keeping manufacturing in mind.

Because of the design limitations I had for the model that would be released fast, I was working on part scale iterations. The results were simple but feasible and I adapted my workstyle to the Swapfiets way of working. My coaches however, missed the bigger picture in the project of a university graduation student and wanted me to design more than just a product optimisation.
To split the desires from Swapfiets for a fast imlemnetable product and my coaches for a more future visioned product, I split the project outcome into two e-Kick models. The e-Kick 2.0 which can be on the market next year and the e-Kick 3.0 containing a more disruptive design for future implementation, the bigger picture.
I created this split up in two versions to satisfy both parties. Combining all new designed aspects into only one new model would be an unclear deliverable for Swapfiets to proceed with.

Of course did the pandemic influence my project. The isolation from a working environment had the most impact. I am depending on an inspiring working environment and people around me to keep me motivated. At the start of my project I frequently went to HQ and had a working spot at the faculty of IDE. This change in the working environment and the people around me helped me stay focussed and energetic. As the regulations for the pandemic sharpened, my motivation had some ups and downs. I missed the interaction with colleagues and coaches and friends to discuss

simple ideas and product iterations.
However, I am very glad I still had the amazing opportunity to visit Berlin, had the TU Delft workshop available and a well organised online communication and meeting platform provided by Swapfiets. This helped me a lot and gave me the feeling of how a graduation project should be.

What have I learned?

I am very thankful for the opportunity Swapfiets gave me with this awesome project. I learned a lot of things I could have never learned at university courses. Next to that working on an individual project for 6 months is a challenge but definitely a learning experience.

I learned a lot about the mobility branch Swapfiets operates in and how it works behind the scenes. I got unique opportunities meeting people from different countries and was introduced to a lot of companies cooperating with Swapfiets.

The fast data driven product iteration Swapfiets uses for their product improvements was a learning objective for me. Luuk has a very no-nonsense way of working that has no room for gut feelings and long term visions which was an inspiration for me to work for and to work along.

From day 1 I was involved in the communication with the Chinese manufacturer about the ordering and development of the current and future e-Kick models. I now have some valuable experience working together with the other side of the world. Communication wise and problem approach wise we differ a lot, this was a challenge and a great experience to have.

The development of a product to a phase of ordering at the manufacturer was also new for me. I learned a lot about the impact a design can have on the lead time of the product. Next to that, the development of the new design needed to be discussed with the manufacturer which pushed me to go even further into detail and make the new design clear for everyone, even the Chinese engineers.

My development process consisted mainly out of design sprints. I did have some experience with it, but I am glad I chose this method. The small milestones you create, motivated me throughout the project.

What would I do differently next time?

The thing I would have done differently was to put more time in my project brief and had an open discussion at the start of my project with my coaches and Swapfiets to have a common goal for my project. Also I would have planned more meetings with everybody together. In this way I could have tackled a lot of mixed expectations from the start.

References

Documented below are all references used for this graduation project. In this report there is not often referred to these references. However almost all links are in the appendices.

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