# E-bike design for commuters

## Designing a luggage carrier for laptop bags


**Master thesis Integrated Product Design**

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**Designing a luggage carrier for laptop bags**

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# Executive Summary

This report presents the research into e-bikes for commuters and the design process of a laptop bag carrier for commuters. The project was carried out for Royal Dutch Gazelle in Dieren.

The project started with the question: How to make electric bikes more attractive to commuters? In order to answer this research question a literature study, user research and market analysis was done, all focussed on the Dutch bicycle market. In order to get a good insight in the commuter's needs and wishes in depth interviews were held with e-bike owners.

The main conclusion from the research phase are that in order to make the e-bike more attractive e-bikes should be more reliable, have a unique design and offer more practicality and ease of use. Under practicality and ease of use issues as charging possibilities, bringing luggage, maintenance and theft prevention are considered. Based on these conclusion a descriptive domain for the solution direction was formulated: Worry-free modern commuting.

Within the domain of worry-free modern commuting the design direction was developed further. As target group young family (wo)men were chosen and as a retail strategy a lease construction was selected. Also it was decided that the design focus would be on bringing luggage. The bicycle type would be a normal e-bike and the design would be based on the Gazelle CityZen model family.

Based on the formulated design direction the idea generation phase was started and along the way more design choices were made. It was for example chosen to focus on bringing your own laptop bag, which would be mounted on a luggage solution at the front or at the rear of the bicycle. After these design decisions thirteen concept ideas were generated. From these concepts two similar rear concepts were selected to be worked out in more detail.

The two concepts, Horizontal bracket and the Diagonal support, both feature a construction were the laptop bag is mounted diagonally along the rear seat stay. This way the bag does not get in the way of the pedalling motion, but can still be placed very close to the centre of mass of the bike. Also it is automatically integrated in the lines of the bike, as it follows part of the bicycles frame. The two concepts were developed further using mock-ups and by modelling and sketching. Based on the second iteration in mock-ups the 'Diagonal support' concept was chosen to be worked out as the final design. The Diagonal support concept is chosen because it works well in terms of looks and position on the bike and it scores more positive on the mounting factor.

The final design was further developed by use of CAD-software and resulted in the Gazelle laptop carrier. This luggage solution boosts a foldable support structure were a laptop bag can be safely mounted on the bike. By means of a elastic mounting strap the bag is securely locked in place and by means of rubber shock absorption the laptop bag is protected from road impact. The Gazelle laptop carrier will be offered as an option on a new commuter lease bike and can be leased from 2,50 euro per month.

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# Introduction

Electric bikes have been around for years, the first known concepts date from the 1980s. In the last ten years the sales of electric bikes have grown rapidly and at the moment 20 percent of new bikes sold in The Netherlands are electric.
Slowly the price of an electric bike is decreasing; at the moment prices start around thousand euro. The image of the electric bike is slowly changing as well: Where some years ago the electric bike used to be seen as a product for elderly and pensioners it is now becoming more popular among a younger audience.

In The Netherlands cycling is already responsible for a substantial part of the daily commutes. The commuting distance covered by bike is still limited though. The further adaptation of the electric bike could change this, as the electric bike makes it easier to cover larger commuting distances by bike.
In this project the following research question will be addressed: How to make electric bikes more attractive to commuters? In consultation with Gazelle the project has been focussed on the local Dutch e-bike market.

**E-bikes**

An e-bike is defined as a bicycle which uses electric propulsion in addition to human power. This means you also have to paddle in order to get assistance from the electrical motor. Internationally the term e-bike is also used for e-bikes or electrical mopeds, where you do not have to paddle. Internationally, an e-bike where you have to paddle to get assistance, is called a pedelec. Because in Dutch the term e-bike is often used and also because in literature the term e-bike is most common we will use the term e-bike to describe the pedelec.

A special variant of the e-bike (or pedelec) is called the speed pedelec. This version of the e-bike can reach speeds up to 45 kilometres per hour and is equipped with a more powerful electrical engine. In this variant you also have to paddle in order to get assistance.

**Gazelle**

This project was carried out for Royal Dutch Gazelle, a Dutch bicycle manufacturer. It is one of the oldest and best known bicycle brands in The Netherlands. In The Netherlands Gazelle has a market share of about 27 percent (2014), which makes it is the biggest bicycle manufacturer in The Netherlands.

**ANWB**

The ANWB is the Dutch motorist and cyclist association. It is based in The Hague and offers a wide variety of services. The ANWB is also involved in bike related projects and for this reason is participating in this project as a knowledge partner. During the research phase they were involved in an advisory role.

# Research question

In the Netherlands the average commuting distance to work is 24 Km and on average this takes people 34 minutes. Most of the commuting distance, 77 percent, is covered by car, about 10 percent is travelled by train and about 6 percent by bike. The bike however is used by 25 percent of the commuters, which means that bikes are mainly used for short distances. The further adaptation of the electric bike could change this, as the electric bike makes it easier to cover larger commuting distances by bike. (CBS, 20160

In this project the following research question will be addressed: **How to make electric bikes more attractive to commuters?**

For the project the commuter has been defined as people who travel to work and the e-bike is defined as a bicycle which uses electric propulsion in addition to human power. This means both the normal electric bike and the Speed Pedalec are included in the research.

In the user research two types of respondents can be distinguished: People who are already (partly) commuting by bike or e-bike and people who are using other means of transport. In the interviews this needs to be taken into account.

**Strategic position**

As the project will be undertaken for Gazelle also the strategic position of the brand Gazelle will be taken into account. Gazelle sees an opportunity in addressing the commuter and would like to expand its product range to address this type of customer.

In order to take this strategic position into consideration a brand analysis and market analysis will be made. The research question for this secondary research will be: How can Gazelle adjust its product portfolio in order to target the growing market of younger e-bike costumers?

This research will be done next to the main research topic described above. Most of it will be based on desk research, although a small survey about brand perception could be useful, although existing knowledge from Gazelle on this topic can possibly be used as well.

# Project approach

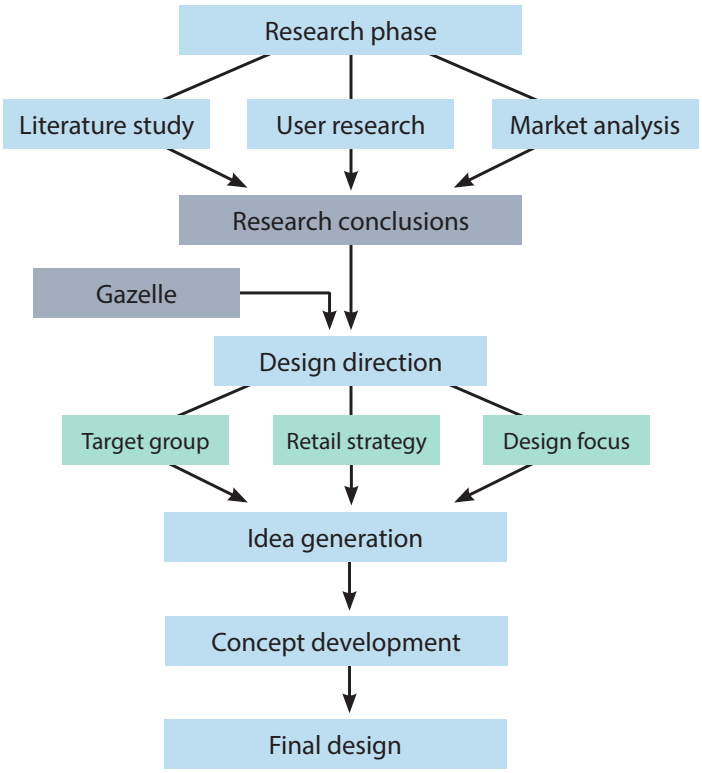
The project approach is based on the Deflt Innovation Model. In the research part the existing product will be evaluated by doing user research and a literature study. In a market analysis the strategic position of Gazelle and the market will be analysed. Based on this a design direction will be formulated, which will be translated in the design brief.

The project will be split in three phases: A research phase, a concept development phase and a final design phase.

- In the research phase the main research question will be answered by doing a literature study and user research. In order to get a good understanding of the commuter, user observation, user surveys, and interviews will be conducted. Next to this an external and internal analysis of Gazelle will be made.
In this phase the third party involved, the ANWB, will assist in the user research part.

- Based on the outcome of the research phase the design direction will be formulated and the design brief will be made. In the concept design phase this design brief will be worked out in one or more concept designs. In this phase possibly brainstorm sessions and focus groups will be organised in order to aid the design process. This part of the project will take place at Gazelle.

- In the final design phase one of the concept designs will be worked out further. Depending on the direction the project has developed a mock-up, (digital) prototype or functional model will be made.




*Overview design process*

# Research methods

The research methods can be split in a literature study, user research and market analysis

**Literature study**
Existing literature will be studied to investigate the existing knowledge about the research topic.
In the literature study all sources will be judged on relevance and quality of the underlying research. The results of the literature study will be used next to the results of the user research.

In the literature study different sources can be distinguished
- Academic papers
- Research from governmental organisations
- Research from public organisations
- Company research
- News articles / journalists' research

**User research**
The user research has been split in two parts: observation and interviews. For the interviews, (potential) e-bike users, dealers, and Gazelle employees have been approached. Also an cycling expert from the ANWB was interviewed. The user research has been done in the Netherlands and is focussed on the Dutch commuter. For this reason, the interviews have been held in Dutch.

*Observation*
To get a good understanding of the research topic observations have been made. The objective of these observations was to get an idea how people behave when commuting. At first it was also tried to get into contact with people, but this proved to be difficult. As people are in a hurry it was difficult to get into contact. Also at traffic light people said not to have time for questions. For this reason, it was decided to do observations at the ferries in Amsterdam. This way people would have some time when waiting for the ferry. During the observations pictures and video footage was made.

*Interviews*
The user interviews have been held at people' homes or a public place. The interviews have been recorded and the answers were noted down in keywords.
The respondents for the user interviews have been approached trough the researcher's network. The objective was to interview five to ten people. It was tried to get a diverse group of respondents with both cycling commuters and people using other means of transport.

The dealer interviews were done at the dealers when visiting them. The dealers were selected based on a list of Gazelle Cityzen models sold. In addition to this an ANWB e-bike expert and the employees at the Gazelle Experience Centre have been interviewed. The interviews have been recorded and the answers were noted down in keywords.

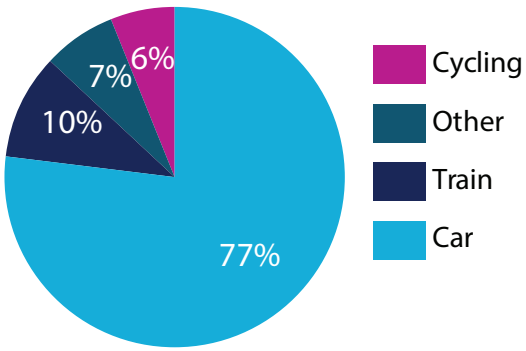
**Market analysis**
The market analysis is based on desk research, store visits and the dealer interviews from the user research. In the market analysis first Gazelle's portfolio and the competitors will be analysed. After this the e-bike sales, pricing, retailing and Gazelle's retailing will be discussed. Based on these analysis' conclusions of the market analysis later on the retail strategy will be formulated.

# Research phase

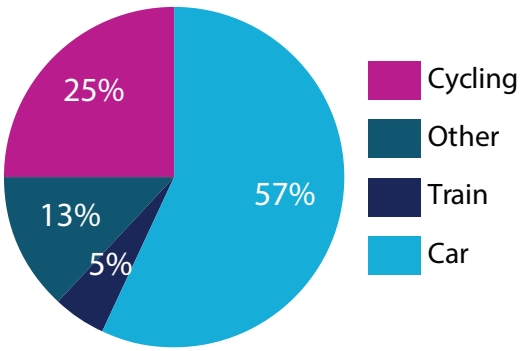
## Literature study

Existing literature has been studied to investigate the existing knowledge about the research topic. The results of the literature study will be used next to the results of the user research.

The following topics will be discussed:
- Commuting
- Cycling
- Bicycle Sales
- Mode choice
- Government policies
- Employers' role
- E-bikes
- E-bike stimulation
- Safety




*Commuting kilometres travelled per mode of transport*




*Commuting trips per mode of transport*

**Commuting**

In the Netherlands there are about 10 million commuting movements per day. In average the commuting distance in The Netherlands is 24 Km and takes 34 minutes. The biggest amount of commuting kilometres, 77 percent, is made by car. The train accounts for 10 percent, the bicycle for 6 percent, and the other 11 percent are accounted to other means of transport. The bicycle is used for 25 percent of the commuting movements, the average commuting distance being 4,81 Km. (CBS, 2016)
It is clear the bike is mainly used for shorter commuting distances. As the e-bike leads to a higher acceptable trip distance, the e-bike could address commuters who have to travel further. This way the percentage of people traveling by bicycle could be increased.

## Cycling

In The Netherlands there are 22 million bicycles, 1,2 per person. This is the highest bicycle density in the world. In terms of distance the bicycle is the third mode of transport (after the car and public transport). (CBS, 2016)

Since 2005 bike usage (kilometres travelled from normal and e-bikes combined) has grown with 11 percent. Both the number of people as travelled distance per person has grown. Most of the bike usage growth can be contributed to usage for leisure, education and work. For shopping the bike was used less than ten years ago. Partly the growth of bicycle usage can be attributed to the electric bike, which is now also used more often by adult younger than 65 years old. (KiM, 2016)

It is clear that e-bike sales are in a lift. The e-bike is getting more popular under younger consumers and bike usage has grown the last ten years. In this growing market there is a clear potential for a commuter focussed e-bike.

## Bicycle Sales

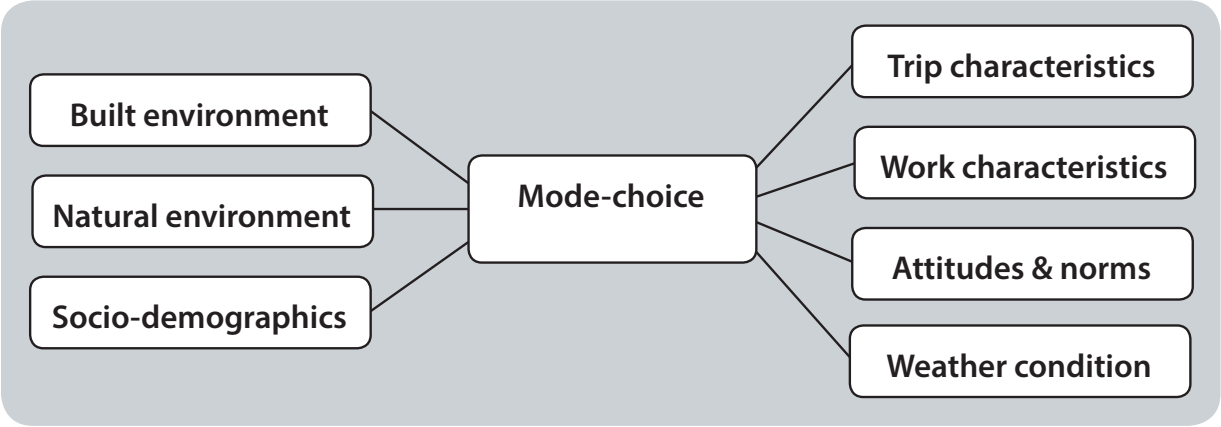
In 2015 276.000 e-bikes (28 percent) were sold. In total 983.000 bicycles were sold. In 2014 these numbers were 223.000 (21 percent) and 1.051.000. The total revenue from e-bikes was 514 million euro, which is 57 percent of the total bicycle revenue of 899 million euro. The average price for a new bicycle was 914 euros and the average price of bikes sold through dealers was 1058 euro. For the first time this lay above a 1.000 euros. (Bovag, 2016) This increase in average price correlated with the rising popularity of the e-bike, which are more expensive than a normal bike. Interestingly the better affordability of the e-bike has led to an increase in the average price of bikes in general. This leads to the conclusion that people are willing to pay more for an electric bike.

In terms of e-bike sales in absolute numbers the Dutch market is the third biggest market in the world (276.000), behind China (29.000.000 estimated) and Germany (535.000). In sales relative to inhabitants it is the world biggest market. (European Cyclists' Federation, 2016) Halfway 2016 more than 8.000 speed-pedelecs were registered, which is a 30 percent rise from end of 2015s 6.185 registered pedelecs. (Bovag, 2016)

## Mode choice

The choice of people to commute by bike is depended on different factors. The choice of transportation people make is described as "mode choice". The mode choice for cycling is influenced by the following factors:

- The Built environment, including the infrastructure, urban form, and facilities at work.
- The Natural environment, meaning climate and landscape.
- Socio-demographics including economic situation and household characteristics.
- Trip characteristics referring to the trip distance and time.
- The Work characteristics, meaning the nature of a person's work situation, like dress codes and the use of a car for work.
- Attitudes and norms, with regards to cycling.
- The Weather condition. (Eva Heinen, 2011)




*Factors influencing mode choice*

The first three factors are related to a person's environment and are not directly influenced by himself. The other four factors are personal and different for every person. For all these seven factors it is easy to see how they influence someone's commuting behaviour. Interesting to see is that from existing studies it becomes clear that socio-demographics do not play a significant role, meaning that income and family composition do not have a big influence on mode choice. More important are the economic benefits of riding a bike, which could be more important for someone with a lower income.

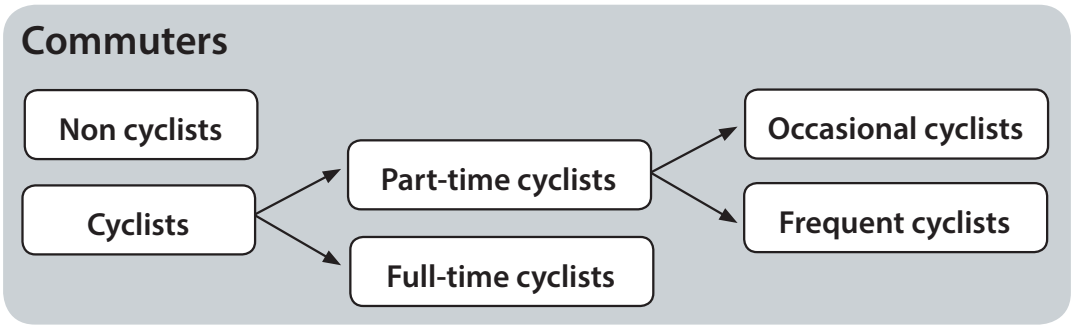
It must be considered that this mode choice model was made for cycling in general and not for electric cycling specific. Obviously the trip characteristics are influenced by the possibility to cycle faster with an electric bike. When looking at this mode choice model it becomes apparent that the design of the bicycle is not represented in the model. In most existing studies this is the case and little is known about the effect of the bicycle design on the choice for cycling.

Only study found on this topic was a Swedish study, where the effect of bicycle design on the choice to cycle was investigated. It was shown that providing the right type of bicycle to the respondents the use of the bicycle could by increased significantly. It shows that it is possible to establish new cycling habits by providing a bicycle that can take away many of the factors hindering utilitarian cycling. (Strömberg and Karlsson, 2016)

This study was focussed on bicycles in general mainly proved that choosing the right bicycle can take away the obstacles  for cycling to work. Although this study does give an idea of how bicycle features do influence the mode choice of people it id not provide insight in the influence of e-bike specific features and their influence on people's choice to cycle or not.

When trying to stimulate people to commute by bike different groups of commuters can be distinguished. Firstly, a distinction can be made between Non cyclists and cyclists can be made. Then this cyclist commuter group can be split in a part-time and full-time cyclist. And lastly in the part-time cyclists we can distinguish the occasional and frequent cyclist. (Eva Heinen, 2011)

From this study it becomes clear that the potential to get people to cycle to work more often is mainly in the part-time occasional cyclist. This person is open to commuting by bike, but because of constraints or obstruction he is not travelling by bike frequently. It was concluded that this group of people will be easier to convince to cycle more than to convince the non-cyclist to cycle to work.




*Groups of commuters*

**Government policies**

In multiple studies it is concluded that government policy stimulating cycling does have a positive influence on the amount of cycling. One way to promote the market share of the bicycle mode is to separate bicycles from motorized transport in order to ensuring a safe and streamlined class of mobility. (Bagloee et al., 2016)

Especially in the Netherlands it is concluded that the highly bicycle friendly policies of the Dutch government have had a positive effect on the high level of cycling. “The impression is, that the policy and the increasing road and parking congestion in cities explain to a large extent why the bicycle retained its market share in an adverse world.” (Van Goeverden et al., 2013)

It is clear that governmental policies in infrastructure play a big role in the stimulation of cycling. In The Netherlands this has led to a widely spread use of the bicycle for personal transport. Making the infrastructure better suited for the electric bike will most likely lead to more e-bike usage.

**Employers’ role**

Employers could encourage cycling the following way: providing bicycles for short distance business trips, providing company cars for longer business trips, developing an explicitly pro-cycling culture, and using financial stimuli to encourage bicycle commuting. (Heinen, E. et al., 2009)

From another study in 2012 it was found that a positive attitude towards cycling, colleagues’ expectations, access to changing facilities, and needing a bicycle during office hours has a positive influence on commuting by bike. Facilities for other modes of transport, an increase in commute distance, the need to transport goods, and a free public transport or car pass have a negative influence to commute by bike. (Heinen et al., 2012)

Clearly the employer plays an important role in the stimulation to use the e-bike to commute to work. When the Dutch government would like to stimulate the use of the e-bike for commuting it should try to work closely together with companies in order to also change the facilities and mentality in companies.

**E-bikes**

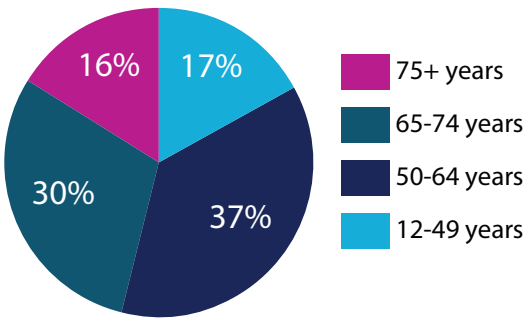
Yearly Dutch people make 300 million movements by e-bike, in which 1,5 billion kilometres are covered (data from 2015). Almost half of driven e-bike kilometres is accounted for by 65+. But usage under people under 65 is rising as well (compared to 2013), especially in the 50 to 65 years old group. In total 10 percent of kilometres is made on the e-bike. For 65+ this is 30 percent, for 50-65 years old 16 percent, and for 12-50 years old 3 percent.
Compared to a normal bike the distance covered with an e-bike is 1,5 times higher: 5,3 versus 3,6 Km. Also the maximum acceptable cycling distance (defined as what 90 percentile finds acceptable) is higher: 15 km versus 7,5 and for commuting 15 versus 10 km. (CBS, 2016) (KiM, 2016)

The findings of Wolf and Seebauer suggest that strategic measures to increase e-bike use should prioritize daily commuters as target groups. In his study Wolf observed limited modal shift from cars to e-bikes on daily work and shopping trips, the high absolute number of these trips promises the most environmental benefits. (Wolf, A. and Seebauer, S., 2014)

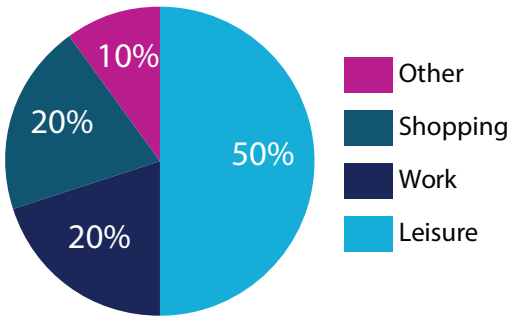
In a study into personal mobility in The Netherlands (Onderzoek Verplaatsingen in Nederland 2015, OViN) it was also research how e-bike users changed their travel behavior after purchasing an e-bike. Acoording to the respondents the e-bike mainly leads to less usage of normal bikes, 75 percent states to make less use of the normal bike. The usage of cars changed less, 40 percent of respondents says to make less usage of the car, where 50 percent says this did not change. (KiM, 2016)

This corresponds with other studies, which also report e-bikes are found to increase bicycle usage. E-bikes have the potential to replace conventional motorised transport, but there are questions about their role in replacing traditional bicycles. E-bikes have been shown to provide health benefits for non-cyclists and produce an order of magnitude less carbon dioxide than a car travelling the same distance. (Fishman, 2016)

The further adaptation of the e-bike leads to higher distances travelled by bike; the distance covered by e-bike is 1,5 times larger. Targeting commuters to travel by e-bike has a big market potential as the group of commuters is very big; even if only a small percentage shifts to traveling by e-bike this will mean a high number of new e-bike sales in absolute numbers. Under current e-bike users the e-bike does not mainly replace car rides, but mainly normal bike rides. This is an unwanted side effect, but if the combined distance travelled by e-bike and normal bike increases this is not a big problem.




*Age e-bike owners*




*Use of the e-bike*

In the OViN study also people's motivation for buying an e-bike was researched. Two-third of respondents states traveling faster is an advantage, where 90 percent says not getting tired is an advantage. This implies that easiness and comfort are more important than speed. Furthermore 60 percent of e-bike owners thinks the e-bike has a positive image, where 36 percent says the e-bike fits their own image. Almost a quarter of respondents says the e-bike does not fit their own image. In earlier research is was seen that the usage of an e-bike was not always approved by friend and relatives and could lead to hiding the battery. (KiM, 2016)

It is interesting to see that the increase in comfort and decrease in needed effort is more important than the increase in speed. Apparently the needed effort and low comfort level are bigger obstructions in commuting by bike than the longer time it takes to commute by bike. Also the results showing the discrepancy between the positive image of the e-bike and the opinion that the e-bike does not fits one's personal image is interesting: people do see the e-bike as a positive development, but owning one still conflict with their own image.

**E-bike stimulation**

*Financial incentive*
In a Dutch study from 3 years back people living 5 km from work and traveling by car got a reward for using the e-bike instead. (10 eurocents per kilometre) Average distance to work was 14 km and on average participants used the e-bike 2,7 days a week. Among people switching to the e-bike (90%) the average travel time increased with 10 minutes. The percentage of people from this group complying with the work-out norms increased from 47 to 93 percent. It is concluded that rewarding people for using the e-bike leads to results both mobility and health related. (TNO, 2013)

*Normative feedback*
In a Swiss study it was concluded that in order to stimulate people using their e-bike supportive normative feedback may be used in an effective way. According to their findings switching to e-biking in a group and comparing the results can give motivation for e-bike usage. (Flüchter, 2014)

*App*
In an American study it was shown that by means of an app active travel can be effectively promoted. By giving route information, weather information and estimated travel time as well as tracking ones result active travel can be stimulated. This study proves that commuter behaviour can be influenced with an app and that help in planning trips and predicting traveling time have a positive outcome on people's behaviour. (Bopp, et al., 2006)

Multiple ways to stimulate the use of the e-bike have been tried. It can be concluded that there are multiple ways to encourage the use of the e-bike. Especially developing an app next to the bike seems an interesting option for Gazelle.

**Safety**

The number of fatalities under cyclist has been more or less stable the last years. From 2005 to 2015 the amount of fatalities under cyclists has risen with 2 percent. With this rise it does not follow the downward trend under car fatalities. In this period however the amount of cycled kilometres has risen with 11 percent as well, so actually the risk of dying during cycling has gone down. (KiM, 2016)
In 2015 63 percent of the fatalities under cyclist were older than 65 years. Also under severe wounded elderly are over-represented. The rising amount of fatalities under elderly can be contributed to the risen mobility and population of the 65+ group. From the cyclist fatalities 12 percent was riding an e-bike, where the percentage in cycled kilometres on an e-bike is 10 percent. The higher fatality rate under e-bike riders can be contributed to the fact that elderly do more often ride an e-bike (30 percent). (CBS, 2016) (KiM, 2016)

It is unclear if the higher speed of e-bikes leads to a higher amount of accidents. It is clear however that the time gap acceptance (the time gap in front of an approaching bicycle) of car drivers becomes smaller as the speed of a bike increases. This could be solved by giving the e-bike a distinctive design as car drivers often mistake the e-bike for a normal bike. (Petzoldt, T. et al. – 2015) In a German study it was proven that e-bikes indeed reach higher speeds than normal bikes, but it was not clear if this also leads to a higher amount of accidents. In case of a crash it does have more severe consequences though. (Schleinitz et al., 2015)

E-bike safety is a concern. However data suggest the increase in e-bike cycling fatalities can mainly be contributed to the high number of elderly riding e-bikes and to the increase of cycling in general. If the higher speed of e-bikes leads to more fatalities is unclear, but this needs to be investigated further.

# Literature study - Conclusions

- E-bikes for commuters have a big potential
It is shown that commuters are an attractive target group for e-bikes. Still only 20 percent of e-bike owners uses the e-bike for commuting. By increasing this share both environmental and health benefits can be achieved. Because daily about 10 million commuting movements take place in The Netherlands even a small change from cars or public transport to e-bike cycling has a big impact.

- Little research on e-bike design factors
Little is known about the influence of the design of an e-bike on the mode choice of people. Only in a Swedish study this was partly covered. The mode choice for a bicycle is also influenced by many factors not related to the bike itself. Infrastructure, trip characteristics, and personal attitudes and norms plat an important role. The last factor is probably also influenced by the design of the e-bike.

- Government and employer play an important role
Both governments and employers have an important role on the choice to ride a bicycle. By supporting the infrastructure and facilities needed for e-bikes they can speed up the adaptation of the e-bike.

- Comfort of less effort important
Most important reason for buying an e-bike is the decrease in needed effort. The comfort of lighter pedalling is more important than the increase in speed.

- E-bike image still a problem
It can be concluded that the e-bike still has an image as being for lazy or old people. It can be expected this will become less of an issue when e-bikes become more common under younger cyclists. Also design-wise steps can be taken to reduce the image problem. By a more modern design people will probably associate the e-bike less with the stereotype e-bike for elderly.

- E-bike stimulation works
Multiple ways to stimulate the use of the e-bike have been found. It can be concluded that there are multiple ways to encourage the use of the e-bike. Especially developing an app next to the bike seems an option for Gazelle.

- E-bike safety is a concern
More research is needed into the concerns about the higher accident risk of an e-bike. Probably a more distinctive design could reduce the chance for an accident.

# User research - Observations

Observations were made at various places. Along the route from Delft to Rotterdam, a bicycle highway, multiple observation sessions were made. On the route from Delft to The Hague and the route from Gouda to The Hague also observations have been made. Furthermore, observations were made at the ferry from Zaandam and the ferry from the NDSM yard in Amsterdam.
The observations along bicycle paths and the observations at the ferries will be discussed separately.

**Bicycle paths**

While observing people on bicycle lanes it became clear it would be difficult to get to talk to people this way. People are not willing to stop for or a short interview. People were in a hurry and were not willing to stop for a couple of minutes. After a few tries this approach was given up.
While just observing people also interesting points became apparent. The following observations were made:
- Quite a lot of sporty / enthusiastic cyclists
- Not that many e-bikes, probably around ten percent
- Normal e-bikes are hard to distinguish from the front
- Speed pedelecs clearly ride faster
- Partly because of the higher speed, speed pedelecs are more easily recognisable
- Speed pedelec users often wear special cycling cloths
- Good lighting is very important
- Although marked as cycling highways there are still situations were one needs to slow down

**Amsterdam Ferries**

While observing people at the ferries in Zaandam and Amsterdam it was a little easier to ask people some questions. Not so many e-bike users were spotted here however.
Based on the observations and conversations with people the following can be concluded:
- Ferries are crowded during rush hours
- Low share of e-bikes, about three to five percent
- No speed pedelecs observed

Based on the conversations with cyclists:
- Waiting for the ferry is annoying
- Some people also like the little break on the ferry
- In Amsterdam the bicycle quickest way to travel when you need to cross the IJ.

**Remarks**

From the observations it becomes clear that most cyclists do dress up for cycling when they need to cycle larger distances. For shorter distances e-bike are not used that often and for use in busy city centres e-bikes do not offer an advantage.

*Observations at the ferry in Zaandam*

## User research - Interviews

The interviews can be split in five groups: Users, Potential users, E-bike dealers, Experts and Gazelle employees. For these five groups specific interview questions were formulated, which were used as a guideline in the interviews. The interview questions can be found in the appendix.
In order to analyse the interviews, the Users and Potential users will be grouped together. For all four groups first a short description of the respondents will be given, after which the main findings will be presented in bullet form.

# User research - Interview e-bike owners

In total six e-bike owners and two potential e-bike buyers were interviewed. Three of the e-bike owners had a speed pedelec. The average age of the respondents was a little high: The age in ascending order was: 32, 34, 42, 45, 50, 53, 53 and 59; which means the average age is 46.
The youngest and oldest respondent were interested in buying an e-bike. The youngest respondent because she was fed up with traveling by car and the oldest because he has to cycle 31 Km to his work, which he used to do twice a week in the summer. In order to keep doing this he was considering buying an e-bike.
From the normal e-bike users the average distance cycled to work was 14,3 km, and for the speed pedelec this was about 24,3 km. In average the respondents would need 45 minutes to cover this distance.

**Findings**

Use
- Most users use the e-bike only for commuting.
- Cycling and being outside is a nice variation of the day
- The e-bike feels like you always have the wind in your back

Weather
- Most users dress up for cycling through the rain
- Protective clothing for weather is available. Could be sold with the bike.
- A little rain is acceptable, heavy rain can be a deal breaker.
- Rain on the way home is less of a problem
- The cold is also problematic

Design
- Reliability is very important. One user reported a lot of repairs.
- Noise of the motor a little annoying.
- Charging is a hassle. Also removing the computer is a little hassle.
- Less is more. The more options, the more can break
- It is difficult to transport a laptop bag
- Parking an e-bike on the streets is not a good idea, needs to be secure.
- Cycling without assistance is very hard.
- It would be nice to go a bit faster than 25 km/h, 30 for example.
- Seating position are important for comfort
- The e-bike should not be recognisable as an e-bike
- The design of the e-bike could be more modern.
- Many e-bikes look the same.
- Clip-on cycling bags become loose too easily

Speed pedelec
- Cycling lanes are not designed for speed pedelec.
- Not suitable for cities
- Higher speed in the countryside handy. Helmet not problematic.
- Speed pedelec user:
  Higher speed very important, often cruises at 40 km/h.
  Switched from a racing bike to a speed pedelec because of reliability
  A good bicycle bell is very important

**Remarks**

In the user interviews it is interesting to see that a reason for using an e-bike is also the experience of being outside. Also most users do also cycling in light rain, for which they dress up in protective clothing, which is adequately available. Furthermore they name reliability as a very important aspect for the design of an e-bike.  Also the users say they would like to go a little faster than the normal e-bike, for example 30 km per hour. Also the users say the e-bike should not be recognisable as an e-bike.

*Weather protection*


*Lighting problems*

*Charging hassles*

*Issues taking luggage*

# User research - Interview dealers e-bikes

In total interviews were held at four dealers. At Peter Terlouw Tweewielers in Barendrecht, two salesmen were interviewed. At 12gobiking one salesman was interview. At Juizz The Hague 3 salesmen were interviewed and at Fietsenwinkel.nl one salesman was interviewed.
Peter Terlouw and 12gobiking are two bigger bicycle shops, both having a big assortment of both normal and electric bicycles. Juizz is a dealer only selling e-bikes and fietsenwinkel.nl is an online seller, also having multiple showrooms.

**Findings**

Use
- Mainly for commuting about 12-25 km.
- Time saving main reason. Less effort important, no sweating. Health benefits over car.

Weather
- Weather not a big problem for many people.

Design
- Reliability very important.
- Maybe a lease construction could work.
- People do not realize an e-bike needs more maintenance.
- The less maintenance, the better. For example a Nuvinci hub and belt drive.
- Better charging possibilities and a larger battery important.
- E-bike should look like a normal bike, sleek frame desirable.
- Technical component should be better integrated

Speed pedelec
- There is a gap between the normal e-bike and the speed pedelec.
- Should not look like a moped.
- Main interest from enthusiastic cyclists: coming from racing bikes.
- Helmet obligation is a barrier. Less interest since this year.
- Place on the road questionable.
- Needs indicators.

**Remarks**

Contrary to what was found in the literature study the dealers consider the time savings as the most important reason for buying an e-bike. In line with the responses from users the dealers also see a gap in between the normal e-bike and the speed pedelec, where a 30-35 km/h variant would make sense. Also reliability was mentioned by the dealers as an important factor for the further adaptation of the e-bike.

# User research - Expert interview

As an e-bike expert for the ANWB Hans de Looij has been working on e-bikes since 2003. He is responsible for the e-bike tests from the ANWB. As such he has a lot of experience with e-bikes and has a clear view on what the perfect commuter e-bike should look like.

**Findings**

Use
- Main motivation is the more relax and faster traveling experience. (traffic jam avoidance)
- Trip-changing important.
- Less assist needed on the way back home.
- Many people want to ride 30 km/h.

Weather
- Good rain suit and shoes are important.

Design
- Integration of cycling bag interesting for commuting.
- Charging hassles still a problem.
- Charging the battery is problematic because of temperature differences.
- Reliability and less maintenance important.

Speed pedelec
- Cruising speed on speed pedelecs about 32 to 35 km/h.
- Lighting important. Mandatory to have it always turned on in Germany.

His recommendation is to make a sturdy commuter bike with the following properties and options:
- Should be a little sporty.
- Sporty, robust, sturdy looks.
- Belt drive
- Reinforced spokes. Braking spokes big problem.
- Rust-free, very good paint work
- No suspension. Simple and sturdy.
- Roller brakes

**Remarks**

Interestingly Hans de Looij sees reliability as the most important aspect of an commuter e-bike. He has some quite concrete suggestions to make the e-bike more durable and reliable. He also shares the thought that a little higher top speed than the top speed of a normal e-bike would be desirable. Furthermore he sees room for improvement in the battery technology.

# User research - Gazelle Experience Centre

At the Gazelle Experience Centre in Amersfoort three employees from Gazelle were interviewed. All three were normally working at the factory in Dieren, but in the weekend they sometimes help out in the Experience Centre.

**Findings**

Use
- Main customers still older.
- From 40 years old people are interested.
- Cost reductions also a reason to ride an e-bike.
- People have many questions about the engine and battery.
- Better testing possibilities would be preferable. Make it possible for people to try the bikes longer.

Design
- The weight of the e-bike still high.
- Cycling without assist is too heavy.
- Customisation or semi-custom designs are an opportunity.
- Too much choice in pre-configured models.
- More colours are needed. Too much bikes are black or grey. Colours could be more attractive.
- Most people want a luxurious bike.
- Navigation, automatic gears etcetera nice options.
- Also comforts like suspension important.

Gazelle
- Gazelle often follows the competition. Looks what other brands are doing.
- There is a conflict between the dealers and Gazelle, who would like to sell bikes directly.

**Remarks**

It is interesting to see that the interviewed employees see customisation as an opportunity, but also say there is too much choice in models. Furthermore they subscribe most of the common e-bike issues, like the weight and battery issues. Interesting to see is that they mention the importance of comfort raising options, like suspension and navigation.

# User research -Conclusions

From the different interviews the most important conclusions are selected.

- Reliability
The reliability of the e-bike is an important concern among all four groups interviewed. Less maintenance is very important according to dealers. They also report not many people understand an e-bike needs more maintenance.

- Charging possibilities
The charging of the battery is also a major concern. Users report this is too much of a hassle and also a higher capacity battery is desirable. The interviewed expert also mentioned the battery does not like the sudden temperature changes.

- Modern design
In general, a more modern and clean design is preferred. Also the integration of technical parts is mentioned as a way to improve the design.

- Higher top speed
Some users and also some dealers mention the wish to have a little higher top speed. Probably a top speed around 30 km/h would already be sufficient. Most users are not interested in the speed pedelec.

- Bringing luggage
It is difficult to find a good solution for bringing luggage. In order to bring luggage many users use typical bicycle bags, which work adequate, but look out of date and are disrupting the bikes design. Other solutions are not always securely attached and are sometimes perceived as unsafe.

- Customisation
Instead of many different models, the possibility to order a custom bike would be desirable.

- Weight reduction
The weight of the bike is considered too high. Preferably the bike should not weight more than a normal bike.

- Weather protection
Protective clothing is used by most users, but cannot solve weather problems for everybody.

# Market analysis - Product portfolio Gazelle

Gazelle offers a range of e-bikes, in total 28 models. The main part of the range are traditional e-bikes. In this traditional e-bike the battery is mounted at the rear rack and the motor is a front hub or a mid-motor. Because of the battery on the rear rack these models are clearly recognisable as e-bikes, unless the battery is covered by a cycling bag.
Interestingly these bikes with the battery on the rear rack is a typical Dutch design future. Bicycle manufacturers from elsewhere usually do not choose to do this. This has to do with the Dutch culture, where many people use a bicycle on a daily basis and where bicycle racks are found on almost every bicycle.

When looking at Gazelle's product portfolio there is not much variation. Most models look very similar and the main differences are in the motor, gearing and brake options. Only different designs are the CityZen, HevayDuty and Balance. The CityZen is a sporty model, the HeavyDuty is a transport bicycle, and the Balance a very low access frame design.
In the eyes of the user probably all other e-bike models are more or less the same. Of course there are differences in motor setup, batteries, etcetera; but in terms of looks these bikes all look very similar. This leaves potential for a specific design aimed at the commuter.

Part of the appeal of Gazelle's bikes lies in brand image. Because of the well-known brand and the trustworthy image people choose to buy a Gazelle. When shopping for a bicycle the brand is still an important factor and people better trust the established big brands, which they know.

*Chamonix C7*

*Ultimate T9*

*Puur NL C7*

*Orange C330*

*Ultimate C8*

*HeavyDuty C7*

*Orange C7*

*CityZen C8*

*Balance*

*Gazelle e-bike portfolio*

# Market analysis - Competitor analysis

**Brands**

There is a large amount of e-bike brands. Especially if you include all Asian brands the list of e-bike brands is enormous. For this reason, not all brands are listed here, but only the most relevant brands for the Dutch market.

- Batavus
- Bikkel bikes
- BSP Fietsen
- Cannondale
- Cortina
- Cross
- Cube Bikes
- Dutch ebike
- Dutch-ID
- Faraday bikes
- Flyer
- Forza Fietsen
- Gazelle
- Giant Bicycles
- Haibike
- Ideal
- Kalkhoff
- Keola
- Klever
- KOGA
- Merida
- Multicycle
- QWIC
- Riese & Müller
- Sparta
- Stella Fietsen
- Stromer
- TREK
- VanMoof

In this list a couple of big Dutch bicycle brands can be found. These established brands have been around for years and are well-known to the public. Gazelle is one of these brands; Sparta and Batavus are other examples. Besides these established brands there are many new brand which have entered the e-bike market. Some of these new brands are only active on the e-bike market and do not produce normal bicycles.

In The Netherlands there are two big holding groups which have a range of bicycle brands in their portfolio. These are the Accel group, which includes Batavus, Haibike, Koga, Raleigh and Sparta, and PON Holding, which includes Faraday Bikes, Focus, Gazelle, Kalkhoff and Union. These two players dominate a large part of the European bicycle market.

**Suppliers**

Next to the bicycle brands the part suppliers play a large role in the bicycle market. Especially the battery and motor manufactures have a big impact on the pricing and features of the Bicycles in the market. Some important suppliers are: Bafang , Bosch, Panasonic, Shimano and Yamaha. Also suppliers of other purchase parts, like Shimano in gearing systems, play an important role. This big influence of suppliers also makes the bicycle market relatively easy to enter. Because the main parts of an e-bike are made by suppliers it is relatively easy to enter the e-bike market.

# Market analysis - Competitor analysis

*Normal e-bikes*

**Design**

When looking at the competition it is clear that multiple solutions for battery placement and frame design are being used. Also the placement of the electric motor differs. For the bikes shown on this page it was chosen to use the most diverse e-bike designs possible. A lot of normal e-bikes however still have the motor placed in the front hub and the battery at the rear rack, like the Gazelle in the middle. This is sort of the typical e-bike design.

**Styling**

Some brands focus more on styling of the bike than others. Especially some of the smaller brands focus on the integration of technical parts and the looks of the bicycle. Some of these brands also try to get a sort of retro look, using steel frames and other elements referring to old bicycle design. With this specific styling they seem to try to address a specific target group.

*Speed pedelecs*

**Speed pedelec**

When looking at the speed pedelecs it is clear that most bikes do have a sporty look. Furthermore almost all speed pedelecs have the motor placed in the middle at the crankset and the battery placed in or on top of the down tube.
Some of the speed pedelecs take more effort in integrated the battery in the frame design than others. Also battery capacity varies. Especially for the speed pedelec the battery capacity is of high importance, as they consume much more energy than a normal e-bike.

# Market analysis - E-bike sales

The e-bike market is still growing, both worldwide and in The Netherlands. On the other hand, the sales of normal bikes have gone down. In 2015 276.000 e-bikes (28 percent) were sold. In total 983.000 bicycles were sold. In 2014 these numbers were 223.000 (21 percent) and 1.051.000. The total revenue from e-bikes was 514 million euro, which is 57 percent of the total bicycle revenue of 899 million euro. In terms of e-bike sales in absolute numbers the Dutch market is the third biggest market in the world (276.000), behind China (29.000.000 estimated) and Germany (535.000). In sales relative to inhabitants it is the world biggest market. (European Cyclists' Federation, 2016)

The sale numbers of speed pedelecs are still limited. In total 3.466 speed pedelecs were sold in The Netherlands in 2016. Top selling brands were Riese & Müller with 812 speed pedelecs sold, Stromer with 715 bikes and Gazelle with 498 bikes. (Speed pedelecs maandrapportage nieuwverkopen 2016 RDW) Compared to the sale figures of normal e-bikes, the speed pedelec still is a niche market.

Gazelle is market leader in The Netherlands in both normal bicycles and e-bikes; both with a market share of about 25 percent. Only in the speed pedelec market they are not leading. This gives Gazelle a comfortable position in the Dutch market. However, with many new brands entering the e-bike market, Gazelle needs to make sure to keep innovating in order to stay ahead.

# Market analysis - E-bike price

In 2015 the average price for a new bicycle was 914 euros and the average price of bikes sold through dealers was 1058 euro. For the first time this lay above a 1.000 euros. (Bovag, 2016) This increase in average price correlated with the rising popularity of the e-bike, which are more expensive than a normal bike. Interestingly the better affordability of the e-bike has led to an increase in the average price of bikes in general. This leads to the conclusion that people are willing to pay more for an electric bike.

The price of the average bike in The Netherlands is the highest in Europe. The main reason for this is the high number of e-bike sales in The Netherlands, where one in three bikes is an e-bike. According to an online article, analysing the e-bike market, a second reason for the high price of the e-bike is the introduction of a new collection each year. This is also called the bicycle fashion, giving each design an updated paintjob each year. One could question the necessity to change the complete model range each year. It would be a better idea to change the model portfolio when needed.

**Price point Gazelle**
The price range of a new e-bike lies in between 600 and 5.000 euro, with some models going much higher than this. Gazelle's e-bikes are priced from 1.700 to 3.500 euro (list price) and the actual retail prices range from 1.360 to 3.350 euro. This means Gazelle is positioned in the mid to high end segment of the e-bike market. (Based on Gazelle website and webs-hop fietsenwinkel.nl)

# Market analysis - E-bike retailing

**Bicycle dealers**
The online sales of bicycles are a big threat to the bicycle dealers. Online shops like fietsenwinkel.nl are able to offer e-bikes online for a price point, at which bicycle dealers simply cannot compete. Also the leasing construction being offered by various parties is a thread to the old model of selling bicycles. Still many dealers make most of their revenues from bicycle sales and living from service alone is not possible for many dealers. This will however most likely be the future for bicycle dealers.

It is clear bicycle dealers need to modernise. By having fewer models in the shops, and having more built to order bikes a lot of money can be saved. In order to do this more cooperation between dealers and manufacturers will be needed. Also not having yearly model collections could significantly reduce the costs for bicycle dealers. A possible solution is an online platform where you can order your e-bike, which is then being delivered by an associated bicycle dealer.

**Service based economy**
The bicycle market will move from a product oriented market to a service oriented market. People will not buy a bike anymore but a mobility service. People do not want the worry about ownership anymore, and want to be able to use the bike anytime. Especially for an e-bike people are afraid of the maintenance costs, especially the costs of replacing drive-train components.
To give people the possibility to use the bike without owning it e-bike dealers and manufacturers will have to focus on the experience and service instead of the product. The design however will still have to be attractive. A modern and unique design will still appeal to the customer.

*E-bike department in a bigger bicycle store*

**Leasing**
A new ownership model for bicycles and e-bikes in particular is leasing. This is being offered by an increasing amount of parties and it is possible to lease anything from a normal bike to an electric cargo bike. Also bicycle manufacturers are entering the leasing market. Next to existing parties which are also in the car lease business. For a leasing construction the retail price is less important, but running costs will define the leasing price in a large extend.

At the moment there are no special rules for leasing an e-bike. This means there is a tax addition of the full purchase price of the e-bike, which in some cases can be more than the tax addition of a car. Many organisations involved with personal transport plead for a complete removal of tax addition on e-bikes. Other tax incentives to promote bicycle leasing are unclear and should be improved and clarified in order to promote leasing an e-bike.

**E-bike Repairs**
It appears as if e-bike repairs usually take a long time. There are a lot of stories of people who have to wait a long time for replacement parts. Especially getting a new battery or other drive-train components can sometimes take a long time. This makes the experience of a broken e-bike even worse and influences the whole experience of owning an e-bike. Also dealers and manufacturers should be clear about the offered warranty and what people can expect. In the last years many people have been surprised by the costs of a replacement battery of their e-bike.

For a lease construction service is key. Replacement bikes should be available and repairs should be quick. In order to make this possible bicycle manufacturer should work closely together with dealers. It must be possible to deliver a replacement part the same day or the day after like in the car industry.

# Market analysis - Retailing Gazelle

In this paragraph the retail strategy of Gazelle will be described. Gazelle is responding to the changing bicycle market and is already offering alternatives to the normal retail networks.

**Gazelle Finance & Lease**
It is possible to finance a new Gazelle bicycle. In combination with an insurance and roadside support the customer can buy a new bicycle and pay in monthly terms. The bike will be delivered by a certified Gazelle dealer.
Gazelle is also offering lease construction where the customer is paying a monthly fee for which he can cycle completely worry-free. In the lease construction also maintenance will be taken care of by Gazelle. These bikes will be delivered and serviced by premium Gazelle dealers.

**Gazelle direct sales**
A third alternative Gazelle offers is to buy a bike directly via the Gazelle website. In this scenario the customer will pay the suggested retail price and delivery will be done via Gazelle dealers.

# Market analysis - Conclusions

- Gazelle could use a distinctive design
The normal e-bikes of Gazelle look very similar to each other. A more distinctive design would be a good way to distinguish a design specifically aimed at the commuter. Also compared to the competitors the Gazelle e-bikes could use a more distinctive design.

- Strong competition
The competition in the e-bike market is strong. There are many players and also many new brands entering the market. Because the e-bike market is still growing it is an attractive market to enter and because many parts are made by suppliers it is also an easy market to enter.

- High influence of suppliers
The influence of suppliers of the battery and electric motors is quite high. By the shape of the battery and electric motor a large part of the e-bike's design is determined.

- Retail channels will change
More direct sales and different forms of ownership will be available for e-bikes. This means the role of the bicycle dealer will change; instead of main retailer they will probably have to switch to service partner.

- Repairs should be quick
Repairs and service could be improved. It seems e-bike repairs take quite a long time because of long waiting time for replacement parts.

- Gazelle is adapting its retail strategy
Gazelle is already responding to the changing bicycle market and is offering alternative ways to buy a bike.

# Conclusions research phase

First the main findings of the literature study, user research and market analysis are presented. Based on these findings the research question and sub questions will be answered.

Literature study
- E-bikes for commuters have a big potential
- Little research on e-bike design factors
- Government and employer play an important role
- Comfort important
- E-bike image still a problem
- E-bike stimulation works
- E-bike safety is a concern

User research
- Reliability
- Charging possibilities
- Modern design
- Higher top speed
- Customisation
- Weight reduction
- Weather protection

Market analysis
- Gazelle could use a distinctive design
- High competition
- High influence of suppliers
- Retail channels will change
- Repairs should be quick
- Gazelle is adapting its retail strategy

**Conclusions research questions**

From the three types of research performed a range of insights and conclusions has been formulated. With these conclusions the main research question and the sub research questions can be answered. The main research question was formulated as: How to make electric bikes more attractive to commuters?
The sub research questions were:
- Why are commuters traveling by other means of transport instead of the e-bike?
- What are the needs of a commuter?
- What are the main problems of cycling (by e-bike) to work?
- What can be improved in the current designs?

Based on the research results first the sub questions will be answered, after which an answer for the main research question will be formulated.

- Why are commuters traveling by other means of transport instead of the e-bike?
The choice of transport mode (mode choice) of commuters is affected by a multitude of factors. These include one's working situation, trip characteristics, weather influences and infrastructure. In many situations traveling by car or public transport is faster and considered more comfortable. In the choice to commute by bike also personal attitudes and norms play an important role.
Although the design of the e-bike does have an influence on the choice of the commuter, it is not the deciding factor.

- What are the needs of a commuter?
The commuter wants a reliable mode of transport. The commuter wants the e-bike to have an appealing design that should not be recognisable as an e-bike.

- What are the main problems of cycling (by e-bike) to work?
Main problems are related to reliability and ease of use. This included the high costs on repairs and multiple problems related to ease of use of the e-bike

- What can be improved in the current designs?
Reliability, design, battery range, charging procedure and possibilities to carry luggage.

How to make electric bikes more attractive to commuters?
The answer to the main research question can be deducted from the sub research questions. In order to make the e-bike more attractive it should be reliable, have a unique design and offer more practicality and ease of use.

**Design directions**

Based on these research conclusions three potential domains have been formulated. These can be considered solution spaces in which a new design will be developed.

**Worry-free modern commuting**
This direction will focus on reliability ease of use and modern design. The aim is to make an e-bike which is as maintenance-friendly as possible and which will offer a reliable mode of transport. Next to this the design should look modern and should have a unique design. This way it will attract a younger group of commuters, which cares about a modern design. In order to allow a nice design all technical components should be integrated and the e-bike should not be clearly recognisable as an e-bike.

**Safe, reliable, fast commuting**
In this direction a speed pedelec will be developed which focusses on reliability and safety. This type of e-bike is meant for a select group of commuters, as only part of the people is interested in traveling at speeds of more than 35 Km/h. For the speed pedelec reliability and high maintenance intervals are important as well. Also safety should be considered in this direction; a good bicycle bell or horn should be incorporated and also indicator lights would be a way to improve safety. The aim of this direction is to develop a bike which enables people to travel fast in a safe and reliable way.

**Commuting in comfort**
In this direction comfort will be the main focus. Cycling on an e-bike already is more comfortable than cycling a normal bike because of the pedal assistance, but in other aspects however the e-bike does not offer more comfort. By adding more comfort-raising features the e-bike should become more attractive for people who value comfort more than speed. Possibly solutions to reduce the impact of bad weather can be put in place and also for carrying luggage more comfort could be added. By making the e-bike more comfortable more people will see the e-bike as an alternative for the car or public transport.

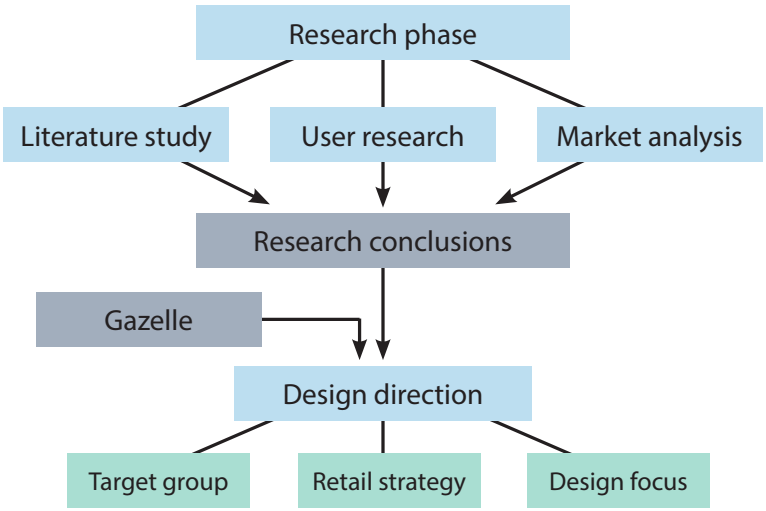
**Design direction choice**

In consultation with Gazelle the design direction **'Worry-free modern commuting'** was selected as the most promising option. In this direction the biggest problems of the e-bike are best addressed and it also fits best with Gazelle's image. Furthermore it will address a younger target group, which is also one of Gazelle's goals for the future.

# Design direction

Based on the research conclusion and the defined domain of "worry-free modern commuting" the design direction will be formulated. In order to come to a specific list of requirements a target group, retail strategy and design focus will be formulated. Also the exact bicycle type will be discussed.

After formulating the design direction the design brief and design criteria will be formulated. A list of wishes and requirements will be made as a starting point for the idea generation and concept development.




*Design process*

# Design direction - Target group

To further develop the design direction a target group will be defined. Among commuting people various target groups can be distinguished. Based on the family stage model outlined by Duvall and Hill the multiple target groups have been defined. (https://parenteducation.unt.edu/online-learning/family-development-theory) The following target groups will be considered:
- High-schoolers
- Students
- Young professionals
- Young family men
- Older family men
- Aging commuter
- Elderly commuter

**High-schoolers**
High-schoolers need a sturdy bike for a low price. High-schoolers in rural areas often need to cycle large distances to school and here the e-bike can make life a lot easier. The price is an important factor for this target group. Although the parents will probably pay the bike, they will not want to spend a large amount of money on a bike, which will be used for high-school duty.

**Students**
The typical students either lives very close to his study place or travels by train and other forms of public transport. Part of the journeys by train and other forms of public transport could be replaced by e-bike rides, but this will probably be a s mall market. The students who are cycling in their student town only cycle small distances and do not have the need for an electric bike. If you want to get students interested in an e-bike durability and price are important factors.

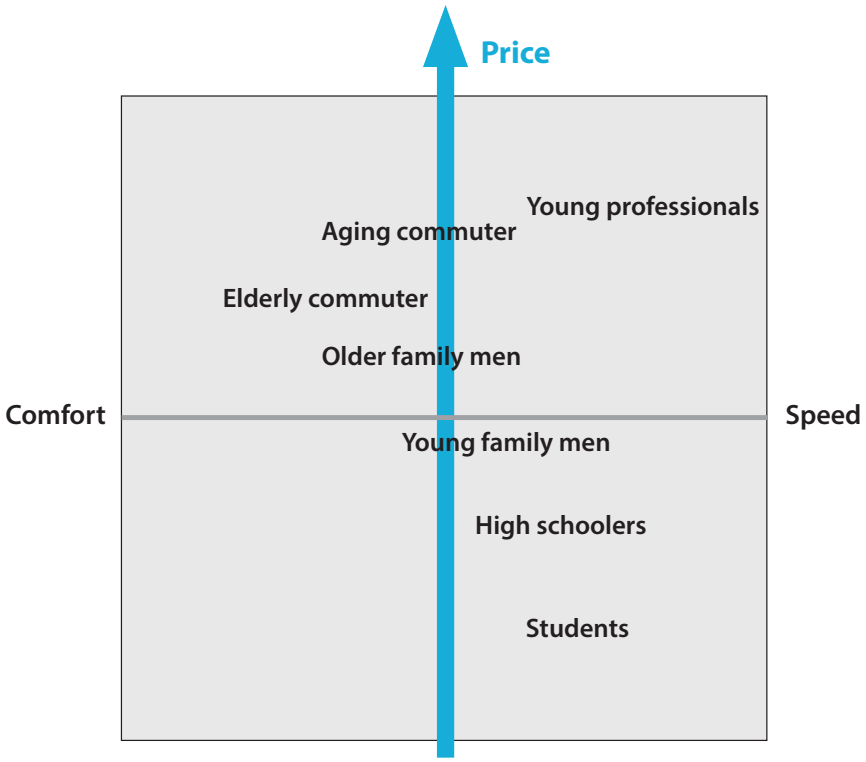
**Young professionals**
This is the person who has just started working after school. This young professional does not have children yet and might life alone or have a partner. This person does have money to spent on an e-bike and is more interested in a stylish bike which fits his own image. This target group wants products to express themselves and is less interested in the practical side of things.

**Young family men**
This is the working person with young children, and who just started a family. This means he needs to take care for his children next to his job. This leads to other demands from his transportation modes, as he also needs to take his children to various destinations. This person is more price-conscious than the young professional as the new born children also lead to high spending. At the same he does value good design and he likes to buy nice products.

**Older family men**
This group has older children, which are in their puberty or adolescence. This person does not need to take his children everywhere anymore and has had a career and probably works in a senior position. The older family man has more money to spend on a bicycle and is more focussed on quality than design.

**Aging commuter**
This group is aging, which means they are over 50 years old. People with a family will mostly have studying (empty nest) or late adolescence children and therefore have more time available as long as this is not consumed by work. Some people in this group may also experience a reduction in physical strength, which gives them a reason to buy an e-bike. This group does have money to spend on an e-bike.

**Elderly commuter**
This group consists of people who could retire but continue working, possibly voluntary. For this group the e-bike gives a high amount of added mobility. For this user the e-bike should be comfortable and safe. The elderly commuters have the possibility to spend quite some money on an e-bike.




*Target group differentiation*

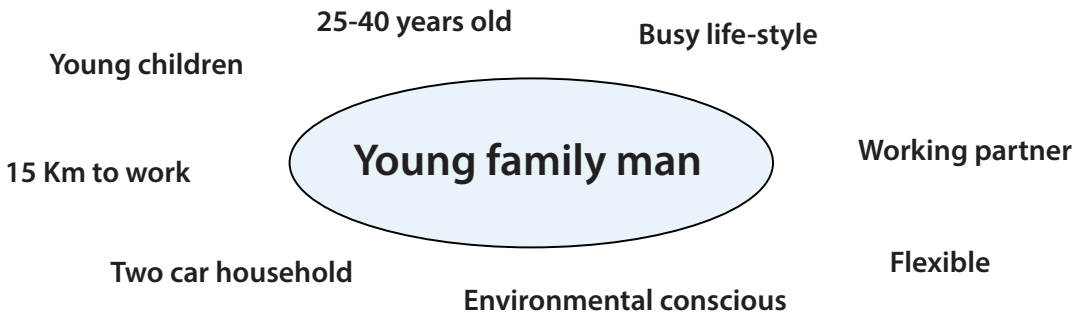
**Target group differentiation**

The target groups can be differentiated based on the price they are willing to pay for the e-bike. Also a differentiation can be made in if the target groups finds speed or comfort more important in their e-bike. In the graph above the diagonal axis represents price and the right bottom half represents the target groups more interested in speed and the left upper half the target groups more interested in comfort.
It can be seen that the aging commuter and elderly commuter have a clear preference for comfort, the older family men has a light preference for comfort, and the other target groups are more interested in speed. Also it becomes clear that the young professional and aging commuter are willing to pay most for their e-bike.

**Target group choice**

In consultation with Gazelle it has been decided to choose “Young family men” as a target group. In combination with the choice for a lease construction as retail strategy this target group is most interesting. For this target group a lease e-bike is most interesting as their financial situation does not allow high investments in an e-bike. Leasing an e-bike would be a good option for this target group, also because that way they do not have unexpected costs for repairs.

Reliability is of high importance for the target group. The bike needs to work every day without any user maintenance. If maintenance is needed a replacement bike should be available. Preferably the bike only needs maintenance once a year.

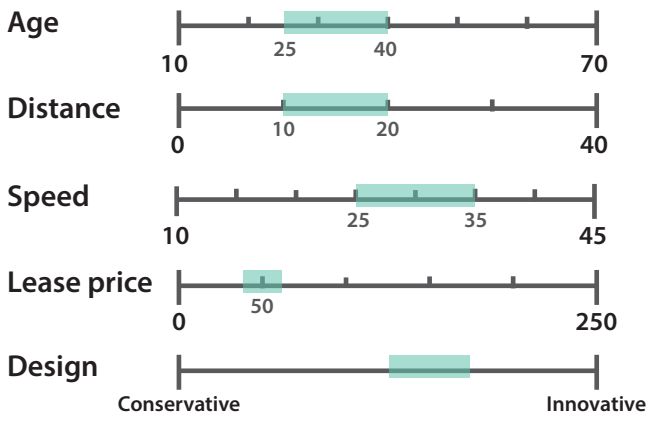



*Key-words target group*

**The young family man**

A typical person in the target group is working full-time or close to full-time. He needs to travel 14 Km to work and normally does this by car. For his work he normally does not need his car and he usually carries an office bag. The young family man (or woman) and has his or her partner have one child of wo years old. His partner works part-time and has time to take care for their child, which also goes to child care some days per week.

In recent years many things have changed for the young family man. Anticipating their child wish he and his partner moved to a bigger house three years ago, which is also the first house they bought instead of rented. The arrival of the baby changed their social lives and also led to even more expenses. Although the young family mans has less financial room than before, he still values nice products and good design. He uses his product choice to express himself and values image and styling when buying something new.

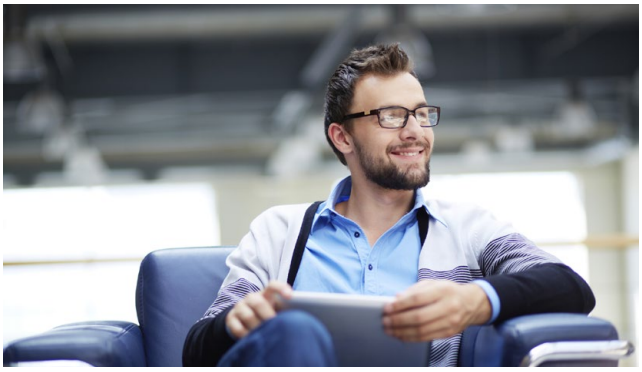


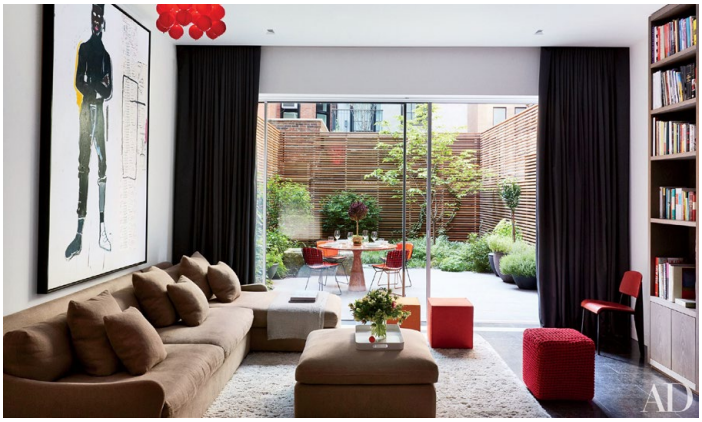

*Characteristics target group*

Things combined the lifestyle of the young family man has changed a lot. Although he feels like he is doing less it seems like his life is busier than before. This has to do with the wish of the young family man and his partner to keep up a sort of social life next to working and taking care for their first child. This has led to a lifestyle where everything needs to be combined and where days are filled with activities.

In this busy life of the target group most trips are made by car. Both he and his partner have a car and are using it normally to get around. They are however open to change to another means of transport, and probably also sell one of their cars, if this presents a viable alternative. This means he should also be able to take his child or do groceries with the e-bike. Being able to use the bike in multiple ways is thus important for the target group.

Important for the target group:
- Flexibility
- Ease of use
- Status, looks
- No fuss
- Price





*Impression target group*

# Design direction - Retail strategy

From Gazelle the wish to develop an e-bike specifically for the leasing market was put forward. As Gazelle has just entered the leasing market themselves they would like to develop a design specifically for this retail channel.
This also suits the target group. As the young family man has just started a family and may also have just moved to a new house they are confronted with many expenses. This means they do not have a lot of money available to invest in a higher-priced e-bike. By offering the e-bike in a leasing contract they can anticipate a monthly expense for their commuting transport.

Also the 'young family man' has a busy schedule and does not want to spend time on small maintenance for his bicycle. He would like a bike which always works and when it needs service or a repair he wants the leasing company to take care of this.
This means that the bike should be maintenance friendly and reliable. In order to make the bike maintenance friendly a smart design and high quality components will need to be used. In the selection of technical components, a balance between quality and purchase price needs to be found.

For a lease bike good service partners for maintenance and good roadside assistance is important. The service partners will mainly be the existing dealers from Gazelle, which will also take care of delivery of the bicycle. In the design of the bike it must be tried to make the maintenance interval big enough that the e-bike only needs maintenance once or twice a year. If driven daily for a commute of 20 Km, the distance covered in a year is about 10.000 km. (20*2*5*50) This would mean the maintenance intervals should at least be 5.000 km in order to limit the maintenance needs to twice a year.

For the roadside assistance two services are available in The Netherlands: The ANWB and FietsNED. As Pon Bike as just acquired FietsNED it is logical that FietsNED will be the service partner for roadside assistance. In order to make the complete experience as convenient as possible FietsNED should closely work together with the Gazelle dealers and it should have replacement bikes available, so they can replace the bicycle when it cannot be repaired on the spot.

**Lease price**

Before starting the design of an e-bike specifically for the lease market it is important to get an idea what people are willing to pay for a lease bike. As leasing e-bikes is not very common yet, not much is known about the lease price people are willing to pay. Only one study was found which, also investigated the price people were willing to pay. In this study from Univé (Univé, 2015) it was found that 9 percent of respondents would be interested in leasing an electric bike. From the group interested in leasing an e-bike 91 percent is willing to pay up to 30 euro a month.

In order to get an idea what the lease price of an e-bike would be, the existing offering of Gazelle Finance & Lease has been used as a reference. Currently only one model e-bike is offered as an e-bike, the Gazelle Orange C7+ HF. If this bike is leased including the Platinum battery and for a lease period of 36 months, the monthly price is 80 euro with a list price of € 2.359,00.

This indicates there is a gap between what the customer is willing to pay and what an actual lease e-bike would cost. It means that either the employer should pay part of the leasing price, or that leasing of an e-bike should get more tax incentives. As a lease bike has several benefits for an employer it is expected that they are willing to pay part of the lease price. Also many organisations have advised the government to introduce better tax incentives for leasing bikes.

The example from Gazelle Finance & Lease also gives an idea of the target cost price for Gazelle. With a list price of 2.359 the cost price for Gazelle is about 1.100 euro. A higher cost price could however be justified if this would result in less maintenance costs. More research will be done during the design process to better define this.

# Design direction - Design focus

In consultation with Gazelle ‘worry-free modern commuting’ was selected as the most promising design direction. In this direction the biggest problems of the e-bike are best addressed and it also fits best with Gazelle’s image. Furthermore, it will target a younger target group, which is also one of Gazelle’s goals for the future. In this design direction three important aspects have been identified: Reliability, ease of use and modern/unique design.

In addition to this design direction a choice has been made for ‘the young family man’ as a target group. Also it was decided to develop a bicycle for the lease market. This also fits the target group as the young family man does not have the money to invest in a high-end e-bike, but still would like to ride one to work. Also he does not want to take care of maintenance and other hassles related to owning an e-bike.

Design direction: Worry-free modern commuting
Target group: Young family (wo)men
Retail strategy: Lease

**Focus**

In order to make the project more specific it was needed to bring more focus in the design direction. In the design direction three important aspects have been identified: Reliability, ease of use and modern/unique design. Reliability is important in relation to the intended lease construction of the design. Ease of use incorporates the aspects listed below and is an important factor in making the e-bike more attractive. Modern and unique design is also important to attract a younger target group to the e-bike. This also includes the better integration of technical parts in order to make the e-bike look like a normal bike.

Ease of use:
- Bringing luggage
- Charging the battery
- No maintenance
- Theft prevention
- Lighting
- Navigation / trip planning

In order to further focus the design direction, the aspect of ease of use will be narrowed down to one or two issues on which to focus he design. From the ease of use topic distinguished bringing luggage was selected as being most important.
This decision was made based on the user research and input from Gazelle. For the target group bringing luggage is an important aspect.

**Carrying luggage**

From the user research it became clear that carrying luggage on a bike is still a hassle. People report difficulties with existing solutions and although normal bicycle bags are an adequate solution, they are unattractive and not stylish.
Some of the users also reported problems with bags attached sideways to the rear rack. These usually attach using some clip design, which does not always work so well: They sometimes rattle and one user reported the bag coming loose, when hit accidentally. A better solution should be developed for this.

*Existing solutions*

**Design integration**
Although there are many systems to carry luggage on the bicycle, most of them do not integrate well into the design of the bike. It is often seen that people add a third party solution for their luggage, which disrupts the design of the bike. As this design integration is particularly important for the target group, it should be tried to make a luggage solution which fits well with the bicycle's design.

**Young family man**
For the chosen target group 'young family man' it is also important to take his family life into account. Although a large part of the target group will use the commuter bike only to cycle to work and back there will also be a part of the target group who want to use the bike for other purposes. This may include bringing his child(ren) to day care or school or doing groceries for dinner. For the weekly groceries the target group will use his car, but for the daily groceries he may also want to use his bike.

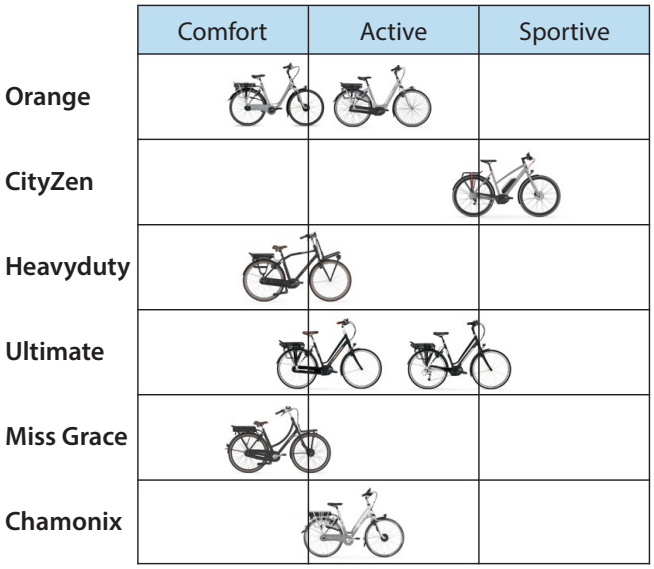
**Lease construction**
As the bike will be offered in a lease contract also the optional luggage extras should be added in the lease contract. People should be given the option to also lease the cargo solution in addition to the e-bike. This way people can choose if they need the cargo solution or not. Also people will have the opportunity or change the extras they are leasing. This can be done at a yearly maintenance check for example.

**Input Gazelle**

The choice to focus on carrying luggage is also supported by Gazelle. Gazelle also sees this as an important design problem for commuter focussed bikes and wishes to offer a solution for this. Another reason for Gazelle to choose to focus on this aspect is the fact that this problem will still be present on future e-bikes were problems associated with charging the battery may well be solved by progressing e-bike technology. In this sense it is also a future prove direction to focus on.

The design should fit the model strategy of Gazelle. Gazelle does not want to develop a new model line specifically for the commuter. Although Gazelle does belief the e-bike targeted at commuters should have a specific design it does not want to develop a specific model family for it. This decision was also made because they do not want to cannibalize their own product range.
The commuter bike however will need specific components, also because it will be offered in a lease construction. Also the frame design can be modified to fit the specific needs of a commuter bike.

In their product range Gazelle distinguishes three segments: Comfort, Active and Sportive. The specific models in the model families are all targeted at a specific segment. For example, in the orange model family there is a specific model targeted at the active segment and one targeted at the Comfort segment.




*Segments Gazelle*

The current e-bike model lines of Gazelle are:
Balance
Chamonix
CityZen
HeavyDuty
Grenoble
Miss Grace
Orange
Puur_NL
Ultimate

The product family which best fits the commuter and the young family man is the CityZen. The CityZen is targeted at the active and sportive segments, which are also the most attractive segments for the target group. Also the CityZen has a sporty and robust look, which will also appeal to the target group. Last and not least it is the most distinctive and unique design in Gazelle's portfolio, which was one of the recommendations from the performed research.

*CityZen C8 HMB*

*CityZen Speed*

# Design direction - Bicycle type

In order to further define the design direction, it is necessary to define the type of bicycle which will be designed. From the start of the project the aim was to design an electric bike. Question is if this needs to be a normal e-bike or a speed pedelec. Also the option to develop a cargo bike was briefly analysed.

**Speed pedelec**

Since January the Dutch rules for the speed pedelec have changed. From this year on you are obliged to wear a special e-bike helmet, mount a yellow registration plate at the back, and have a liability insurance for you speed pedelec. Also the speed pedelec are not allowed to cycle on most inner-city bicycle lanes; only on bicycle lanes accessible for mopeds they are allowed. Basically the same rules for a moped now apply to the speed pedelec.

A lot of protest has risen against this new rules for speed pedelecs. Users say that especially the new place on the roads will be problematic. Users doubt if the police are able to actively control these new rules and they say they will keep cycling on bicycle lanes within the inner-city. Also bicycle dealers expect this to have a negative influence on the popularity of the speed pedelec. Although the speed pedelec was still a niche product it was proclaimed to become a good alternative for people who need to travel a little further to work. It is uncertain how the speed pedelec adaptation will develop further, which makes this a less attractive market to develop a new design for.

However, users and also dealers mention the wish to have a little higher top speed. A top speed of 45 Km/h is not necessary, but they would like to have assistance up to 30 or 35 Km/h. In the current laws the normal e-bike is only allowed to give assistance up to 25 km/h. VanMoof is tricking these rules by having an USA mode available, which gives electric support up to 20 Mph, which corresponds to 32 Km/h. Although illegal, users can select this mode themselves.

Probably a new category of e-bikes in between the current normal e-bike and the speed pedelec would be desirable. This “e-bike plus” may for example have a top-speed of 35 Km/h and may require an insurance and blue license plate like the speed pedelec in the past. It would thereby legally qualify as a slow moped. Gazelle however can only lobby in the government or possibly in the EU for this new regulation, which obviously is out of the scope of this project.

For this project it has been decided to develop a normal e-bike. In the design however it can be anticipated that the design will be upgraded to a “e-bike plus”. This means that in the design it should be possible to add a license plate holder in the future.


*Urban arrow electric cargo bike*

**Cargo bike**

A bicycle type which is well suited for the target group ‘young family man’ and which is also more and more available in electric versions is the cargo bike. Especially in big cities the cargo bike is very popular among (young) parents. Gazelle is also offering a cargo bike, with the Gazelle Cabby. At the moment only a non-electric version is available, but with a new or updated version it would be a good idea to introduce a version with electric support.

For commuting to work a cargo bike is less attractive as it can be difficult to store a cargo bike in the bicycle parking at work. Also cargo bikes require more effort to cycle and it does not make a lot of sense to use a cargo bike when you are cycling alone. For this reason and because Gazelle already has a cargo bike in its portfolio it has been decided to not focus on the design of a cargo bike, but design a normal bike instead. As driving the children around is important for the target group cargo bikes can be used as an inspiration for solutions to facilitate this.


*Gazelle Cabby*

# Design direction - Luggage

When considering luggage one does normally take on a bike, the types below can be distinguished. For cycling holidays and other events people may want to carry more and other items but in day to day life these are the most important. Below also the typical dimensions of each type are listed.

Luggage types:

Laptop bag
(with shoulder strap or handles)
- 42 x 31 x 15 cm

Laptop backpack
42 x 35 x 24 cm

Messenger bag
(no laptop)
37 x 28 x 4,5 cm

Normal backpack
36 x 30 x 22 cm

Hand bag
(with shoulder strap or handles)
28 x 23 x 15 cm

Grocery shopper
50 x 48 x 28 cm

Sports bag
56 x 23 x 26 cm

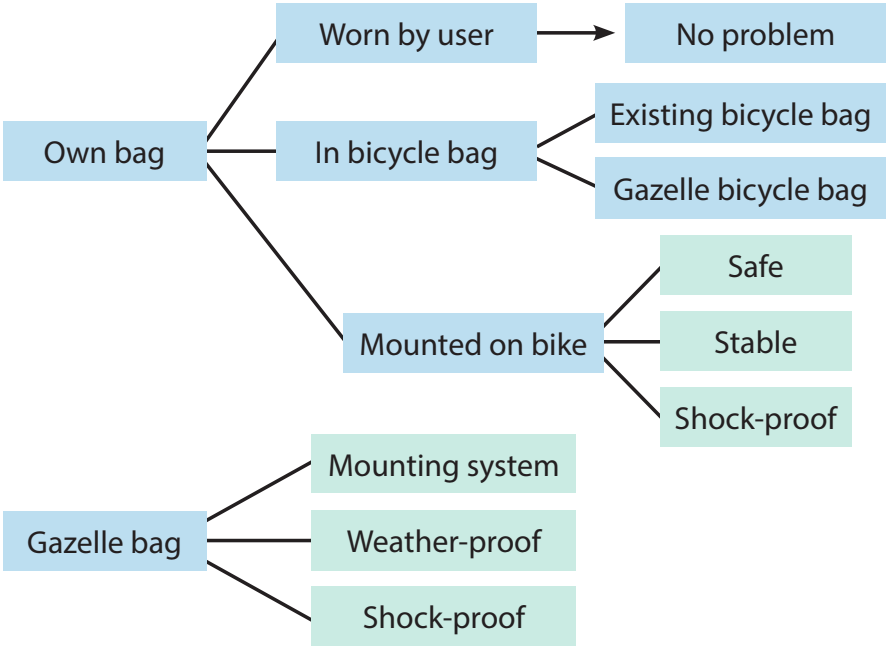
For the commuting target group the first four types of luggage are most important. For the initial design phase focus will be on brining a laptop bag. This has been chosen because this type of luggage is typical for a commuter and a 15,6 laptop bag is the most problematic type of bag people tend to bring. Of course it would beneficial if other types of luggage will also fit on the bike, but in the idea generation this will not be focussed on. The maximum size of the laptop bag was determined based on the size of 15,6-inch laptop bags.

*Dimensions laptop bag:*
- 42 x 31 x 15 cm
- Dimensions 15,6-inch laptop: 37,4 x 24,5 cm (thickness differs per model)
- Weight 15,6-inch laptop: 2-5 Kg (with charger)
- Weight of bag: 4-7 Kg (with some lunch etcetera)

From the user research it also came forward that transporting your laptop can be a challenge. People do not feel comfortable putting a laptop in a bicycle bag at the rear, where it can easily be taken out of. Also some of the solutions which clip on the rear carrier are not considered safe because they can easily come loose or be taken off.

When transporting a laptop bag it is important that the laptop is protected from shocks and weather. This should partly be guaranteed by the bag itself, but also a carrying solution should support this by for example having some kind of shock absorption. Also a laptop bag can be quite heavy, especially when a high-spec 15,6-inch laptop needs to be transported. The maximum weight of the laptop bag has been set at 7 Kg, with a 5 Kg laptop and 2 Kg left for other items.

In the figure below the different scenarios are shown. As seen a choice need to be made if Gazelle will offer a laptop bag or if Gazelle will develop an solution to carry existing laptop bags. In the design phase this is one of the design choices which needs to be made.

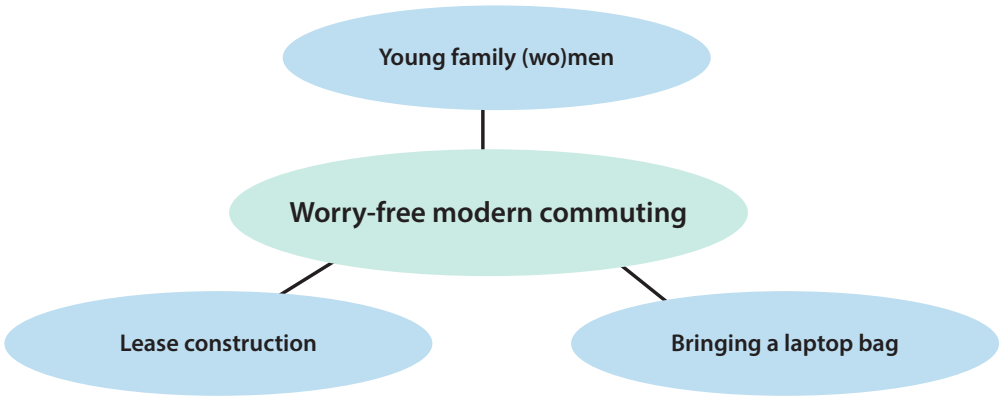



*Laptop bag scenarios*

# Final design direction

As described the design direction will focus on a solution aimed at ‘bringing you luggage’  This will be developed for the ‘young family wo(men)’ and be offered in a lease construction. The design direction can still be described as ‘Worry-free modern commuting’.

- Design domain: Worry-free modern commuting
- Target group: Young family (wo)men
- Retail strategy: Lease construction
- Design focus: Bringing a laptop bag
- Bicycle type: normal e-bike
- Gazelle model family: CityZen




*Overview design direction*

# Design criteria

Based on the design direction the design criteria have been formulated. First the design criteria for the luggage solutions will be described, after which also the design criteria for the lease bike will be shortly described. Although the project will focus on the development of a luggage solution it is important to keep the design criteria for a lease bike in mind.

**Luggage solution**

- Room for a 15,6-inch laptop bag (42 x 31 x 15 cm)
The size of a 15,6-inch laptop bag has been defined based on the dimensions of laptop bags on the market. Especially the width of 15 cm is purposely defined quite high as people will want to also take some lunch and maybe a fresh shirt or jacket.

- Weight laptop bag: 4-7 Kg
The weight of the laptop bag is based on the typical weight of a 15,6-inch laptop with charger, which is about 2-5 Kg. The weight reserved for the bag, a drink, lunch and other items is 2 Kg.

- Secure attachment
The luggage solution should enable the laptop bag to be securely attached to the bike. It should not be possible to take off the bag too easily in order to prevent the bag getting stolen in front of a traffic light Also the bag should not rattle during cycling, as tis will potentially harm the laptop and also irritate the user. By having a secure mounting system the user will feel confident the laptop bag will not fall off or get stolen.

- Shock absorption
In order to protect the laptop some kind of shock absorption will be needed. This can either be provided by the bag or by the mounting solution or other type of luggage solution which will be used. It needs to be determined how much absorption will be needed.

- Weather-proof (rain)
The luggage also needs to be protected from the weather, especially rain. This can best be done by making sure the bag itself is weather-proof. Depending on the decision if Gazelle will offer a gazelle branded bag or a solution for existing bags this will be important.

- Easy to clean / easy to keep clean
The luggage solution should be easy to clean and keep clean. This in line with the design direction worry-free modern commuting and making the e-bike maintenance friendly. This means the luggage should be placed in a position where it does not get dirty too easily and that the materials should be easy to clean.

**Design wishes**

- Luggage visible during cycling
It is desirable to have the luggage in sight during cycling. This way the user can watch if the bag is still securely attached and if it does not get stolen. This would mean the bag should be placed in front of the user, either in front of the steer or in the middle of the frame.

- Not attached to the steering of the bike
When the luggage solution will be placed at the front of the bike it is better for the handling if it is not

attach to the steering parts of the bicycle. With a cargo rack or similar mounted to the steering of the bike the steering becomes heavier and more difficult to control. This would mean the design should be mounted to the frame.

**Styling**

- Should fit the Gazelle CityZen model family
In consultation with Gazelle it was chosen to design the luggage solution for the Gazelle CityZen model family. This model family is aimed at the commuter and is also a little sportier than most e-bike designs from Gazelle, which will best fit the chosen target group. This means not a complete new bike frame will be designed, but that the design will be based on the current Cityzen frame. The frame can be modified to fit the luggage solution.

- Integrated in the design of the bike
The luggage should fit the design of the rest of the bike. Instead of having a generic cargo solution mounted on the bike, the luggage solution should integrate into the design of the bike. This design integration can be done in multiple ways: By form language, graphics and shape continuation or integration. With all three methods it should be very clear that the designed luggage solution does belong to the CityZen model family and not to any other bike.

- Modern / unique design
The design of the luggage solution and the complete bike should have a modern and unique look. This means the bike should look contemporary and should have a distinct design. As the bike will be placed in and be based on the CityZen model family it will have a form language in line with the CityZen model family., which does have a modern and little sporty design.

**Cost price**

- Cost price luggage solution: 40 euro
Since the bike will be offered in a lease construction the cost price is dependent on the lease price one can ask for a luggage solution. In consultation with the account manager of Gazelle it has been concluded that the lease price of the e-bike should just under 50 euro (for a 48-month lease period).
In order to make the luggage solution attractive to the user there should only be a small lease premium. When leasing the luggage solution for the complete leasing period we think a price premium of 2,50 per month will be the maximum people want to pay. This means the total lease income for the luggage solution is 120 euro in 48 months. This means the cost price for the luggage solution can be around 40 euro, also taking possible replacements and repairs into account.
It is also an option to offer the luggage solution as an accessory you can change during the leasing period. In this scenario the user can change his choice of accessory every half year for example. In this case we think a lease premium of 5 euro would be a good price. In this scenario it should be possible to lease the accessory to a second customer after the first leasing period.
Another thing to think of is the possibility to buy the e-bike and the luggage solution after the leasing period.

To summarize, the intended lease price should be:
- 2,50 euro per month (48 months fixed)
- 5 euro per month per accessory (with the possibility to change every half year)

**Design criteria Lease bike**

The design will focus on the luggage solution and will be based on the existing CityZen model family. This means no complete new frame family will be designed, but the next generation CityZen will be taken as a basis for the design. It is however possible to adjust the frame if needed for the luggage solution and in order to make it suitable for a leasing construction. For this reason also a list of design criteria for the complete lease bike have been formulated. In these design criteria maintenance plays an important role, as a lease bike should be reliable and maintenance free.

- Possibility to add a child seat
As the design is aimed at 'young family (wo)men' it should be possible to attach at least one child seat. This means that either at the steering bar or at the rear it should be possible to add existing child seats.

- Part of the CityZen model family
The lease bike will be part of the CityZen model family. This means the styling will built on the CityZen model line and the bike will be based on the next generation CityZen.

**Components**

- Parts from Gazelle's preferred suppliers
The technical part for the bike will be sources from Gazelle's preferred suppliers. As Gazelle does have long-standing contacts and appointments with suppliers the parts for the new bike will be sourced from these suppliers. This significantly influences the choices in technical components and makes choosing drive train components quite straightforward.

- Parts with low failure rates
For a leasing bike it is important to choose components with low failure rates. Especially for wearing parts like tyres and brake sit is important to select good performing parts. Here a consideration between price and expected durability needs to be made. This component choice will need to be based on experience.

- Parts which need little maintenance
In order to make the lease bike a successful proposition, parts which need little maintenance need to be selected. As the lease bike will be driven a lot the maintenance intervals need to be as big as possible. The proposed maintenance interval is 5.000 km, which would mean the bike needs maintenance twice a year when driven daily for 20 Km (20 * 2 * 5 * 50 = 10.000 Km per year). For many users this will be about once a year since most users will not use the lease bike every day and/or for a commute of 20 Km.

**Styling**

- Technical parts should integrated as much as possible
In the design of the lease bike the technical parts should be integrated as much as possible. This means it should not be too visible that the bike is an e-bike and the design should be clean without too much parts looking like bolted on afterwards.

- Unique / modern design
The lease bike should have a distinctive contemporary design. It should be clearly recognisable and stand out from the other gazelle e-bikes. This way it will differentiate itself clearly as a lease bike for commuters.

**Cost price**

- Cost price lease bike: 1.900 euro (with battery)

Based on the existing lease bikes Gazelle is offering the cost price for a lease e-bike has been calculated. Together with Gazelle it has been concluded that 50 euro would be a monthly price people will want to pay for a lease bike. With a 48 month lease period this gives a total lease income of 2.400 euro. Based on the price built up of the currently offered lease e-bike the cost price after production has been calculated. This is the price of the bike after assemblage in Dieren and with the battery included. This cost price needs to be 1.900 euro to come to a 50 euro monthly payment for a 48 month lease period. Currently the 'gold' (400 W) and 'platina' (500 Wh) have a cost price of 549 and 749 euro respectively. Expecting a small price drop in the battery price the coming years the cost price for the e-bike will be 1.400 euro. This would mean that the base lease model comes with the gold battery and that for a small extra lease fee the platinum battery can be chosen.

# Design brief

**Design direction**

- Design domain: Worry-free modern commuting
- Target group: Young family (wo)men
- Retail strategy: Lease construction
- Design focus: Bringing a laptop bag
- Bicycle type: normal e-bike
- Gazelle model family: CityZen

**Design criteria Luggage solution**

- Room for a 15,6-inch laptop bag (42 x 31 x 15 cm)
- Weight laptop bag: 4-7 Kg
- Secure attachment
- Shock absorption
- Weather-proof (rain)
- Easy to clean / easy to keep clean

**Design wishes**
- Luggage visible during cycling
- Not attached to the steering of the bike

**Styling**
- Should fit the Gazelle CityZen model family
- Integrated in the design of the bike
- Modern / unique design

**Cost price**
- Cost price luggage solution: 40 euro

**Design criteria Lease bike**

- Possibility to add a child seat
- Part of the CityZen model family

**Components**
- Parts from Gazelle's preferred suppliers
- Parts with low failure rates
- Parts which need little maintenance

**Styling**
- Technical parts should integrated as much as possible
- Unique / modern design

**Cost price**
- Cost price lease bike: 1.900 euro (with battery)

# Idea generation

Based on the design brief the idea generation phase was started. In the first phase of this idea generation the solution space was still quite broad and during sketching and idea generation more design choices were made.
At the start of the idea generation also a brainstorm session at Gazelle was held in order to gather input for the idea generation phase. A brief overview of this session is presented in appendix 1.

## Design choices

While sketching and developing ideas it became clear some more design choices need to be made. Mainly the bag's position on the bike and the choice if the design would need to be a rack carrying existing bags or a Gazelle bag. These two decisions have been made in order to give more direction to the idea development. In order to make this decision additional user research was done in Arnhem, asking commuters and bicycle dealers their preference. Also the bags position was studied in Photoshop.

Although the project has been focussed on a luggage solution also some design choices for the lease bike have been made. In consultation with Gazelle the main components for the to develop lease bike have been chosen. On the next pages the design choices for both the lease bike components and the luggage solution will be presented.

# Design choices - Lease bike

Before starting the design of the luggage solution some attention will be given to the design choices for the complete lease bike.
The lease bike will be based on an existing model family and no completely new frame will be developed. However, some component choices will need to be made in order to make the bike better suitable for a lease construction. Later in the design process also the frame design might be changed slightly in order to integrate the design solution for the luggage problem. The choice to base the design on an existing Gazelle model family also implies that technical parts will be sourced from the same suppliers as they are now. This means for example that the e-bike technology will be sourced from Bosch. At this point only drive-train components and the brakes will be specified.

Components choices:
- Motor: Mid-drive Bosch
- Battery: Bosch (power-tube)
- Electronics: Bosch
- Gearing: Shimano or Nuvinci internal hub
- Power transmission: Continental belt-drive
- Brakes: Roller-brakes Shimano

**E-bike system**
As Bosch is now preferred supplier of the mid-motor e-bikes for Gazelle they will also be the supplier for the motor and battery on the new lease bike. This means the motor will be a mid-drive motor from Bosch and also the battery will be bought here. For next season Bosch is also introducing a new battery shape, which will be used on the CityZen as well. Probably the lease bike will also use this Bosch motor and battery technology.

**Gearing and transmission**
The gearing will be a Shimano or Nuvinci internal hub. These require less maintenance than an open derailleur type gearing. Also it does not wear down as quickly and is well protected against weather. The choice for the exact hub is a matter of price. The Nuvinci hubs are more expensive, but offer a continuously variable gearing. In the future the Nuvinci system might come down in price or they might introduce new more affordable models.
The power transmission from crank to rear hub will be done using a belt-drive from Continental. A belt-drive requires practically no maintenance and also does not need to be greased and thus dirty in order to work. The belt-drive will be sourced from Continental as PON already has good contacts with Continental and also the existing belt-drives in Gazelle are coming from Continental.

**Brakes**
The brakes will be roller brakes from Shimano. Another option would be disc brakes but they require more maintenance and wear down quicker. Shimano has specifically developed roller brakes that can be used for e-bikes.

*Belt drive and Shimano hub and brakes on a non-electric CityZen*

# Design choices - Luggage solution

**Design choices luggage solution**

During the design of the luggage solution some design choices needed to be made. In consultation with Gazelle and based on existing and new user research these design choices have been made. The two main choices which have been made are the luggage position and the choice to make a solution for existing bags.

**Luggage position**

The luggage solution can be placed at different positions on the bike. Basically there are three options: At the rear, in the middle of the frame and at the front. First all three positions will shortly be described and then an overview with score chart will be presented.

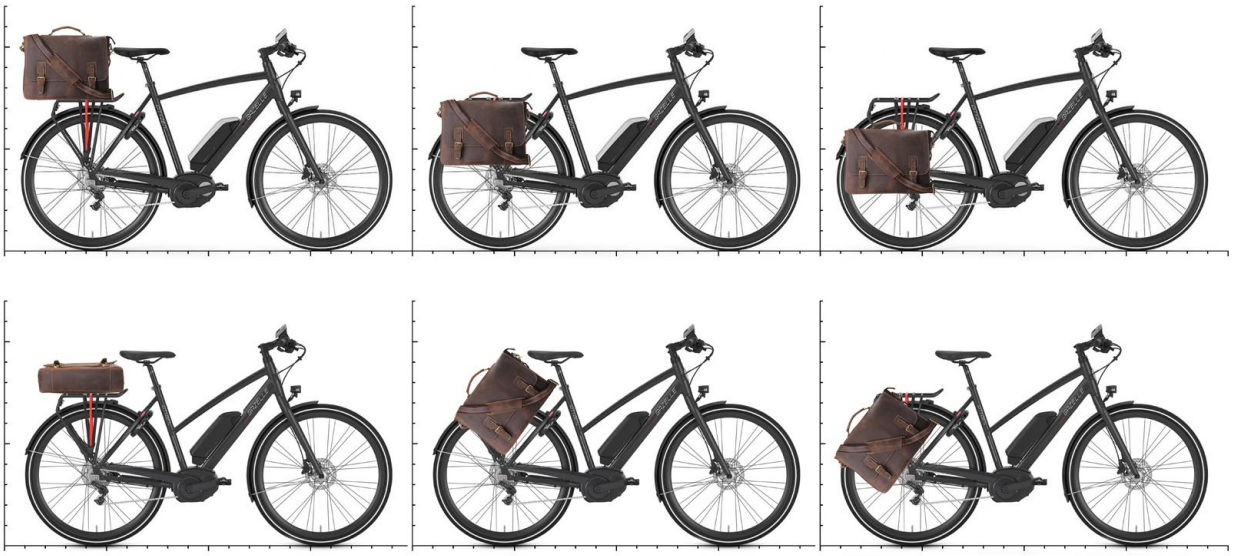
*Front positions*

**Front**
With the luggage placed at the front it will be visible during cycling. This way the user can make sure it does not fall off or gets stolen. When placed at the front the choice to mount the luggage solution to the steering parts or to the frame will need to be made. From a bicycle handling the attachment to the frame is better but when the front rack or mount is not moving with the steering this can feel strange to the user.
An argument against a front mounted solution is that people want to be able to see the front wheel moving when cycling. Also the most common front-mounted solution of a crate on a front rack creates problems in bicycle parkings. Also the image of a front mounted solution can be perceived old-fashioneble, as it is associated with old bicycle baskets.
In the picture above it can be seen that the bag can be rotated in multiple ways. It can either be transported standing right up or laying on one of its sides.

**Frame**
Because of the defined width the laptop bag will not fit in between the frame. The maximum width of which will comfortably fit in the frame is about 15 centimetres, which is the same as the defined 15 centimetres for the laptop bag. This means it will also be impossible to fit the bag here in a realistic way as

*Frame positions*

to make the frame strong enough it will have to run around the bag.
Also in length and height is will be nearly impossible to fit a laptop bag inside the frame. This was studied using the Photoshop file, displayed above, with the right scaling for both the bike and bag.



*Rear positions*

**Rear**
The typical position to put luggage. Not visible during cycling and therefore perceived less save in relation to bags falling off or being stolen. The space in the length is limited because of the space needed to make the cycling movement.
Also when putting the bag in the middle of the rear carrier the height will be quite high, and for many people it will be impossible to get on the bike by swinging their leg over the back of the bike.

**Conclusion**
As it is clear the frame position will not accommodate the width and height of the laptop bag this option had been discarded. This means the laptop bag will either be positioned at the front or at the rear of the bike.

**Existing versus Gazelle bag**

Another important design choice is to design a solution to carry existing bags or to design a Gazelle branded bag. Both directions can be implemented for the front, frame and rear of the bike.

Existing bags
When designing a solution to bring existing bags a solution to attach or mount an existing office bag to the bike will be designed. This way the user does have the choice in which bag he wants to carry. This solution should be designed in a way that it fits all kind of laptop bags.

Gazelle laptop bag
The alternative would be to design a bag branded as a Gazelle bag and sold together with the bike. In this scenario Gazelle would probably cooperate with a bag manufacturer in order to produce the bags.

*Bicycle bags at dealers*

**Additional user research**

In order to make this choice more user research was needed. This was done on Thursday 6th in Arnhem. Six bicycle shops were visited and about ten people were asked at the station bicycle parking about their opinion on the topic.

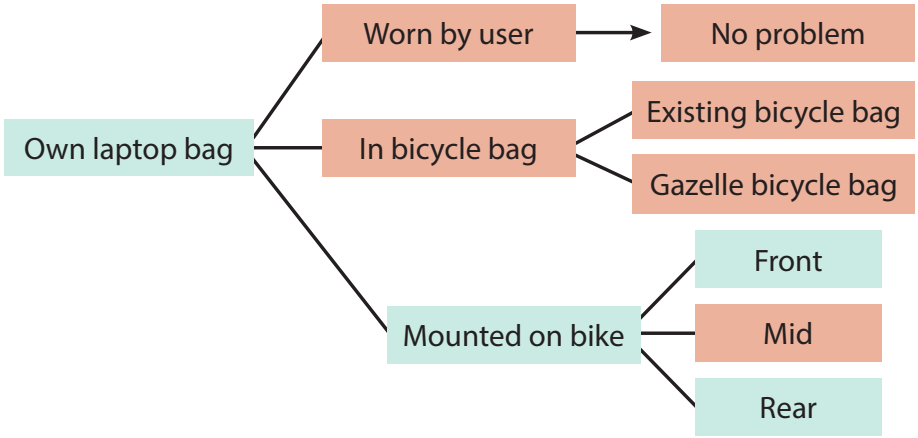
From this small user research and from observation, it can be concluded that nowadays most people do bring their laptop bag either by carrying it themselves with a shoulder strap or by putting it in Bicycle bags at the rear of the bike. The research took place in Arnhem city centre, so probably the longer distance commuters were not included.

When asked, people did not have a clear preference for a Gazelle bag or their own bag. Even though most users did already have an office bag about half of them would consider to buy or lease a Gazelle bag with a new bike. The price and design needs to be good in order to make it attractive though. Also people do want to have a choice when shopping for a bag. So, probably multiple design should be available to convince people to buy a Gazelle bag.

The bicycle dealers were also divided about a Gazelle branded bag. Some thought there is already too many brands active on the bicycle bag market and that it would be impossible for Gazelle to compete with those brands. They thought that a universal solution for existing bags would have more potential than a Gazelle bag. On the other hand, there were also dealers who thought selling Gazelle bags with the bikes would have potential as many people do buy a bag together with a new bike.

**Conclusion**

Although the research showed various opinions on the topic it has been decided to make a luggage solution for existing bags. The argument of the user having more freedom of choice and the strong competition in the bicycle bag market were considered more important than the benefits of a Gazelle bag.
The luggage solution needs to be designed for existing laptop bags, and should be able to fit a standard sized 15,6-inch laptop bag.




*Overview design choices*

**Design choices**

In the figure above the design choices are shown. It has been decided to design a solution for the users own laptop bag which is mounted on the bike at either the front or rear position.

# Design research - Stability

In the design choices the position of the luggage solution is still left open, so for both the front and the rear position concepts will be developed. In the concept development it was investigated how the position of the bag will have an influence on the stability of the bike.

**Expert**

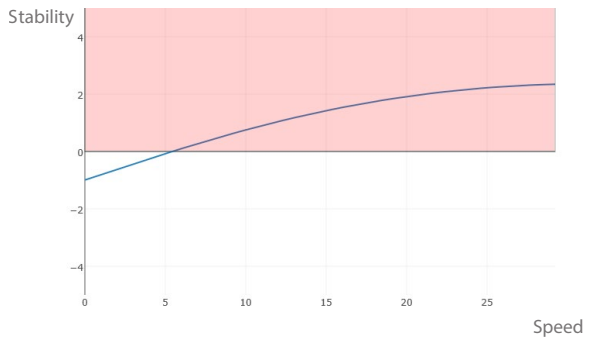
On April 24th bicycle dynamics expert Arent Schwab (3ME TU Delft) was asked for his opinion on this subject. He confirmed that adding weight to the front fork is risky for the handling of the bike. In order to make this work caster and rake need to be changed. Adding weight at the front attached to the frame of the bike will influence the bike's handling a little bit, but might also be beneficial. It might also have a positive influence on the tire wear of the rear tire. Adding weight to the rear of the bike will probably have the smallest influence on the stability of the bike.

**Wobble tool**

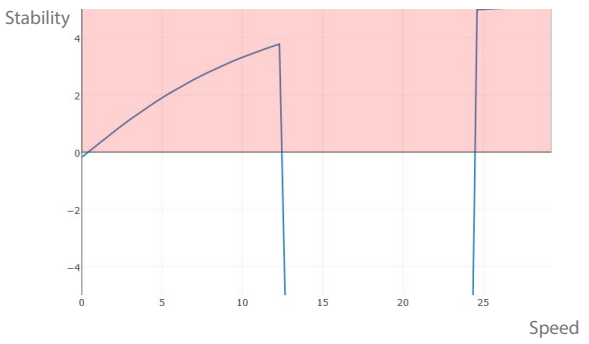
In cooperation with 3ME at TU Delft Gazelle and other bicycle brands are developing a simulation tool to simulate the stability of a bike. This instability is called "wobble" and therefore the tool has been named the "wobble tool". The tool is still in development, but for the project it was possible to already use it.
In the tool the final simulation plots the stability against the velocity. Everything under zero means the bike is stable and above zero (the red area means the bike is unstable.
With the tool it was only possible to model a predefined bike, which was specially selected for the tool because it showed unstable behaviour. By adding the luggage to the rear of the bike the stability did change a little bit, but not much. However the tool did not work correctly when placing the luggage load at the front, as this did result in strange simulation results. Also must be taken into account that the bike model used is not the CityZen but another already unstable bike. For this reason the results only have limited value for the project.

**Conclusion**

From a stability perspective it is difficult to predict the influence of the position of the luggage system. The placement at the rear will have a limited effect on stability and placement at the front, attached to the frame, will probably have a bigger influence, but still within acceptable limits.




*Original bike in wobble tool*




*Strange results wobble tool*

# Design research - Vibration damping

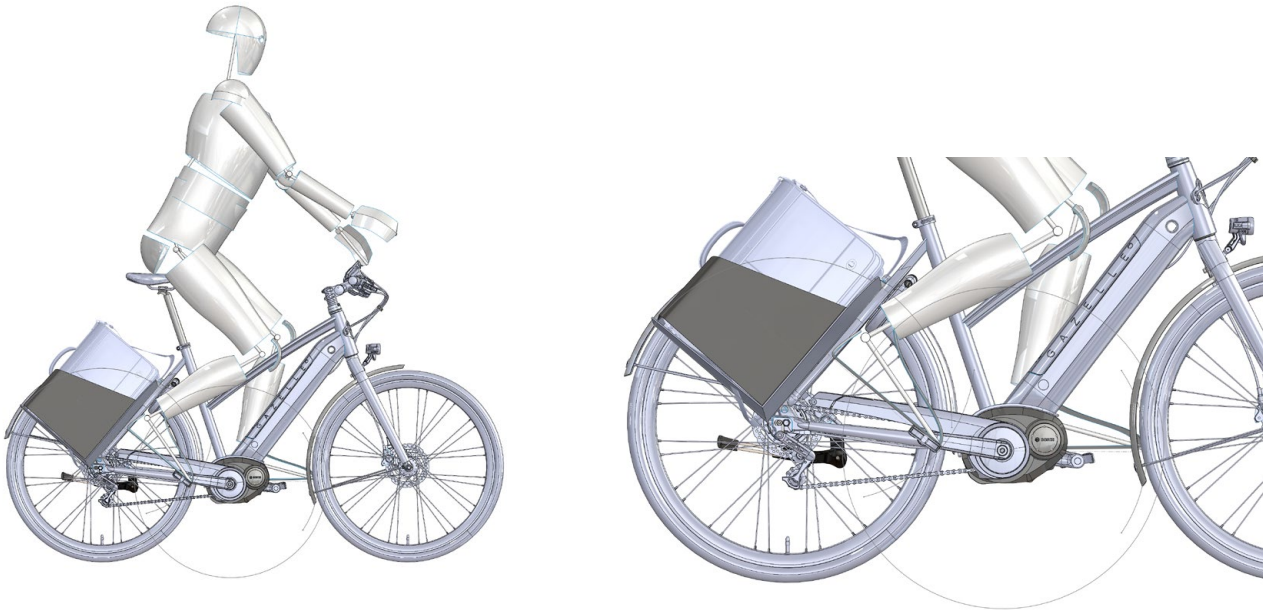
Vibration can be dangerous for laptops and other electronic devices. Therefore a solution with build in vibration damping is desirable. Most laptop bags do have some cushioning, and in this way already damp part of the vibrations, but built in damping could add more protection to the user's devices and could be a unique selling point.

There are multiple ways to integrate the shock absorption.
The most obvious way would be by a shock absorbing layer at the contact area with the bag. This would probably be a synthetic rubber (elastane) to make it both shock absorbent and weather proof.

Different ways of shock absorption:
- Shock absorption in laptop bag
- Shock absorption in frame mount.
- Shock absorption on contact area.
- Shock absorption in bag mounting. (Suspended mounting)

# Design research - Pedalling clearance

To check pedalling clearance a P95 mannequin was put on the bike. It becomes clear that the 700 mm diameter which is considered a safe clearance is on the low side. As the concepts were all built in 3D they were all checked to clear the pedalling P95 mannequin.

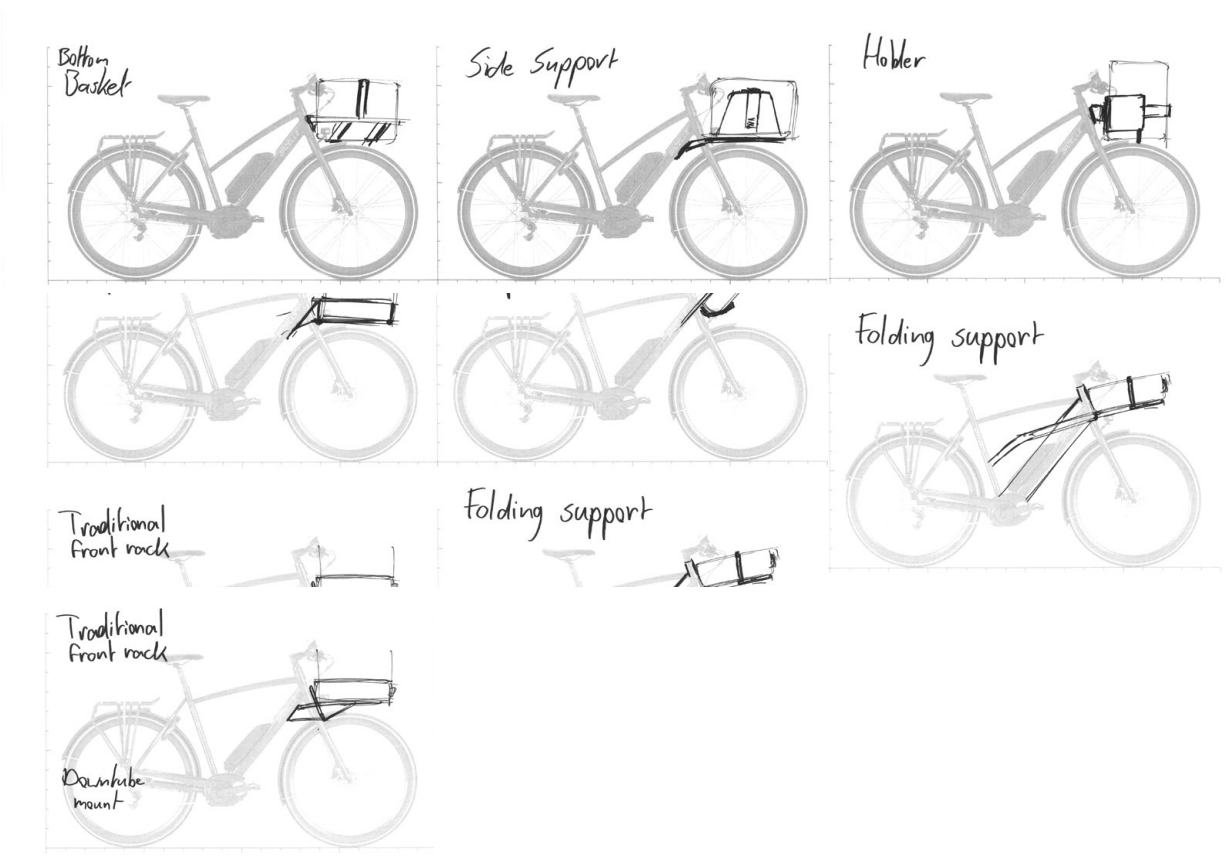


*Pedalling clearance withP95 mannequin*

# Concept ideas

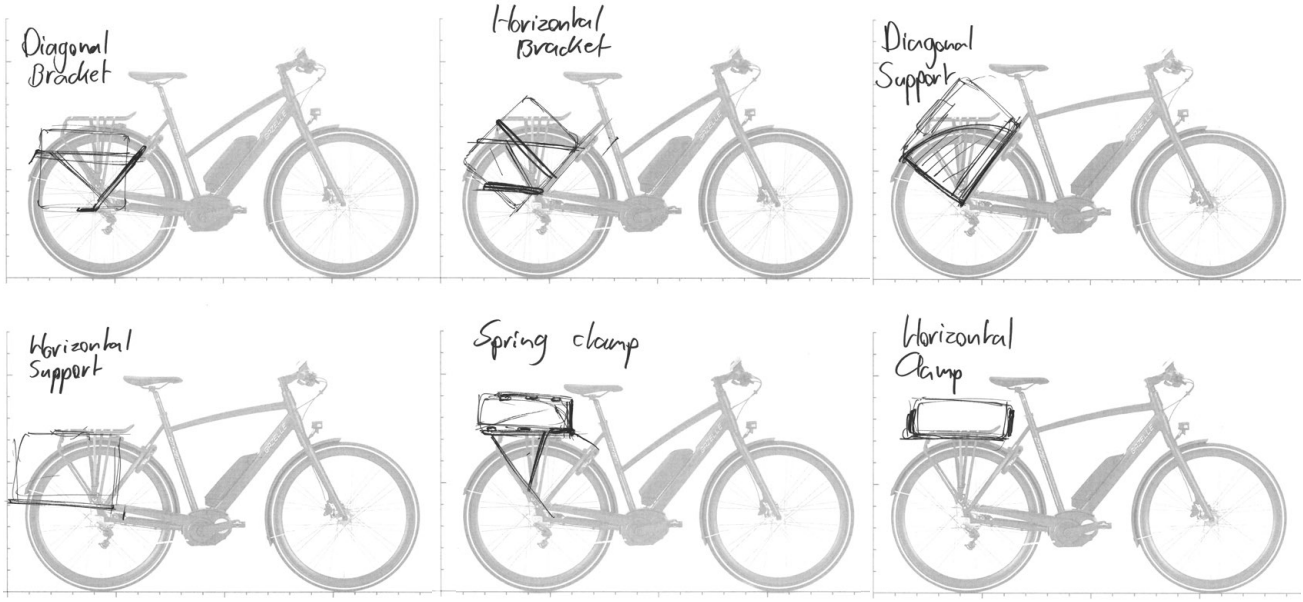
The ideas generated in the ideation phase have been worked out into thirteen concept ideas. These concept ideas are still on a conceptual level and only first ideas about materials use and production methods are thought out. In relation to the cost price an estimation of the relative costs will be given based on the complexity and material use of the concept idea.

# Front concepts



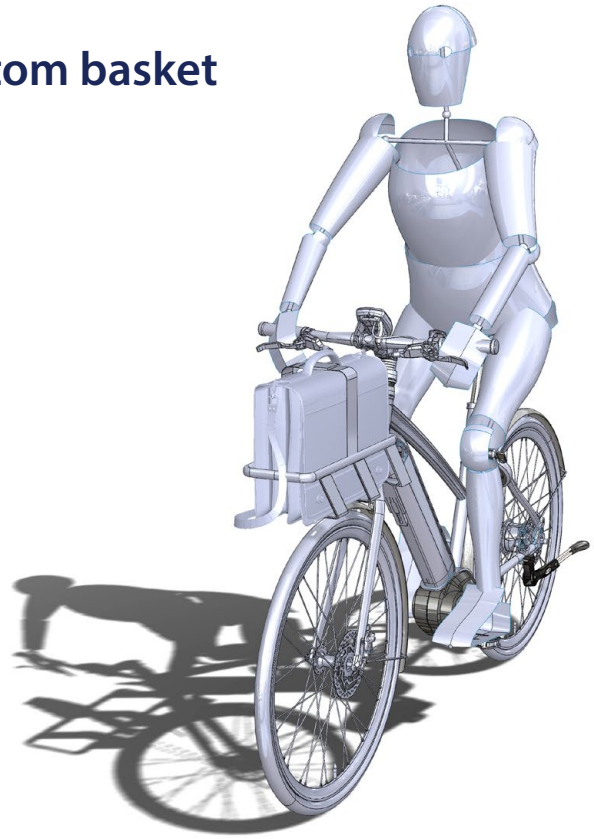

For the front position seven concepts have been developed. All concepts are mounted to the frame of the bike an not to the steering components as described earlier in design choices.
As can already be seen in the overview above the bag has been placed in various orientations and different was for mounting the bag have been developed. Many of the front concepts will be connected to the frame via a mounting system at the front of the frame. For this mount various ideas have been generated, which could be used on multiple concepts.

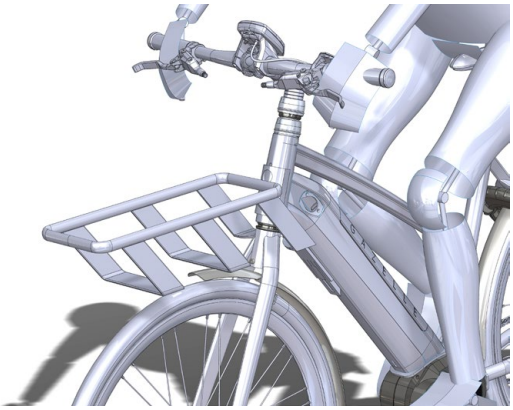
## Rear concepts




For the rear position six concepts have been developed.
Like with the front concepts different positions and bag orientations have been tried. In some concepts also ideas for the shock absorption have been implemented.

# Bottom basket

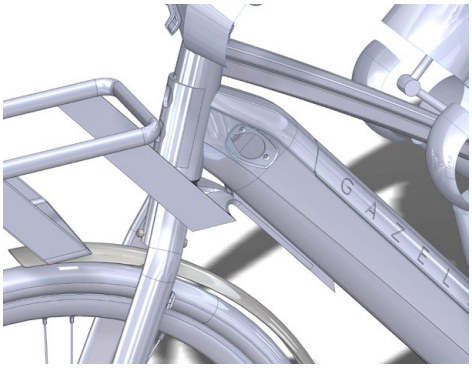




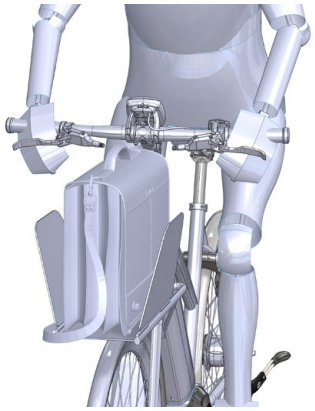
In this concept the bag is placed in a minimalistic front basket. This basket will be mounted to the frame of the bike at the down tube.
The basket will be made of aluminium or steel and will include rubber dampers at the horizontal support faces. The bag will be secured with an elastic band over the top of the bag.

This concept will mainly be made from aluminium. Main production processes are forging and welding the tubular and other parts. In order to make the concept feasible careful attention must be paid to the stresses in the structure of the basket. Because t does stick out quite far in front of its mounting point it might be necessary to include an extra support tube at the bottom.

The cost price of this concept will be comparable to a normal front rack, as the concept is made  from the same material and has the same kind of shape. Because of the extra support it offers and the integrated elastic mounting strap it will be a little more expensive than a traditional front rack.



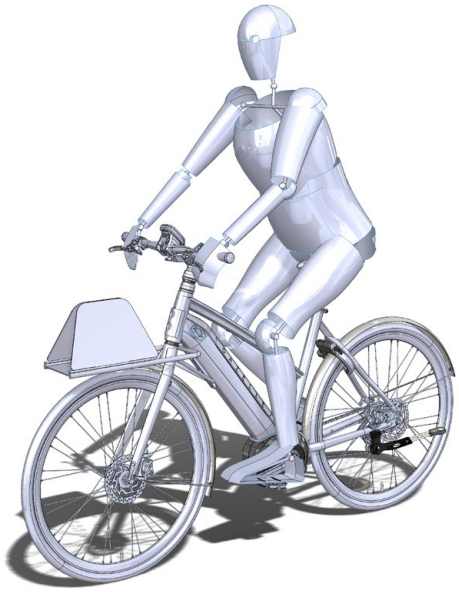

# Side support



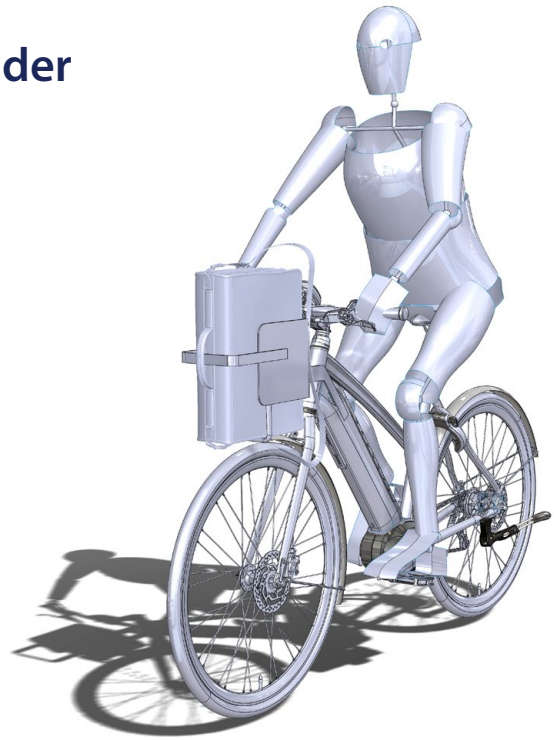
In this concept the bag is placed in between two rigid side supports. These are mounted to the baseplate with hinges so they can rotate inwards. This way the sides will hold the bag in place.
The sides are fixed around the bag using a elastane strip which wraps around the bag.
The baseplate will be made from a steel frame combined with elastane dampers at the bottom. The sides will be made from plastic.
The whole thing will be mounted to the frame under the down tube.

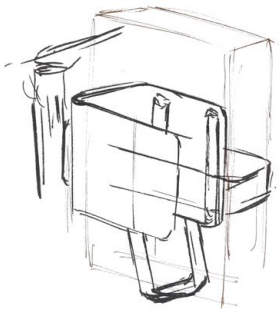
The base of this concept is a metal support, much like a smaller front rack. As it has been drawn it will probably have to be made from steel in order to allow the small cross sections. To make this frame the frame profiles will need to be forged and welded in the right shape. The supports plates on the sides will be made from a plastic and will be injection moulded or thermoformed.

The cost price for this concept will be a bit higher than the first concept because of the added hinges to make the sides hinge around the bag. This adds complexity to the design and results in a higher cost price.



# Holder



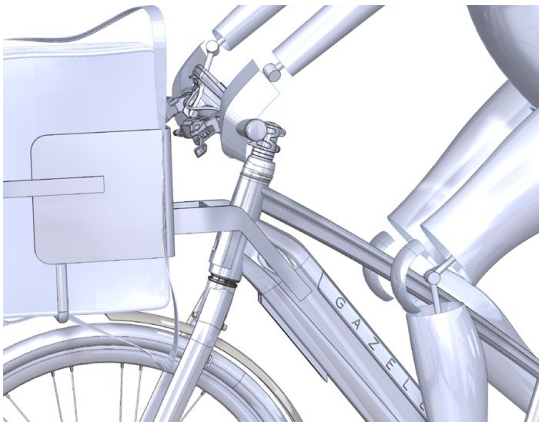


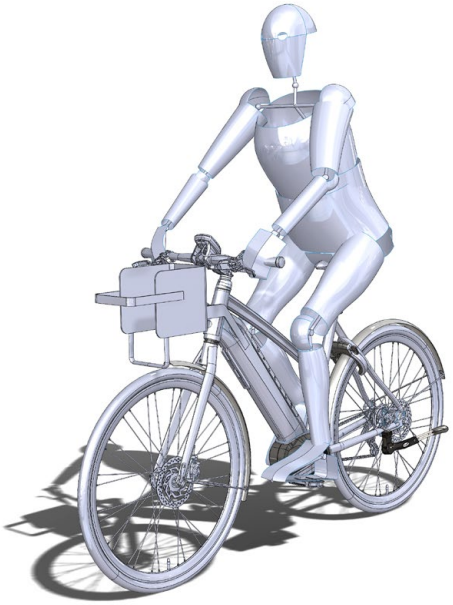
In this concept the bag is hold in a vertical U-shape with a bottom support to carry the bag. The bag will be rotated 90 degrees compared to its normal orientation. At the front an elastic strap will be used to secure the bag in place.
The design will be mounted to the steering tube of the bike.

In this concept the bag is positioned such that it sticks out above the steering bar. This means the whole Holder will need to be moved forward in order to give enough steering clearance. It needs to be seen how much this is really necessary.

This concept will be made from aluminium mainly Both the attachment to the frame as the U-shape holding the bag will be made from this material. The frame will need to be welded to the U-shape, which can be forged out of aluminium sheet. Only the elastic strap holding the bag in place will be made from a different material, most likely elastane or nylon.

The cost price of this concept will be slightly above average as it features quite a lot of aluminium parts. Apart from the mounting strap it does not include moving parts though, so that keeps the costs down.



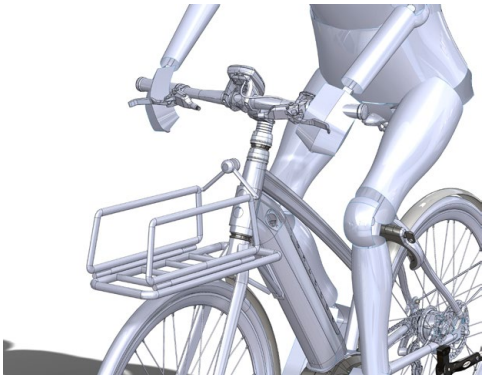



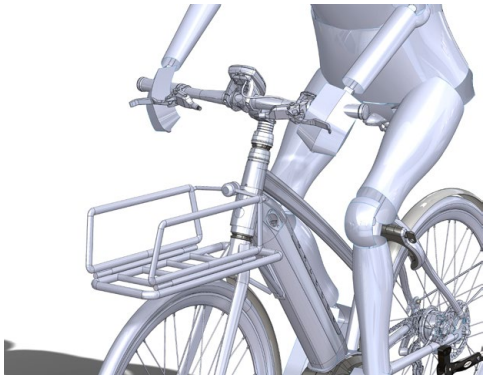
# Bottom clamp

The bottom clamp is a spring loaded bottom bracket for the bag. This way no elastic strap or other solution is needed to mount the bag. In order to place the bag in the clamp a simple mechanism is added in order to press it open.
The carrier will be mounted to the bottom tube.

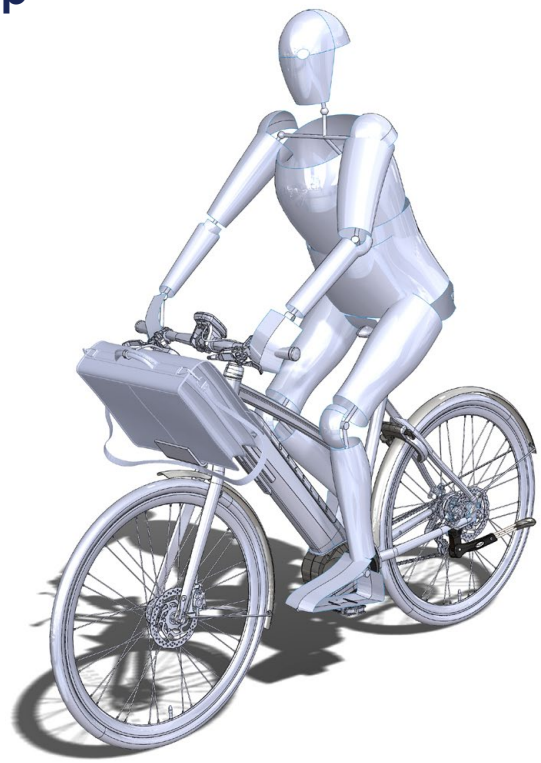
This concept is entirely made from metal parts, probably from steel to keep costs down. These will need to forged and welded together in the right shape. Also the clamp like structure holding the bag will be made of steel and will include springs in order to really hold the bag firmly

The price of this concept is a higher than average because of the spring clamp mechanism. This will add considerably to the cost price of the concept.





# Hook clamp

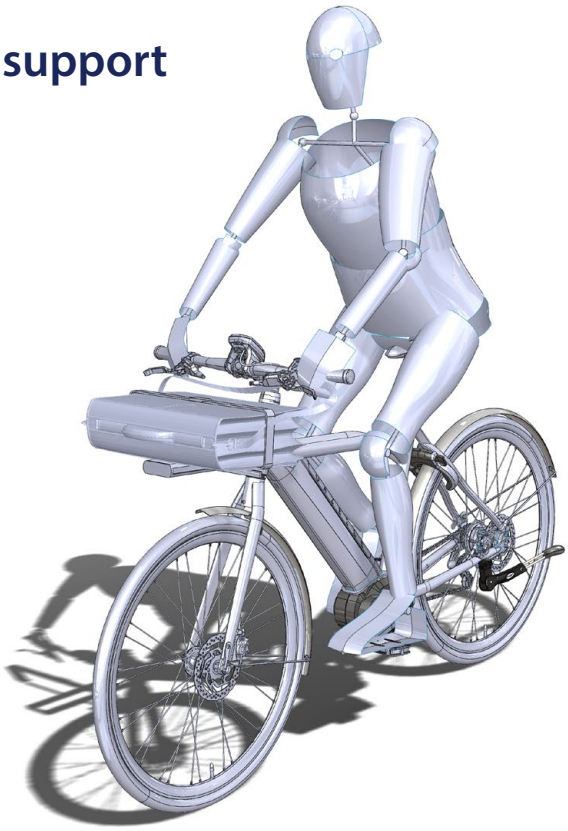


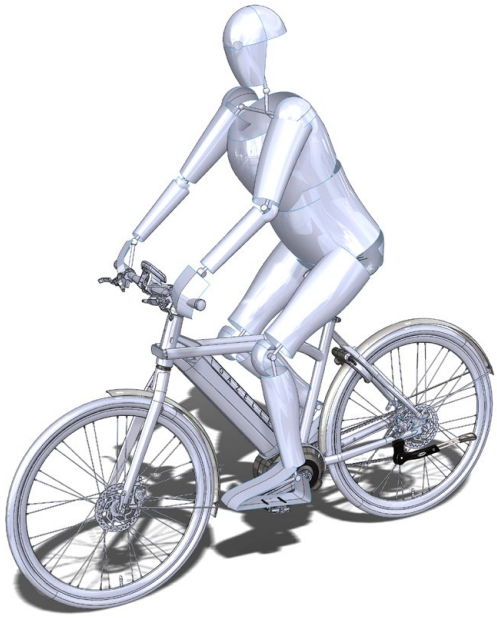
The ‘Hook clamp’ concept a rod with a hook is collapsed in the down tube. When pulled out a spring puts a force on the hook. This way the bag is pulled against the front of the bike. At the bottom of the steering tube a support is mounted against which the bag is pulled down.

This concept is made from aluminium which is spring loaded in a cavity in the frame. Also the support surface under the bag will be made from aluminium. For this concept the bike's frame will need to be changed in order to fit the sliding aluminium profiles.

Because the frame would need to be adjusted and because of the spring mechanism this concept will be quite expensive.

# Folding support

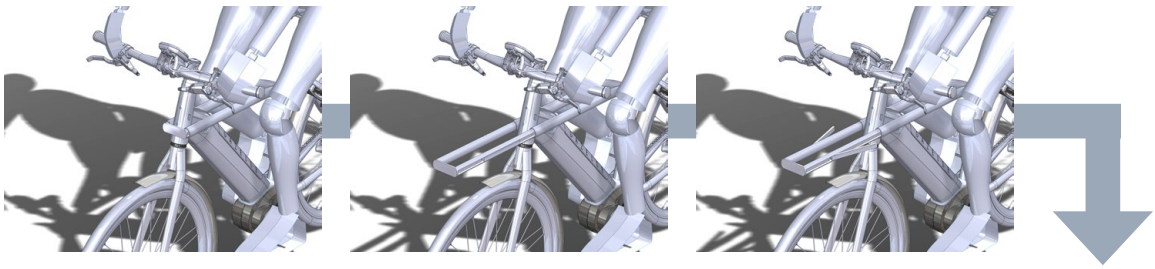


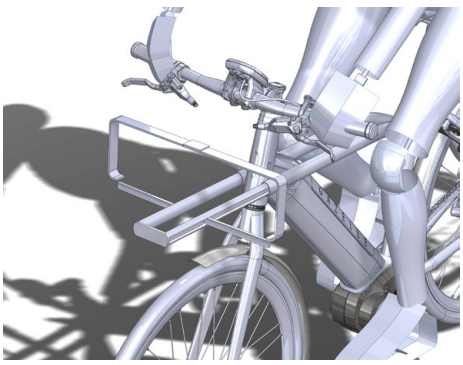


This is another retractable concept. In this concept the CityZen frame will need to be modified further in order to be able to fold out the supports in a horizontal or close to horizontal direction.
When deployed two more metal rods fold out where the elastic cords are attached to. These wrap around the bag and hold it in a secure position.

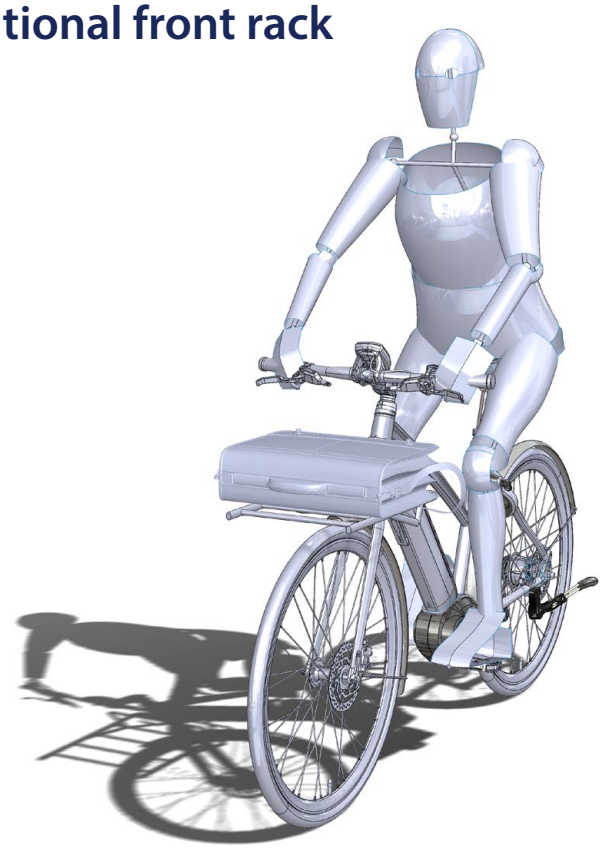
The folding tubes in this concepts will be made from aluminium. The used aluminium extrusions will need to be custom made in order to exactly fit in the sliding mechanism. To make this mechanism work the frame will need to be adjusted considerably. It basically is more of a new frame variant.

The cost price of this concept will be quite high. This has to do with the necessary adjustments to the frame and the sliding and folding mechanism.





# Traditional front rack

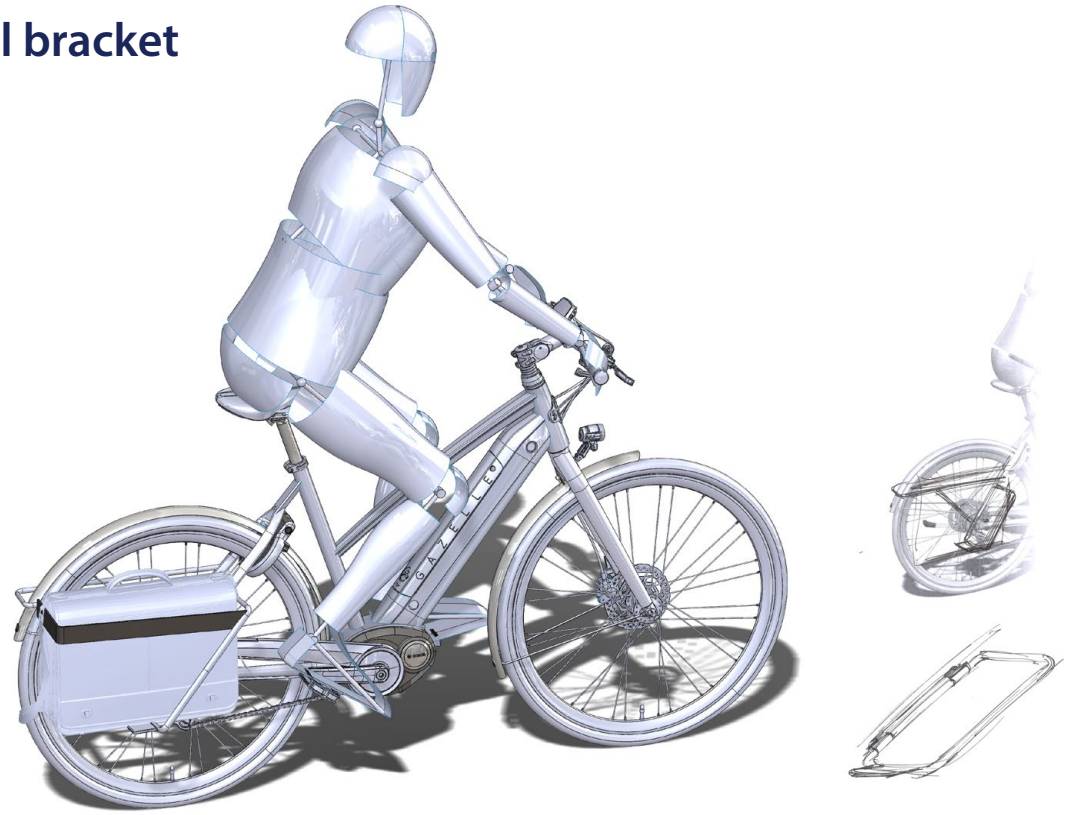


In this concept the laptop bag will be placed on its side and than secured using a standard bicycle elastic or an integrated elastic strap. Placing the bag on its side means that shock absorption will need to be applied to a large area, as the bag is supported on a large area.
In this concept the bag will not conflict with the bicycle's steering.

This concept is basically the traditional front rack. It will be made using aluminium tubes, welded together. The mount under the frame tube will also be made from aluminium.

The cost price of this product will be quite low as it does not feature moving parts or any other parts except for the metal rack itself.

# Diagonal bracket

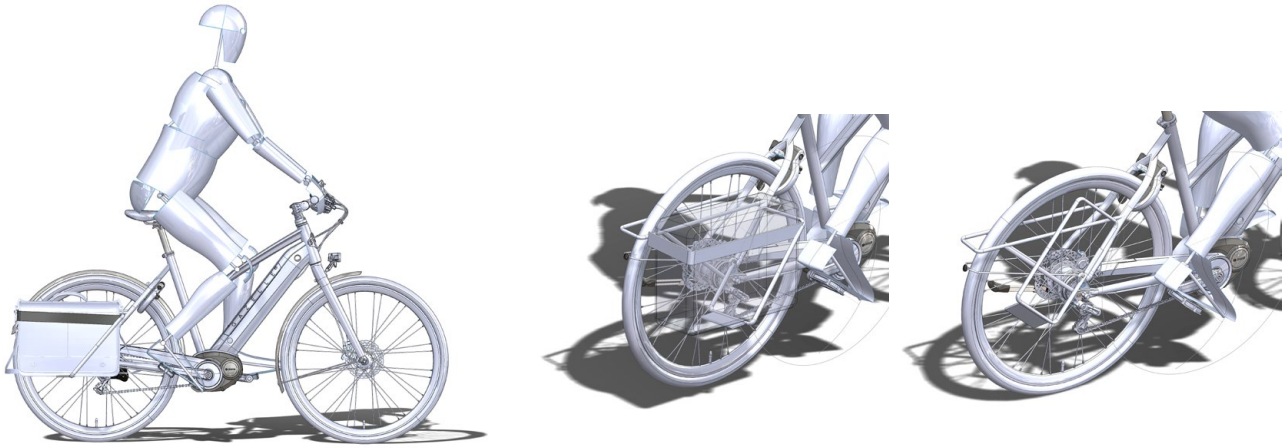


The bag is placed in a bracket which is placed diagonally next to the rear wheel.
In combination with a minimalistic rear carrier it will support the bag. In order to do is will use an elastic strap which will attach to the rear carrier.

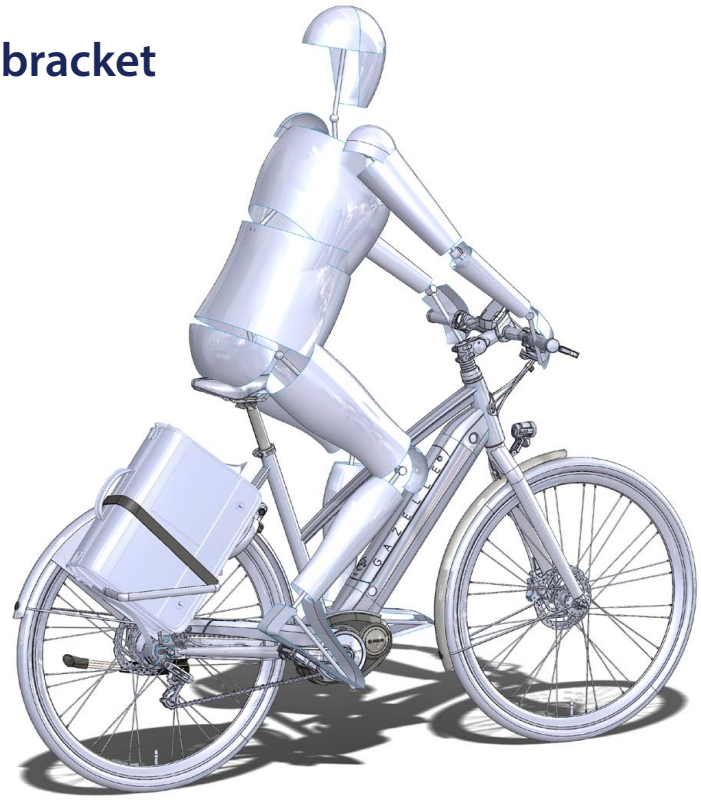
This concept does rely the rigidity of the bag.
Normally a laptop has some rigidity, but it needs to be checked to see if it really works. In order to support the laptop bag the bracket has a small horizontal support at the bottom. Because the bottom is only supported in the middle and the bag is further secured with the elastic band it needs to be tested how stable this is in reality.
The bracket can be folded up in order to make it less noticeable when not in use.

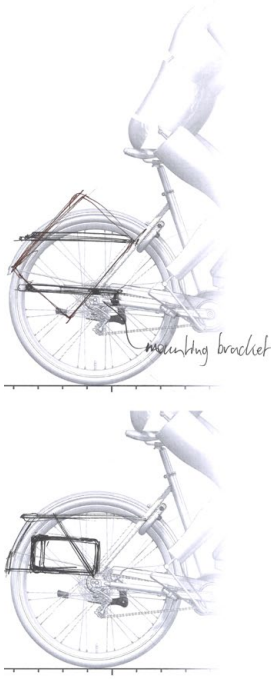
The material for this concept will be aluminium The frame will need to be forged and welded in the right shape. Also a hinge mechanism will need to be included in order to make the bracket foldable. Lastly also a elastic mounting strap will be added in order to secure the bag.

The cost price of this concept will be higher than average because of the complexity of the hinge mechanism.



# Horizontal bracket



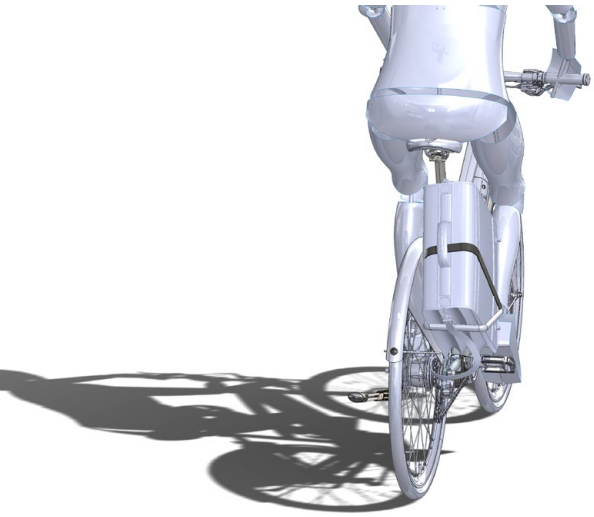


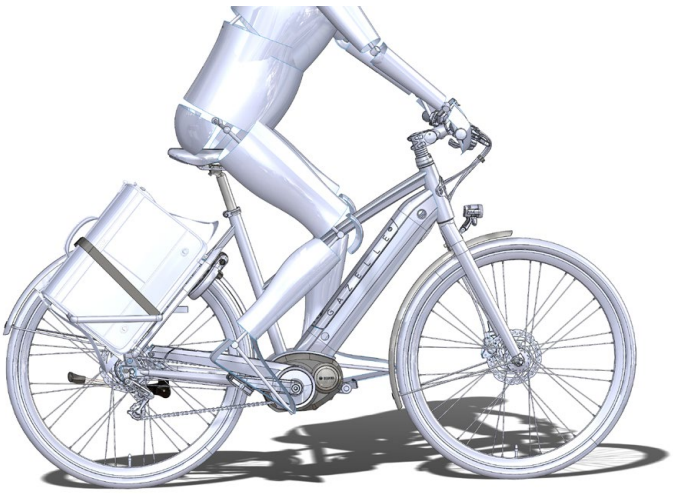

This concept is quite similar to the concept with a diagonal bracket.
It uses a horizontally mounted bracket in which the bag is placed diagonally. Same as in other concepts the bag is securely attached with an elastic strap, which connects to the top of the rear fender.

Also in this concept the bracket can be folded upwards in order to make it look more clean when not in use.

This concept is very similar to the diagonal bracket concept. The material for this concept will be aluminium, which will be forged and welded in the right shape. Also a hinge mechanism will need to be included in order to make the design foldable. Like in the diagonal bracket concept the bag will be secured using an elastic strap.

The cost price of this concept will be higher than average because of the complexity of the hinge mechanism.





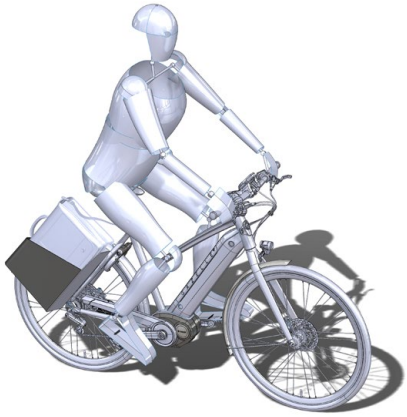
# Diagonal support

In this concept the bag is placed on a support integrated with the rear fender.  his will place the bag in a diagonal position, so it will not be in the way of the pedalling, but will also be placed close to the rider and centre of the bike.

It is still open how the support is constructed. It could be constructed from plastic or aluminium in one piece with the rear fender. Another option is to make a steel or aluminium frame which is mounted along the seat stay. In this variant a protection between the bag and rear wheel should be included.

This concept will be made from a plastic that will need to be moulded in the right shape. This will become quite a big part, so it must be investigated how to manufacture this in cost effective way. The bag is hold in place with an elastic fabric stretching around the bag. Probably also an aluminium or steel frame is needed in order to support the carrier.

The cost price of this concept depends a lot on the cost price of the big plastic support part. It will probably be a little higher than average.



# Horizontal support

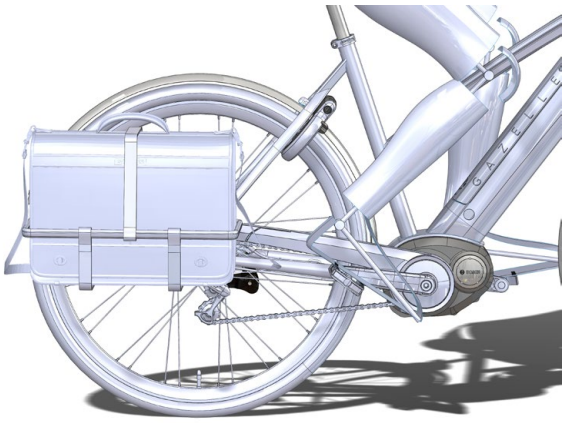


In this concept the bag is placed horizontal next to the rear wheel. Because of this position the concept is placed quite far backwards in order to allow enough room for pedalling. It is placed on a supported profile or in a basket.

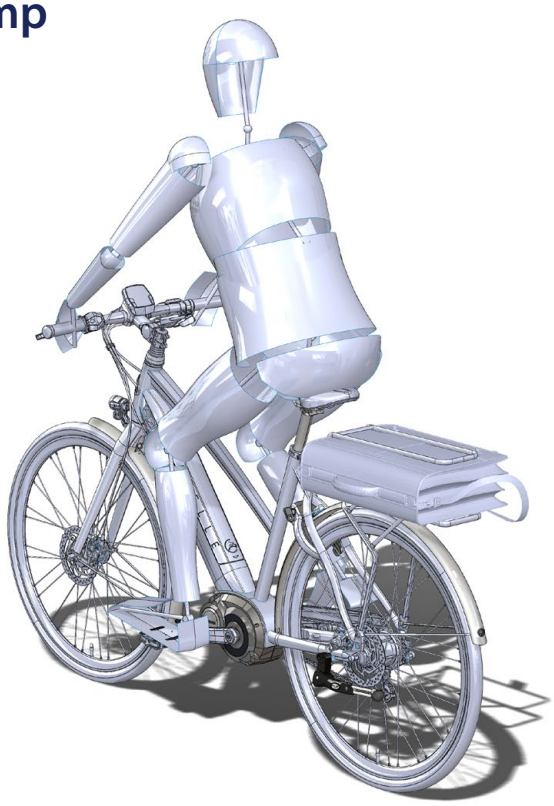
In the second iteration of this concept it was decided to include a form of shock absorption in the design of the basket. The basket is made up of a metal bracket with leather or synthetic rubber brackets to place the bag in.

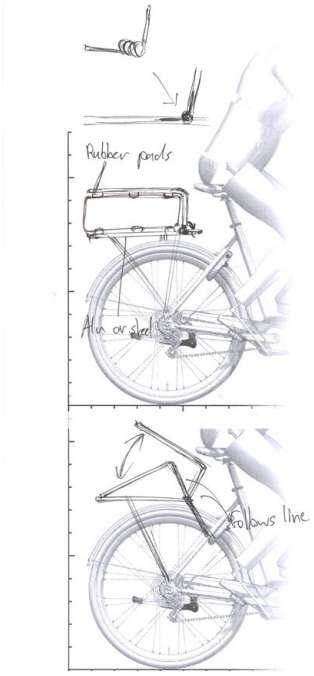
The material of the bracket in this concept will be aluminium. The leather straps where the bag is put in are made from (fake) leather in order to offer some shock absorbency. The strap to attach the bag will be made from the same material.

The cost price of this concept will be a little higher than average. Although it does not include difficult moving parts it does need the two leather straps to support the bag.




# Spring clamp

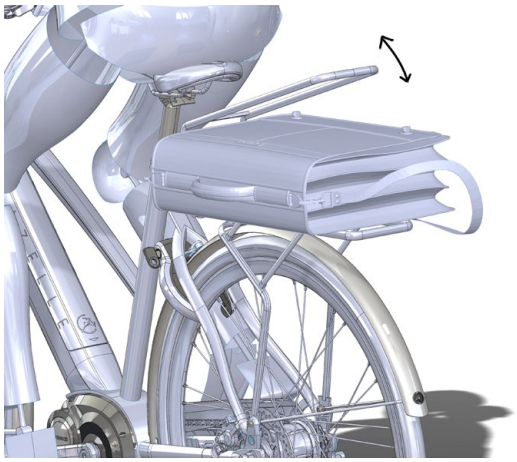





In this concept the bag is placed horizontally on the rear carrier. It is hold in place by a big clamp which presses down the bag by means of a spring in its hinge.
The rear carrier has a four bar mechanism included with a shock absorber to make the carrier shock free. This mechanism is mounted to the normal rear carrier attachment points and to the rear fender.

The main material for this concept will be aluminium. Only for the chock absorber a synthetic rubber will be used. The rest of the frame and actual clamp will be made from aluminium by forging and welding.

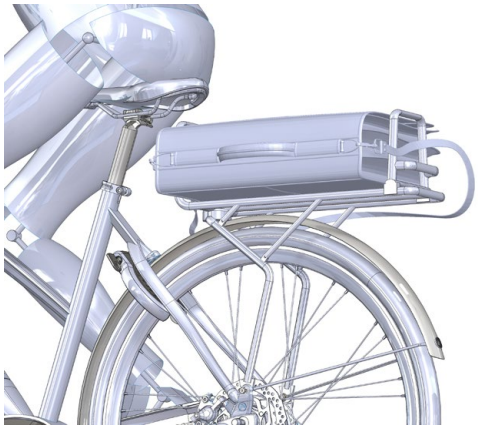
The price of this concept will be quite high because of the shock absorption system and the clamp mechanism.

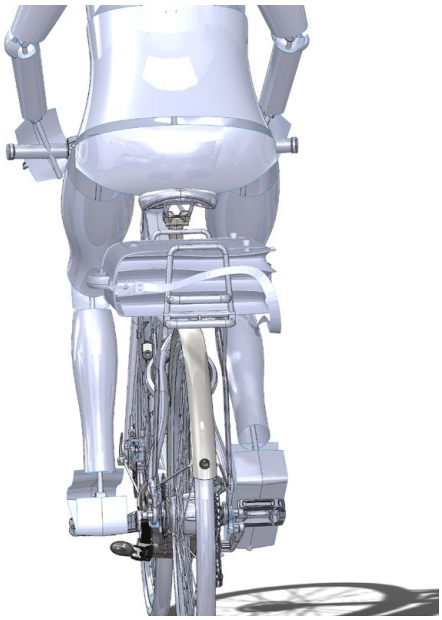


# Horizontal clamp


This concept features the same rear carrier as the other horizontally placed concept.
Here the bag is hold in place by a horizontally moving part, which is connected to a hidden horizontal spring. By pulling this holder back the user can place his bag inside and than fix it with the spring loaded rear support.

The frame and sliding mechanism for this concept will mainly be made from aluminium.
The price of this concept will be quite high because of the shock absorption system and the spring loaded sliding mechanism.

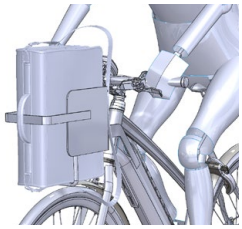


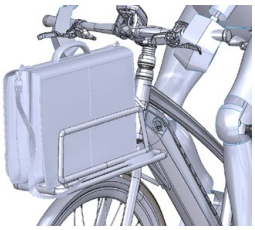


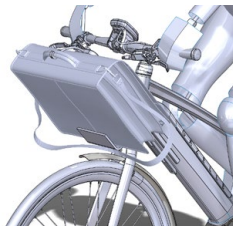
# Overview concepts

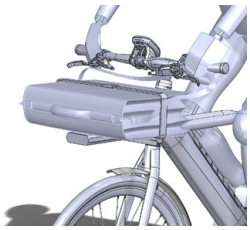

Bottom basket


Side support

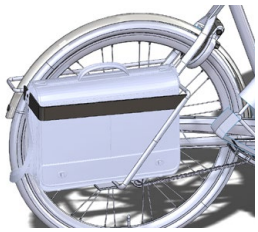

Holder


Bottom clamp

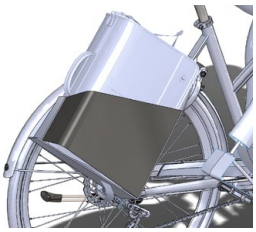

Hook clamp

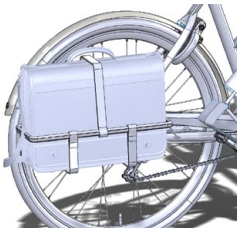

Folding support

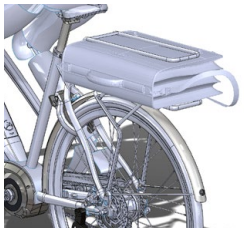

Traditional front rack

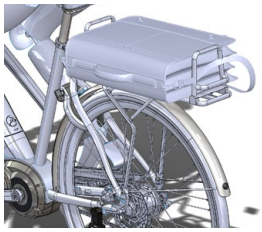

Diagonal bracket


Horizontal bracket


Diagonal support


Horizontal support


Spring clamp


Horizontal clamp

# Concept selection

In total 13 concept ideas have been developed. In order to make a choice from these concepts the concepts will be judged on five aspects. The concepts will be scored relative to each other. For this reason it was also chosen to score the concepts only good, average and worse on the different factors. The concepts will be evaluated on the following aspects:

**Position**
With this first term the position of the solution on the bike is judged. In some front concepts the CityZen would need to be adjusted in order to fit the concept or the concept would need to be moved forward. Also in terms of (perceived) aerodynamics and practicality some positions are more preferable than others. It is for example undesirable to have the concept stick out beyond the dimensions of the bike too much.

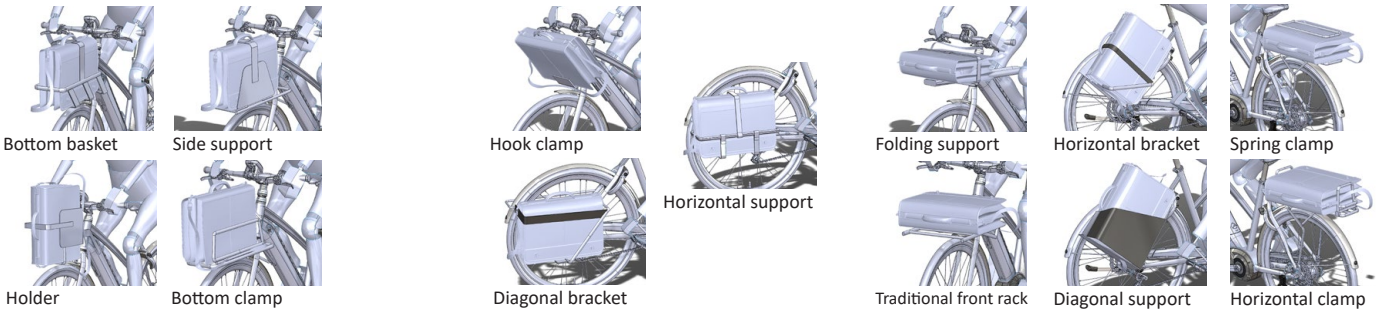
**Design**
For the defined target group design is very important. The luggage solution should be integrated in the design of the bike and Based on the concepts that have been developed it is possible to already give some clues about the design possibilities. Some of the concepts will be easier to integrate in the design of the bike than others.

**Mounting**
The way the bag is mounted to the bike obviously is very important. With the mounting of the bag various aspects are important: The bag needs to be placed on the carrier in a stable and secure way; it should not fall of or rattle. Also shock absorbency is in this aspect. Also the easiness to put the bag on the bike is considered and lastly also the theft protection is important. Because shock absorbency and theft protection are not worked out on all concepts to an equal level they are not included as separate selection criteria.

**Price**
Although the concepts are not worked to a level where the cost price can be calculated, the concepts will also be compared on the expected price. In the price of the product three potential costs need to be considered: The cost price, the assembling costs and the transport costs. The luggage solution might lead to higher assembling costs, but also to higher transport costs if the bike becomes wider of longer than the standard transport boxes Gazelle uses (195cm x 24cm x 117cm). For the assembling it would also be possible to let the dealer or service partner mount the luggage solution.

**Future**
For Gazelle it is important that the designed luggage solution can also be mounted on other bikes. This depends a lot on the mounting method of the concepts, which for some concepts will only fit on the CityZen bikes. For most concepts the mounting methods need elaboration in the further development to see if they can be made fit for other bikes.

**Position**

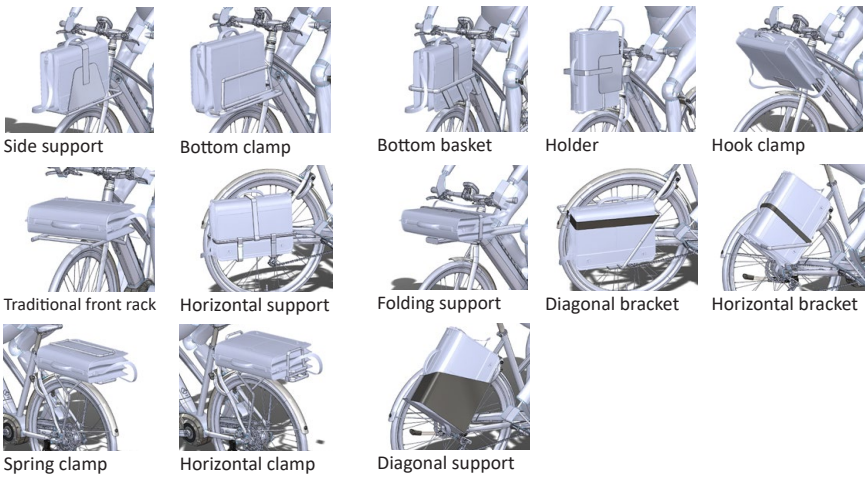



Front
In terms of position the first four concepts (Bottom basket, Side support, Holder, and Bottom clamp) are scored negative. In these concepts the bag is positioned in front of the steering bar in an upright position, which makes the bag intervene with the handlebars of the bike. This could be solved by adding more spacers to the steering stem or by designing or mounting a different steering bar. Placing the steering bar higher influences the riding posture of the bike, which is not an option for Gazelle, as this would place the bike in a different model category.
Another possibility would be to move the bag further forward in order to avoid this problem with the steering bar. Both for aesthetic reasons as for stability concerns it is undesirable to move the bag too far forward and in order to clear the handle bar it would need to be moved forward quite a lot.
The fifth concept, the Hook clamp scores average because it will intervene with the steering bar at larger steering input.
The folding support and traditional front rack are scored positive on position as both concepts do not interfere with the steering.

Rear
The diagonal bracket and horizontal support score average on position. In both concepts the bag has to be moved quite far backwards to avoid contact with the pedalling movement of the cyclist. Both in terms of looks and stability this is something which is not preferable.
The other four rear concepts (Horizontal bracket, Diagonal support, Spring clamp, and Horizontal clamp score positive on position as in all four concepts the bag is placed relatively close to the centre of the bike and well out of the way of the cycling movements.

**Design**

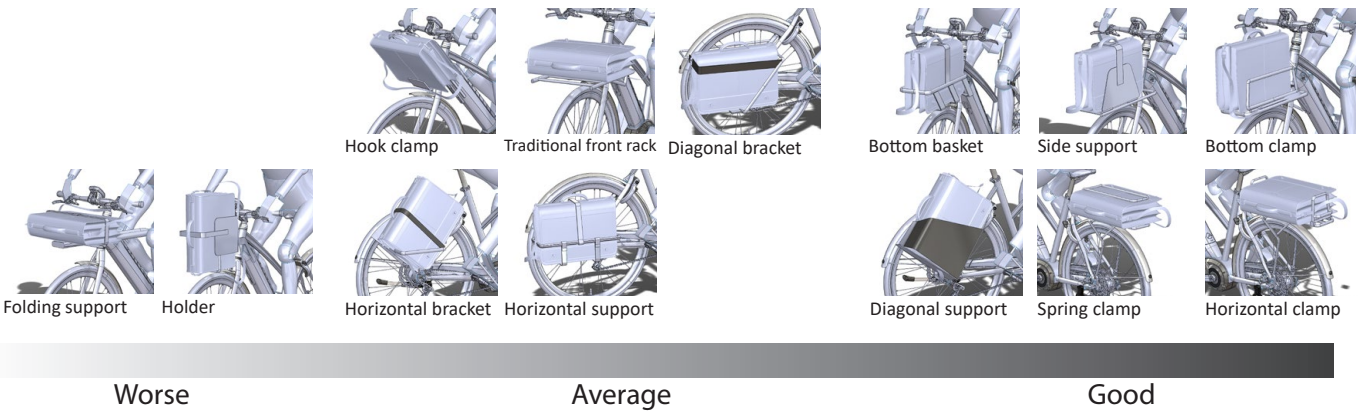
Front
The bottom basket and Holder are considered relatively easy to integrate in the design of the bike. As both concepts are not very voluminous it is easier to integrate them in the overall design of the bike. Both concepts mainly use metal profiles for its construction and therefore the design can be easily adapted to fit the CityZen.
The Hook clamp and Folding support also score positive in terms of design. As both concepts fold away when not in use they do not impact the design when not in use. For the looks when folded out both concepts need to be worked out further, but as they slide into the bike's frame it should be possible to integrate them well in the design of the frame.
The Side support, Bottom clamp, and Traditional front rack score average on design. For the Side support




this is due to the bigger side support panels, which will be difficult to integrate in the design of the bike. The bottom clamp especially does not look well when not in use, as you can then see the clamp mechanism. The traditional front rack also scores average in terms of design, as it quite wide and thus difficult to integrate with the bike's design.

Rear
In the rear concepts the diagonal bracket and horizontal bracket score good on design because they are very minimalistic and fold away when not in use. Also it is possible to design the bracket in a way which fits the bike's design.
The diagonal support also scores positive as it will follow the lines of the bike and also looks good with the bag on it. When made fold-able it will even be less noticeable when collapsed.
The Horizontal support concept scores less as it visually seems to stick out behind the bike and therefore looks out of place.
The spring clamp and horizontal clamp do score average as both concepts add a big volume on top op of the rear carrier, which will be difficult to integrate in the design.

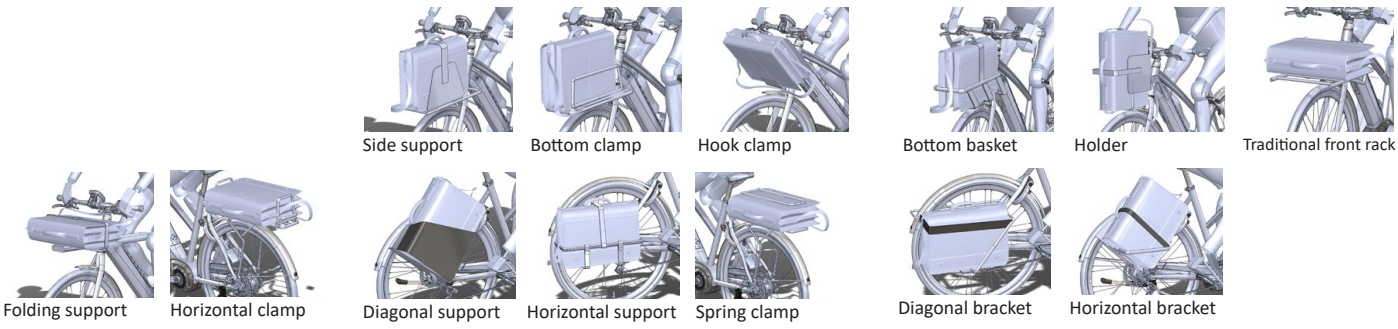
**Mounting**



Front
The Bottom basket, Side support and the Bottom clamp make for easy mounting of the laptop bag. In all three concepts the bag is also secured in a secure way and will not rattle or fall of. Also in terms of theft protection the all front concepts are favourable as the bag is always visible for the user.
The Holder and Hook clamp score average on mounting as it can be imagined it is a little more difficult to securely fix a bag on these two concepts. In the Hook clamp concept the bag is pulled against the frame with a spring, which would need to be strong enough to ensure the bag does not fall off. Also the traditional front rack is considered average as it does not feature a special mounting method.
The Folding support is scored bad in terms of mounting as it will take some effort to fold it out in the right way and to mount eh bag on it. Also it is questionable how stable the concept will be as there is the combination of the hinge and the sliding mechanism influencing the stiffness of the concept.

Rear
In the rear concepts the diagonal support, spring clamp and horizontal clamp are scored positive in terms of mounting. These three concepts have the bag positioned relatively high, which makes mounting easier. Also the Spring clamp and Horizontal clamp make it easy to mount the bag and both have shock absorbency built in the carrier construction.
The diagonal bracket and horizontal bracket score average on mounting as in these two concepts the bracket needs to be folded out and as it is questionable how stable the bag will be, when put into the bracket.
The horizontal bracket is rated average for mounting as it is positioned quite low to the ground and it will be difficult to attach the elastic strap to fasten the bag.

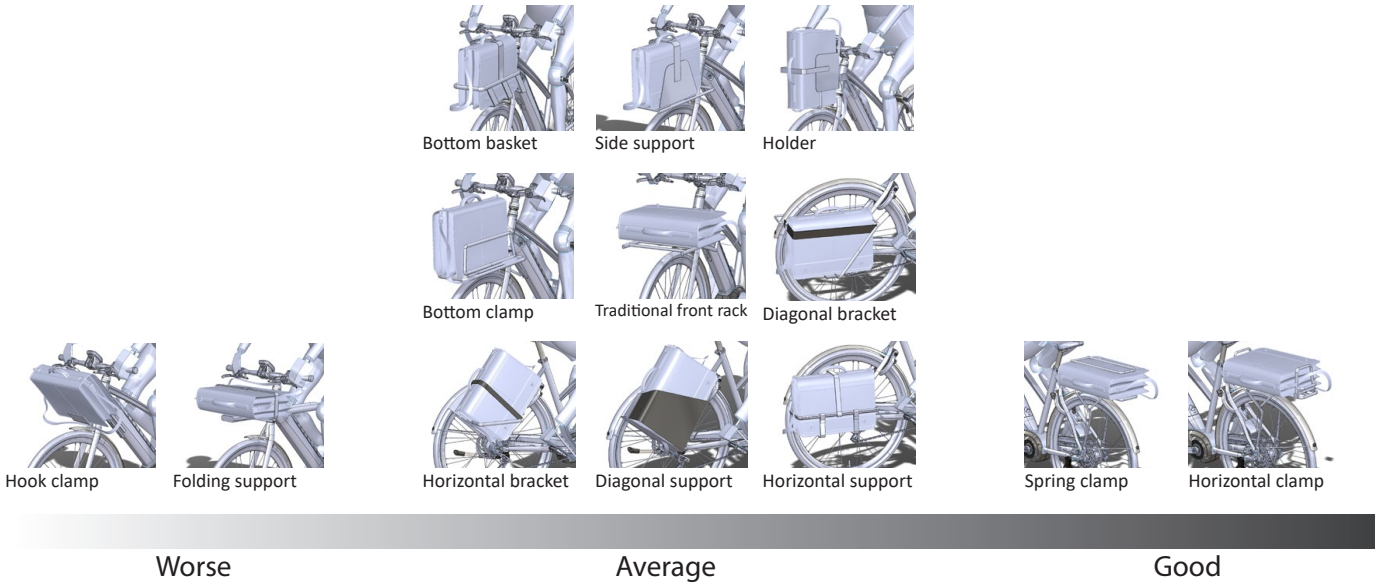
**Price**




Front
The Folding support scores worst on price. This is due to the concept existing of parts which will need tight fitting in order to make the sliding and folding possible. Also the bike's frame would need to be modified substantially, which will also increase the cost price. For this reason this concepts scores worst of all concepts on cost price.
The Hook clamp is scoring average on cost price as it will also need modification of the frame in order to make it slide into the down tube. Also the spring construction will increase the cost price.
The Bottom clamp and Side support also scare average on price as both concepts feature part that will hold the bag in place and a mechanism to allow them to clamp the bag into place.
The Bottom basket, Holder, and Traditional front rack score positive on price as these three concepts do have a relative simple construction and low amount of parts.

Rear
The Horizontal clamp scores unfavourable on cost price. This is due to the complexity of the needed sliding mechanism and spring construction.
The Diagonal support and Horizontal support score average on cost price as both concept need quite big parts and also both concepts probably need a bigger box to transport them.
The Spring Clamp scores average on price as it needs an high amount of parts and also the fitting of the spring mechanism is important for the concept to work properly.
The Diagonal bracket and Horizontal bracket are score positive because they both need a low

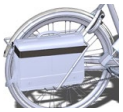
**Future**




Front
Two of the front concepts, the Hook clamp and Folding support score negative on the future component. Both concepts rely on a mechanism that collapses from the frame of the bike, which means the frame of the bike needs to be changed, which makes it difficult to implement these concepts on other bikes.
The other front concepts score average on the future aspect, as they all require the change of the mounting mechanism in order to fit on other bikes.

Rear
From the rear concepts the Spring clamp and Horizontal clamp score positive on the future possibilities, as these two concepts mount only to the traditional rear rack mounting points, which means they will easily fit on other bikes as well. The other four rear concepts score average on this point as the mounting methods would need to be changed in other to fit on other bikes.

# Overview concept selection

| | Position | Design | Mounting | Price | Future |
|---|---|---|---|---|---|
| **Front** | | | | | |
|  Bottom basket | - | + | + | + | +/- |
|  Side support | - | +/- | + | +/- | +/- |
|  Holder | - | + | +/- | + | +/- |
|  Bottom clamp | - | +/- | + | +/- | +/- |
|  Hook clamp | +/- | + | +/- | +/- | - |
|  Folding support | + | + | - | - | - |
|  Traditional front rack | + | +/- | +/- | + | +/- |
| **Rear** | | | | | |
|  Diagonal bracket | +/- | + | +/- | + | +/- |
|  Horizontal bracket | + | + | +/- | + | +/- |
|  Diagonal support | + | + | + | +/- | +/- |
|  Horizontal support | +/- | +/- | +/- | +/- | +/- |
|  Spring clamp | + | +/- | + | +/- | + |
|  Horizontal clamp | + | +/- | + | - | + |

# Concept selection

**Conclusion**

The two best scoring concepts are the Horizontal bracket and the Diagonal support. In both concepts the laptop bag is placed in a diagonal orientation, which does work well in terms of looks and position on the bike. The Diagonal support also scores positive on the mounting factor, where the horizontal bracket scores average on this point.

These two concepts also appear to be the most innovative ideas, as no other concepts have been found where a bag was placed in a diagonal position. The only bicycle luggage option which comes close is the Attaché-mee from Steco, where a design similar to the Bracket concept is used to mount an hardshell briefcase. In this design however the bag is places in a diagonal position towards the back of the bike, which make it quite different.

The diagonal position also seems to be quite a logical way of placing the bag on the bike and it does integrate with the lines of the bike quite well. It is also the best way to place the mass of the bag as close to the centre of the bike as possible.

*Attaché-mee from Steco*

*The two chosen concept ideas*

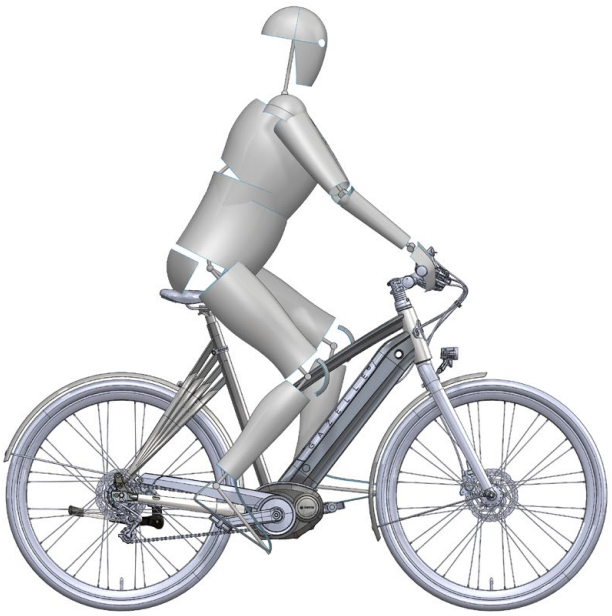
# Concept development

## Diagonal laptop support

It has been chosen to place the bag in a diagonal position, either with a support like the Diagonal support concept or in a bracket like in the Horizontal bracket concept. Further development and testing is needed to determine what is the best way.

**Right side**
Both concepts have the bag in a diagonal orientation positioned on the right side of the rear wheel.
The reason for mounting the bag to the right is because most people get on their bike from the left side. As a result of this the kickstand is usually located on the left side of the bicycle, which also makes it logical to mount the bag to the other side.

**Different frame sizes**
From most bikes different frame variants and sizes are available.
From the CityZen these frame size are 49, 53, 57, and 61 centimetre for the mid-step model and 53, 57, and 61 for the high-step model.
The different frame size have an influence on the angle the bag will be mounted. In both ideas the bag is mounted parallel with the seat stays (diagonal part of the rear fork), which changes in angle depending on the frame size. This angle varies from 43 to 56 degrees. In the picture below this change in angle of the seat stay can be seen. Note that normally the down tube and head tube would also change, but for clarity this is not shown in the picture below. The length of the chainstay (distance from pedals to rear axis) stays the same for all frame variants.
In the tests with mock-ups it needs to be tested if this changing angle influences the function of the designs. Also the changing angle will have an influence on the way the carrier is attached.



*The different frame sizes*

# Proof of concept

In order to test the two concepts mock-ups of the designs were made. With these mock-ups various placements on the bike were tested. Especially for the bracket option the exact position on the bike was found critical. Also for the support option it was studied how the placement on the bike needed to be exactly.

The prototypes were made from black PVC and mounted to the bike using duck-tape, ty-wraps and bolts at the existing mounting points. This way small alterations could easily be made.

The bracket concept was made from solid PVC rods and was kep in a simple rectangular shape. In this first version the hinge mechanism was not added yet. Also an extra support was added at the seat stay, made from the same PVC rod. With a small adapter plate the bracket was attached to the bike's frame and this way also the position of the bracket could be altered.
The support concept was made from PVC sheet taped together. The design in this phase was still a single piece box, with just a general idea of the final shape it could get.
For both concept an existing luggage strap was used to secure the bags.


*Diagonal support concept*


*Horizontal bracket concept*

*Testing various positions*



*Testing different bag types*




*Horizontal bracket concept*



*Diagonal support concept*

**Findings**

With the mock-ups in place various bags were positioned on the concepts: a 15-inch laptop bag, a 17-inch laptop bag, a small backpack, and a bigger backpack.
On both concepts all four bags did fit, although the bigger laptop bag and the bigger backpack did stick out quite a lot. It did become clear that it is easier to place the bags on the support concept. Also the straps of the backpacks and the shoulder strap of the laptop bags were easier to stow away in the Support concept.

It was also concluded that the support concept would need to be foldable in order to make it less obstructive when not in use. The support concept does form quite a big volume on the bike. Compared tot his the bracket concept appeared to be more lightweight and probably also cheaper to make.

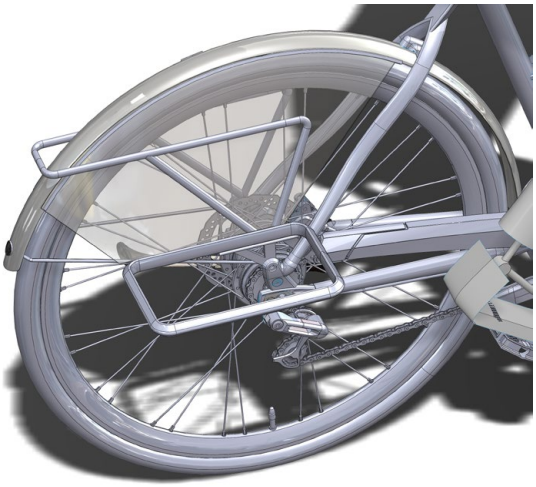
**Conclusion**
Both concept did work quite well. Also other bags were easily fit on the carriers. Both concepts do have some flaws and need to be developed further in order to make a well motivated choice.

# Concept development

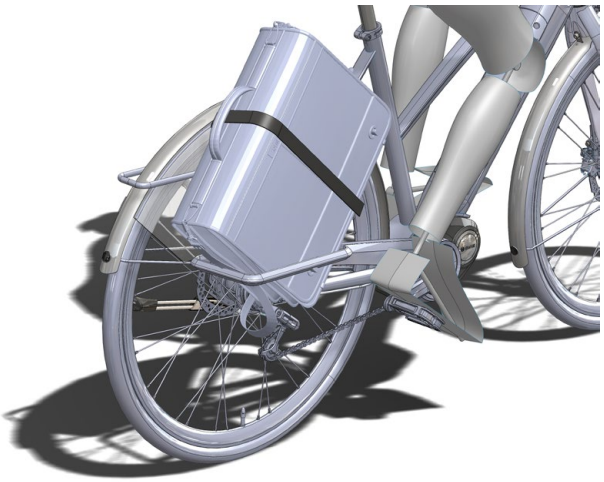
**Horizontal bracket**

The bracket would be made from aluminium or steel.
Also a protection cover to prevent the bag from getting into the rear wheel will be added. This cover will probably be made from a clear plastic, much like the jacket protection found on existing bikes.
Also a small rear rack will be added for additional support for the bag and to attach the elastic strap.

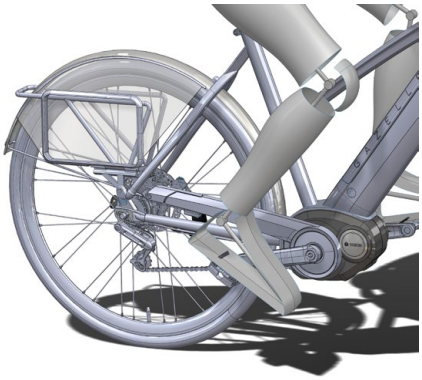
From the mock-ups it was concluded the bracket concept works well without extra support at the seat stay. Just the bracket and an elastic strap around the bag is enough to keep the bag in place.
Also it became clear that different sorts of bags also fit well on the bracket.



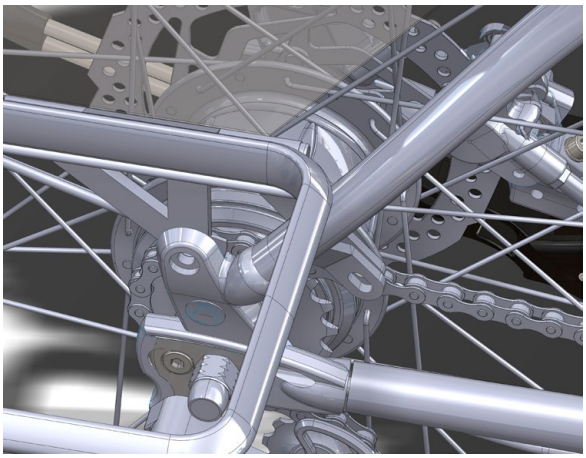
*Small rear rack*



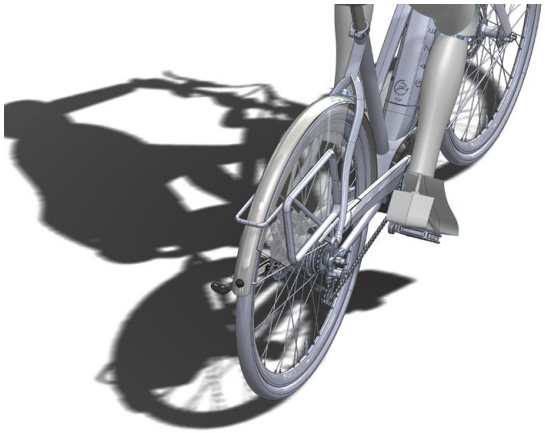
*In use*



*Bracket folded in*



*Mounted to existing mounts*



*Small profile when folded in*

**Diagonal support**

The original idea for the diagonal support is to make it from plastic. In order to make it less wide when not in use the plastic supports could be folded in.

Based on the original concept idea various materialisations are possible. Possibly it is undesirable to make it from plastic as this will not look stylish and luxurious enough and thus will not fit the CityZen and Gazelle.

Options:
- Moulded one piece
- Carbon
- Aluminium frame with plastic (or carbon) covers
- Aluminium frame
- Fabric (on an aluminium frame)
- Fabric without frame

*Aluminium support*

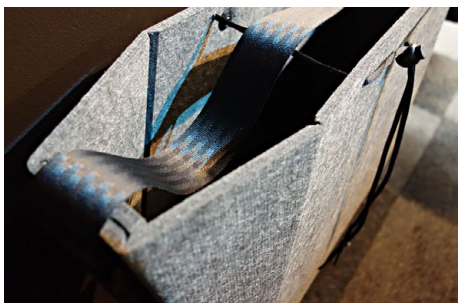
**Fabric support**

Another idea is to make support from a sort of fabric-like material. This way the concept could easily be folded in and also the shock absorbency would be taken care of. Furthermore this could also look well in terms of design. Obviously a stiff type of material would need to be used ans possibly this would also need to be a plastic reinforced fabric.

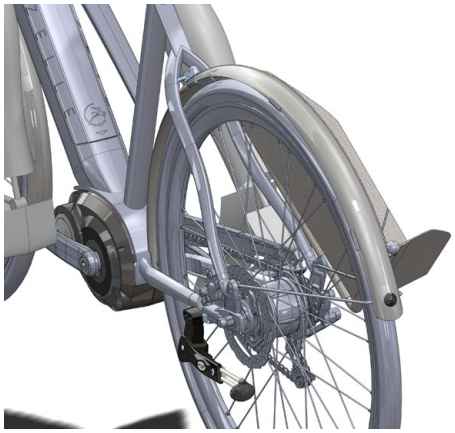
In this fabric version also the part covering the wheel would need to be made from the fabric like material. This way it will not be transparent however.
The folding idea was tested using cardboard and would work if the material is prevented from bending in the other direction than it is supposed to be flexible.

Different materials are considered:
- A felt-like material like the Curano bags.
- Water-proof paper
- Truck material
- Fake leather

*Fabric support variant*



*Felt-like material*



*Mounted directly to existing point*

# Mock-ups

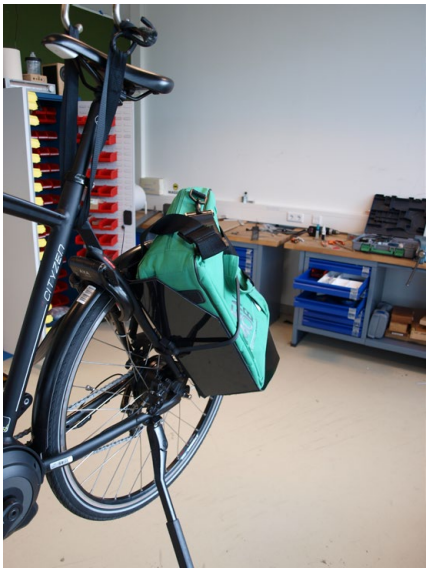
**Second iteration mock-ups**

A second iteration for the mock-ups was made in order to test the shape possibilities for the two concepts.
For the support concept also the foldability was tested.
For the bracket concept the bracket itself was 2D-printed in order to experiment with the exact shape of it.
Also the hinge mechanism was included in this second version.

For the support concept skai and PVC sheet were used in order to make a foldable version of the design.
This way the folding mechanism could be studied.

The mock-ups were made in order to get a better understanding of the physical properties of the two concepts. Especially testing the differences in the way the bag is mounted on the carrier provided useful insides for the further concept development.
Based on the testing of the mock-ups a choice was made for the support concept.

*Bracket concept*



*Support concept*

**Conclusion**

Based on the mock-ups is has been concluded that the Support concept is performing better than the Bracket concept.
Because of the closed shape it is more easy to use both for placing the bag and getting the should strap out of the way. Also it is envisioned there are more possibilities to give the carrier a luxurious design, as the design gives more freedom in material choice.

# Concept development - Details

Most details were designed with a combination of pohotshop ans 3D CAD modelling.

*Rear light design*

*Mounting strap*

# Final design

*The Gazelle laptop carrier*

In the following pages the final design will be presented.
The different parts will be presented and for all parts the production methods will be presented.

In the design the user can select his own bag and put it on the bike. Although the carrier is specifically designed for laptop bags it can also be used for other types of bag. A backpack also easily fits and also a grocery shopper could work, depending on the design.
This gives the user the flexibility to select a bag to his likings and also to mount different bags on the bike. In the weekend for example he can mount backpack and in during the week a laptop bag.

**Ease of use**

In use the concept is easily folded out and the bag can easily be put on the carrier. Securing is easily done as the mounting strap can be easily attached with one hand.
The process of putting your bag on the bike has been made as easy as possible. t is a matter of detaching the mounting strap, which also unlocks the supporting parts, which then fold out automatically.

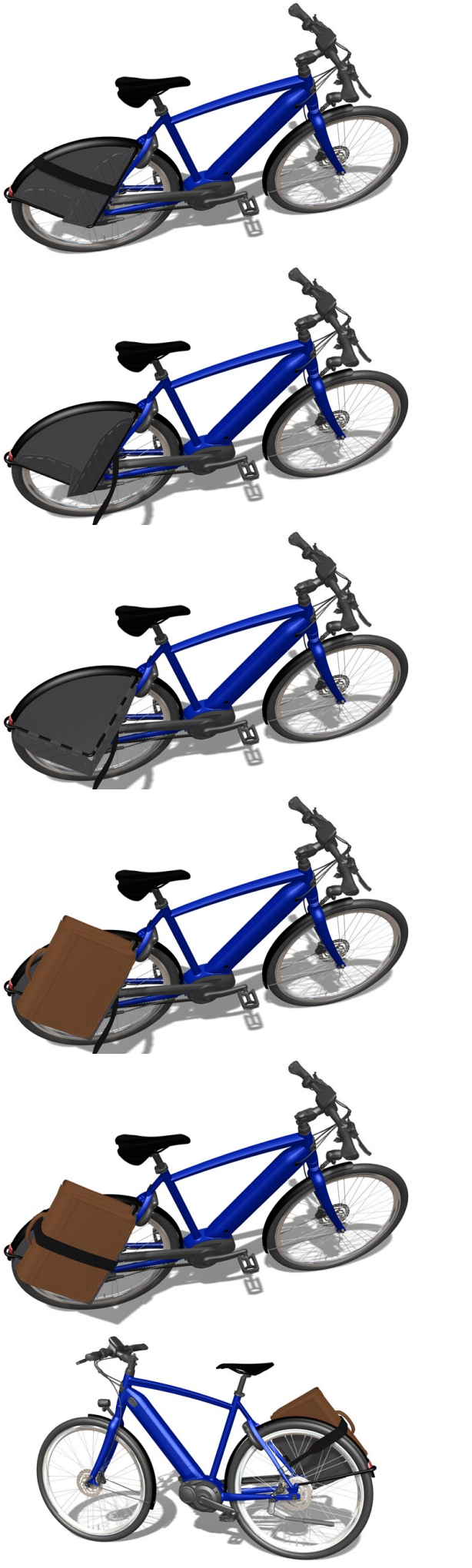
**Theft**

From a theft perspective it is quite difficult to de-attach the mounting strap. It is connected to the seat stays  at quite a low point and therefore it is not easily reachable. Also the user can guide it through the Handles of his bag, which makes stealing even more difficult. Optionally an extra release spring can be added to the hook. This would make unstrapping the bag also more difficult for the user. Even a little lock could be added to make it even more secure.

**Aesthetics**

The design has a modern and unique look. By making the design modern and giving it some sharper form in combination with rounded corners the design fits well with the CityZen's design. The CityZen also has some quite angular forms, but also some more rounded surface treatments. Also the CityZen has quite sporty and technical looks, which the carrier does fit in too.

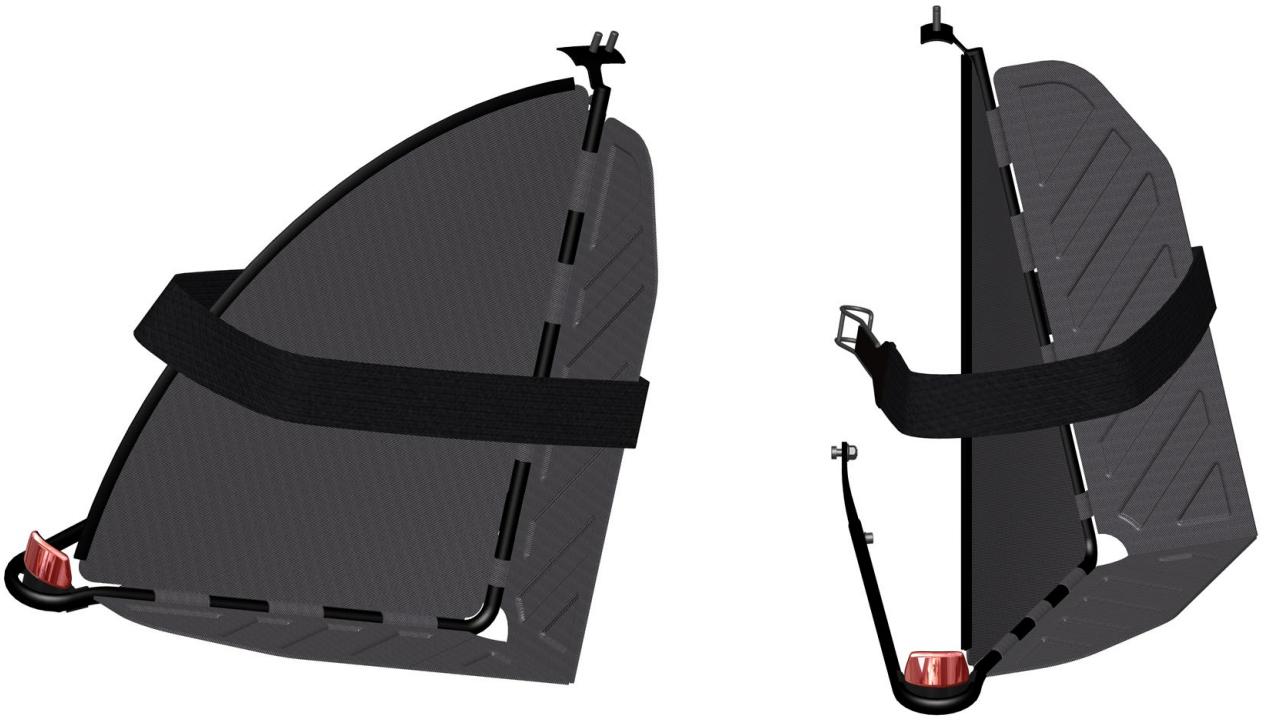
One thing that can not be avoided is the volume of he carrier design.
Since the 15,6 inch laptop bag it is designed for is quite large the design also has become quite large. When the laptop bag is mounted on the design this is not a big problem, but when the design



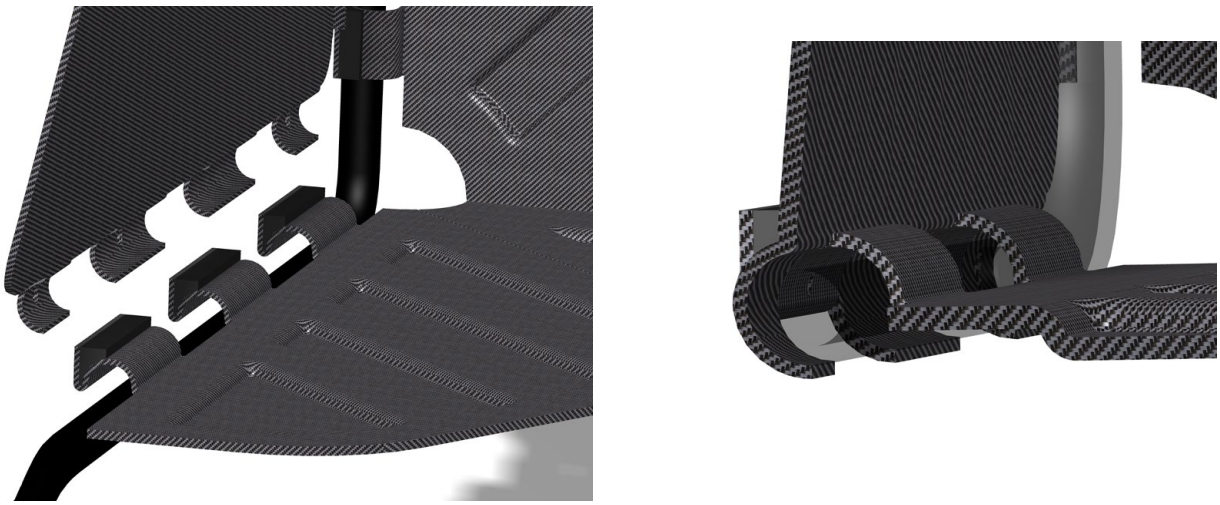
*Use scenario*

is folded it is becomes apparent the design takes quite some volume on the bike. By making the carrier foldable it has been tried to make this visual impact as little as possible
It has been chosen not to make the carrier detachable as this would make the design more complex and therefore more expensive. Also the carrier will be mounted on a commuter bike and therefore most of the time the carrier will be used for its intended purpose.

The material of the carrier will be polypropylene with a textured finishing. The standard version will have a carbon fibre like appearance. This way variation in the finishing of the design is possible. Optionally the user can also choose a leather finishing fitting the saddle and steering handles, or a material looking like Suede. The material of the mounting strap will be woven nylon.



*The carrier on its own*



*Hinge design*

**Hinge design**

The hinge design is made in a way that it locks itself when folded out. By the way the wheel cover and hinging parts are mounted around the aluminium frame the wheel cover and hinging parts lock each other in place.
The wheel cover is also attached by screws in the aluminium frame, but when folded out these are not necessary to keep the parts together. When folded up the screws are needed in order to keep the parts together.

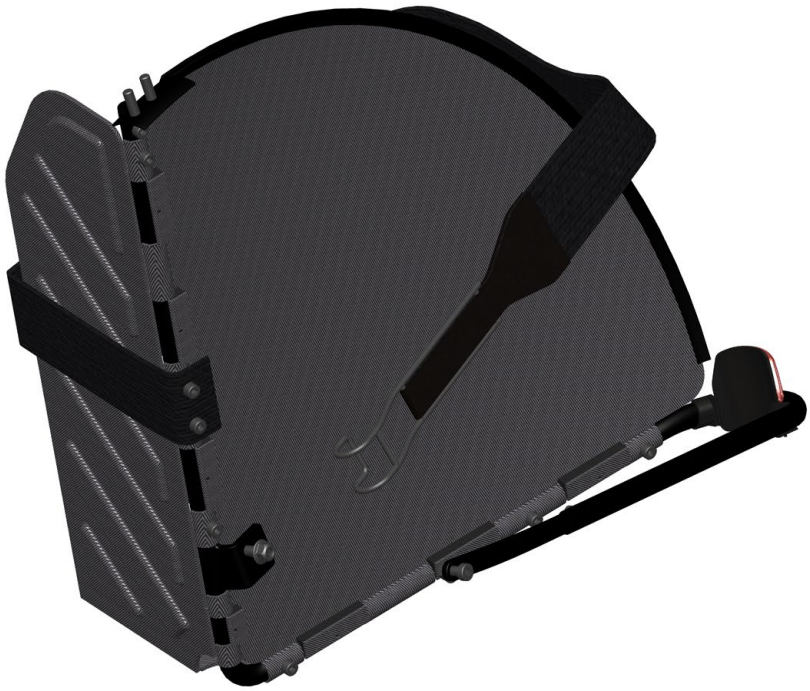
**Shock absorption**

The shock absorption is build in the hinge design. By integrating rubber blocks in between the wheel cover and hinged supports when folded out damping is added to the design. These rubber blocks do exactly fit in the shape of the thermoformed parts and lock in place with a snap-fit like design. The blocks are basically pushed in a cavity behind the hinge design in the hinging parts.

The blocks are modelled slightly different from each other so the angle of the folded parts varies slightly along the rotational axis. This has been done to ensure that the load of the bag is better distributed over the hinges and the shock absorption blocks. Because the highest load will be in the angle of the carrier parts the block have been made one millimetre shorter as at the end of the two carrier parts. This way more load will be transferred to the blocks at the end of the carrier parts.
This also has the additional benefit that the carrier parts, at the end are more restricted from bending downwards. It is the end of carrier parts which is most prone to bending from the bags load, so the uneven blocks make sure this is prevented.


*Backside of the carrier*

# Final design - Mounting



*Backside with bolts and mounting points visible*

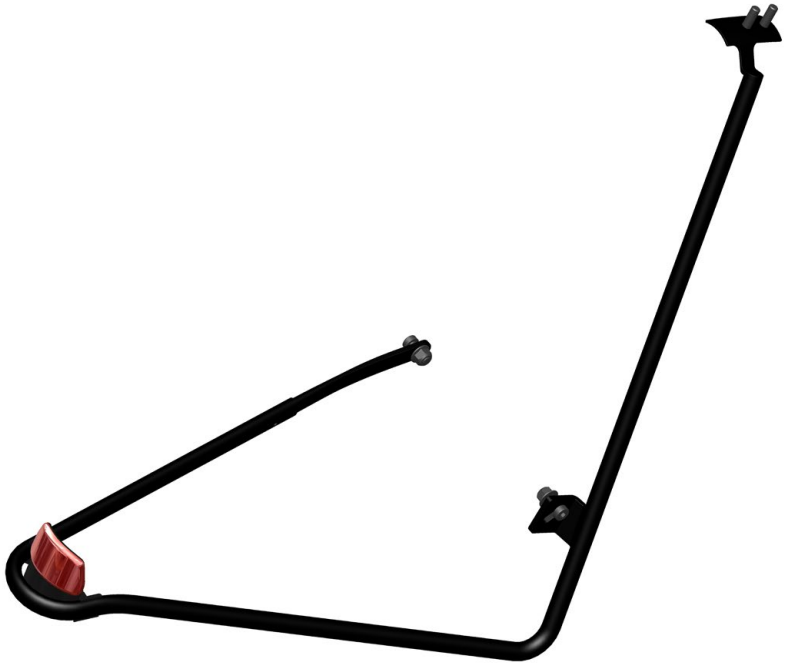
**Mounting points**
The first attachment point for the carrier frame will be mounted to the mud guard mounting point at the seat stays. Furthermore it will be mounted tot the rear rack carrier points on both sides of the bike. These three attachment points will make the carrier frame statically defined.
The carrier will support the rear of the mud guard and also it will fit to the rear mud guard at the top.

The mounting strap will be  connected to the carrier frame on the carriers side and the attachment hook will be attached to the seat stay on the other side of the rear wheel.

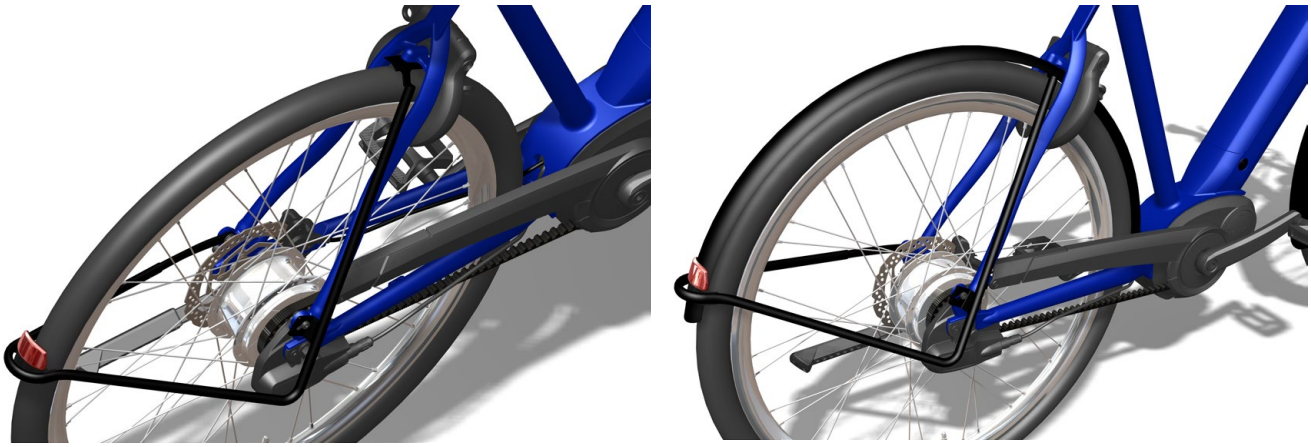
**Different frame sizes**
In order to fit the carrier to different frame sizes some adjustable mounting points have been created.
On the carriers side the mounting hole for the rear carrier is made in a circular shape, in order to make the carrier movable around the wheel axis.
On the other side the connecting rod to the rear has been made adjustable to adjust the length to the different frame sizes. Also the mounting hole on this side has been made two millimetre larger in order to allow some extra room for adjustment.

In order to mount the carrier correctly firstly the seat stay mount and the carrier side's rear rack mount are connected.

*Different frame sizes*



*Frame with mounting bolts*



*Mounting frame without and with mud guard*

Then the rear rack mount on the other side is connected, but the sliding adjustment is still left loose. Next the carrier will be connected to the rear mug guard both with the wheel cover and the frame. After this the rear wheel can be placed and the carrier can be adjusted to fit the rear wheel exactly.

**Assemblage**

As described above the carrier requires some work to be mounted on the bike. When the carrier is offered as a factory option this is not a big problem as the carrier will be mounted instead of the standard rear rack. Compared to mounting a standard rear rack the laptop carrier might require a little more work to fit on the bike, but this would probably be acceptable. In the factory it is also not a problem to first mount the laptop carrier and then place the rear wheel.

When the design is also offered as an after market option the mounting on the bike is a little more problematic. For this the user would probably need to go to a dealer because the rear wheel needs to be taken out in order to do so; especially when the bike is fitted with a gear hub and roller brakes this takes some effort. Another problem which rises when the normal rear rack is removed is the mounting holes in the mud guard for it becoming visible. When the laptop carrier is mounted in the factory the mud guard can be ordered without these mounting holes.

# Final design - The CityZen 'Powertube'

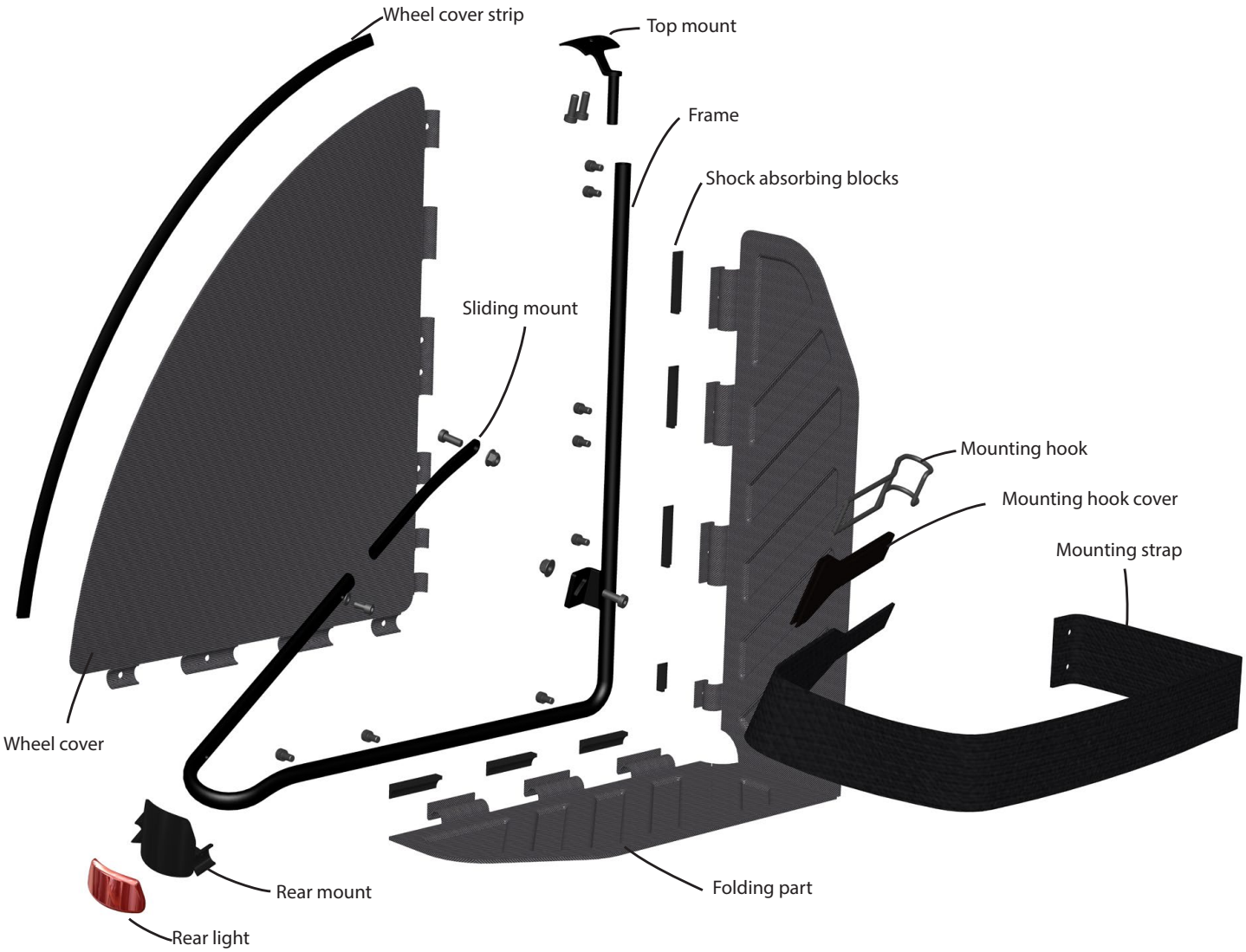
The laptop carrier has been designed for the upcoming new CityZen bike. Internally in Gazelle this bike is known as the 'Powertube' as it feature Bosch' new built in battery. This new battery design allows the battery to be integrated in the down tube. This way the battery is less visible and better integrated in the design of the bicycle.

For the lease bike were the laptop carrier is meant for this new model would need to be fitted with a belt drive and a gear hub. In the model configured for the laptop carrier a Nuvinci 380 gear hub was used, which is a continuously variable gear system. Although this system in combination with a belt drive would be well suited for the commuter e-bike it might turn out to be too expensive, in which case a Shimano hub should be used. In the final design phase of the project nu calculations on the complete lease bike were made, since the design focus was on the luggage solution.
The belt drive is a Continental belt drive, which is also used in other Gazelle bikes.

In the 3D model the new CityZen model has been fitted with the Nuvinci gear hub and Gates belt drive. The frame was not adapted however, so basically only the wheels, chain and gearwheels have been replaced. In order to make the frame suited for a belt drive a frame opening and a horizontal belt tension mechanism would need to be added. Gazelle has done this on other bikes in its current portfolio and this should also be relatively easy to implement on the new CityZen.

*CityZen 'Powertube' with Nuvinci hub and belt drive*

# Final design - Exploded view




Above an exploded view with all parts of laptop carrier is shown.

Part list:
- Frame
- Sliding mount
- Top mount
- Rear mount
- Rear light
- Mounting bolts
- Folding part
- Wheel cover
- Shock absorbing blocks
- Wheel cover strip
- Mounting strap
- Mounting hook
- Mounting hook cover

# Final design - Material selection

For the concept to function properly the material choice and corresponding production methods are of high importance. The folding mechanism needs to work in an easy and stable way. Also the design needs to support the load of a full laptop bag, which can weight up to 7 Kg. This means the material will need to withstand quite high stresses under load.

The material choice is also important for the look an feel of the bike. In order to attract the commuter the carrier should add value to the design of the bike. In the CityZen the main materials used are aluminium, plastics and some fake leather for the saddle. These materials are carefully matched together and all combined with the good material finishing the CityZen does get its high quality looks.

**Expected production**

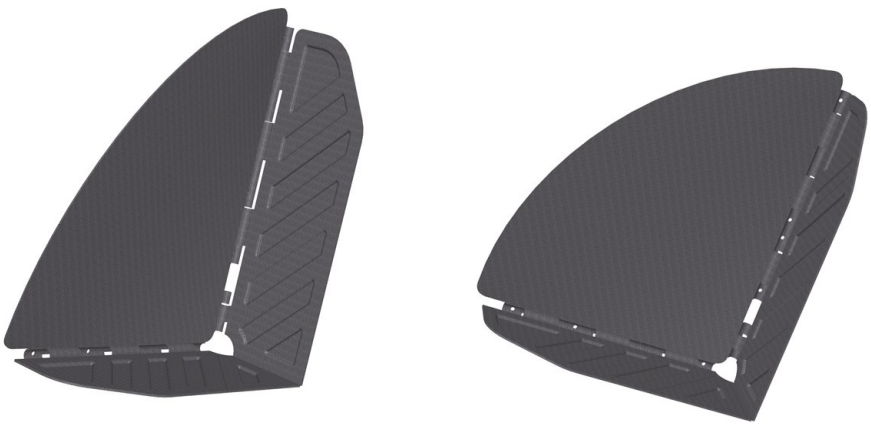
In order to select the right material and in order to calculate the cost price the expected production numbers need to be formulated. It is difficult to estimate the production numbers for the laptop carrier as the carrier is meant to be mounted on the Gazelle lease e-bikes At the moment Gazelle has just started leasing e-bikes and for that reason it is difficult to predict how many e-bikes per year will be fitted with the laptop carrier. If Gazelle would also sell the carrier as an accessory the production numbers will probably be higher, but as an accessory it should not be too expensive of course.

In order to be on the safe side it has been decided to calculate the cost price with a production run of 10.000 pieces. This way the real demand and thus the tooling costs per product can only surpass expectations.

**Material selection**

For the frame supporting the carrier the material choice was quite straightforward; the frame will be made from aluminium, as will the most important support brackets. Steel would also have been an option, but this would not fit the rest of the bike, as the bike's frame is made out of aluminium.

More critical in terms of material selection were the folding carrier parts and the wheel cover. These parts are very important for the looks of the bike, but also for the functioning of the folding mechanism. In order to select the right production process and material also the hinge design needs to be optimised and vice versa. For the finishing of the carrier parts and the wheel cover the following materials were considered:



*Folding part and wheel cover*

*Curano felt bag*

*Felt chair*

*Leather*

**Material folding part and wheel cover**

*Felt*
During the design phase the suggestion to look into a felt-like material was made by one of the coleugues of Gazelle. This felt like material has been used in a concept bicycle bag by Curano. (See image next page) The bag has not been brought tot the market yet and little to no information about the material can be found. In other designs a similar felt-like material has been used to make chairs and other furniture, but no weather-resistant design has been found.

*Leather*
Another option which has been investigated for various concepts is the use of leather. This way the material of the carrier could match the saddle and you would get a smooth easy to clean material. An artificial leather could easily be laminated with a plastic core material to make the carrier parts.

*Suede*
Another material which looks a bit like the earlier mentioned felt material is suede. Also faux suede would be a good option, as this material is more easy to clean and more durable than real suede. Like with the leather option the faux suede could be laminated with a plastic core for the folding parts.

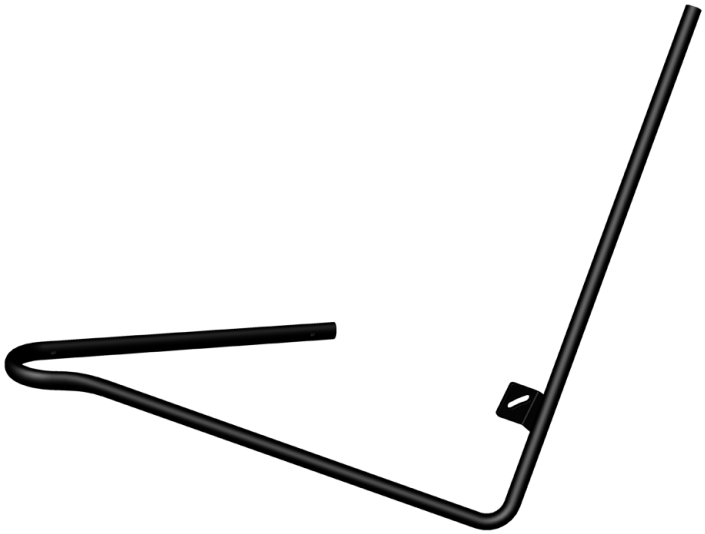
*Plastics*
The design could also be made from a plastic, for example ABS or polypropylene. By giving it a nice surface texture a nice material finish could be achieved. It should however not become a big lump of plastic, and careful attention must be given to how to give this plastic material a high quality look.

*Suede bag*

*Leather covered dashboard*

*Leather laminated phone cover*

# Final design - Frame



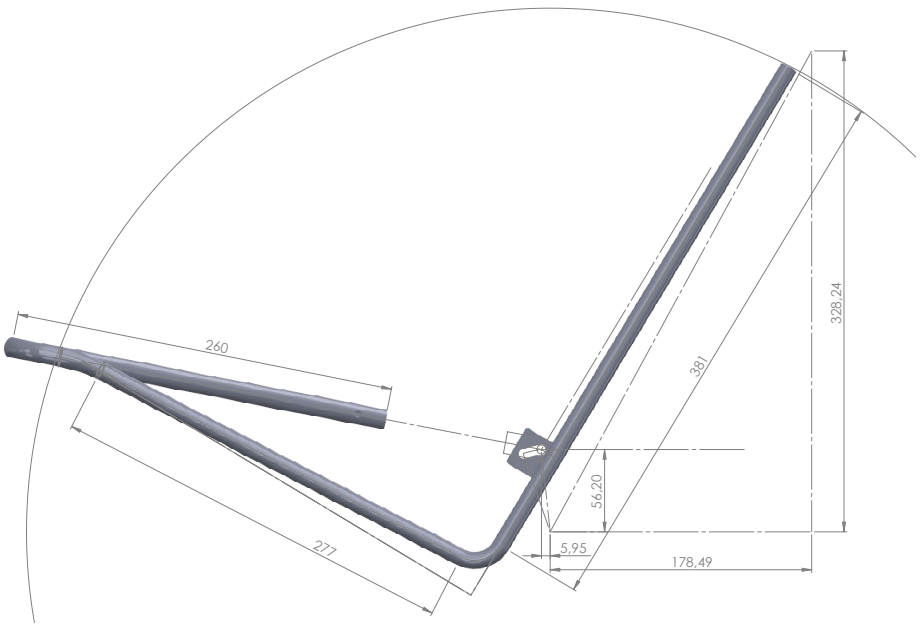
*Frame*

*Sliding connection*

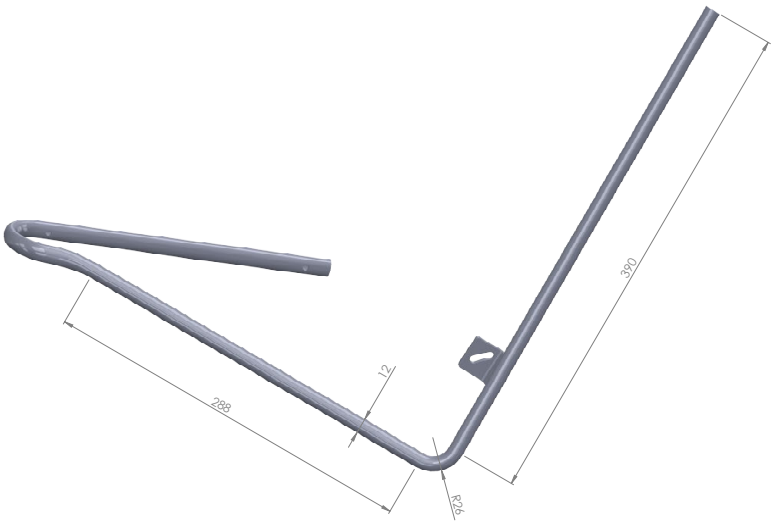
The frame will be made from aluminium. This will be made from two different profiles of extruded aluminium which will be bended and then welded together.
The right side part of the frame (the side of the carrier) will be made from a round extrusion and the left part from an elliptical extrusion. Both extrusion will have to be bend in the right shape before they can be joined together. At the joint the round profile will need to be shaped so t does fit to the elliptical profile. Also the mounting point at the right-hand side needs to be welded to the frame.

**Sliding connection**
On the left hand side there is a sliding connection, which forms the connection to the mounting point on that side. This part will have to be forced in the right shape in order to slide in the frame and to mount to the right-side rear carrier mount.

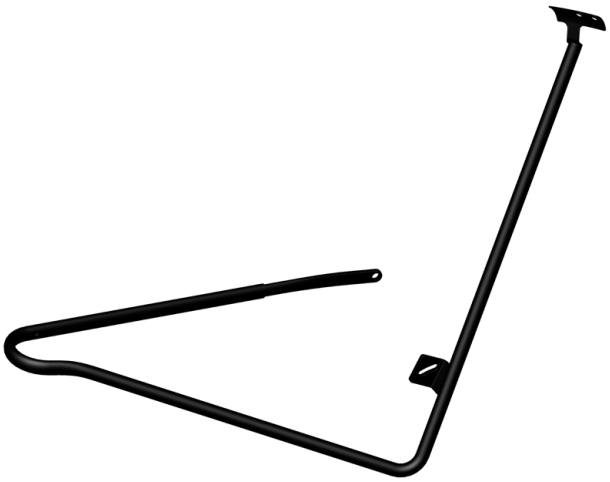

*Rear view with dimensions*




*Side view with dimensions*




*View on the hinge's plane*



*All aluminium parts*

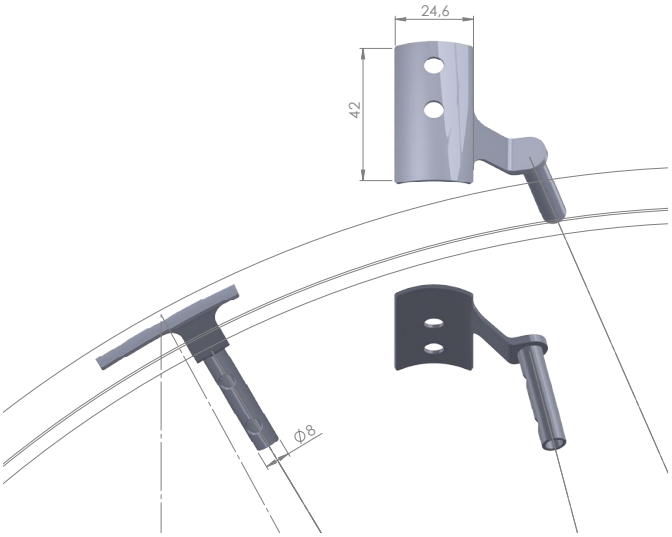
In the frame also the mounting points for the wheel cover will need to be made. The wheel cover will be attached by form fitting and seven M5 hex bolts. When the carrier is in use the forces will be transferred by form fitting and the mounting bolts are not needed at that moment. Only when folded in the screws are needed to keep the wheel cover and folding parts in place.

The rear mount will be connected to the frame by form fitting. The rear mount is made out of ans can thus be slightly deformed in order to for the force fitting to work. For this two five millimetre holes will be made at the position of the rear mount.
The top mount the will be attached to the top of the frame by two M5 hex bolts, of which one is shared with the wheel cover.

For the frame, the top mount and the sliding mount aluminium will be used. This will be forged in order to reach the desired shape.
The frame will need to be bended and welded. At the transition point from a circular to an elliptical profile, the profile will need to be forged in order to transition from a circular cross section to an elliptical cross section. This will be done by cold closed die forging.

*Cost price*
The cost price for the aluminium frame has been estimated at 5 euro. This is based on the price of existing rear carriers, which are made in a similar way. The cost price of the sliding part on the other side has been estimated at 3 euro.

# Final design - Mountings




*Top mount*

**Top mount**

The top mount will be made from aluminium. Next to the two connection to both rear rack mounts this is the third mounting point of the laptop carrier and therefore it is an important part for the stability of the design. For this reason the top mount will be made from aluminium like the carrier's frame. It would also be possible to weld the top mount directly to the frame, but by making it a separate pat it is easier to make the laptop carrier fit to different bike models.

The top mount will be connected to the bike's frame using two M6 hex bolts. The top mount is attached to the carriers frame by two bolts as well, in this case M5 hex. By making different versions of the top mount the design can be adjusted to different bike models.

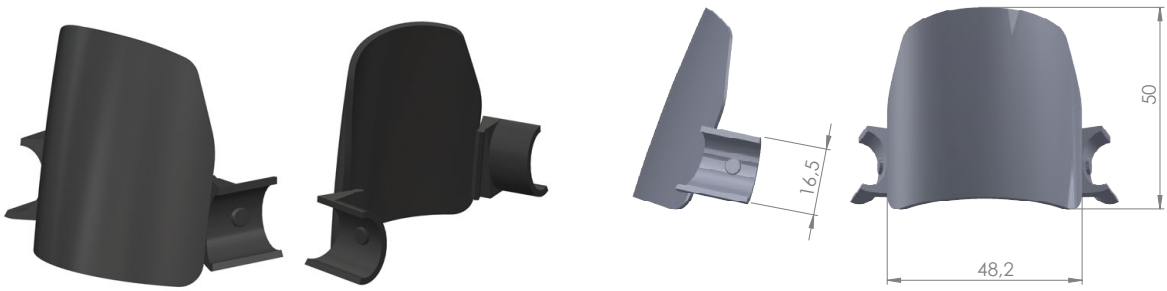
Basically this part will be made of two parts welded together. The bended part which fits in the mud guard will be made from pressed sheet metal and the round part will be an aluminium extrusion which fits in the top of the frame.

*Cost price*
The cost price of the top mount has been estimated at 2,50 euro.

**Rear mount**

The mounting at the rear of the mud guard will be made by injection moulding. This is a relatively small part and therefore tooling costs will be relatively low. The rear mount will be mounted by form fitting. This way no bolts or screws will need to be fastened when assembling the rear mount.

It will first be connected to the frame, after which the mud guard can be clicked in place. The Mud guard is attached to the rear mount by use of small snap-fits. The rear mount is connected to the frame by form fitting and can only be de-attached from the frame when the mud guard is not in place, as the whole part needs to be bended to make the form fit come loose.




*Rear mount*

The mounting at the rear of the mud guard will be made by injection moulding. This is a relatively small part and therefore tooling costs will be relatively low. The material will be polypropylene.

*Cost price*
The production costs were calculated using the online cost calculator of an injection moulding supplier, namely QDP B.V. The mould costs would be about 2,500 euro and part costs around 0,50 euro. This means that the intended production batch of 10.000 would result in a cost price of 0,75 euro.

**Rear light**

In the rear mounting also the rear light can be integrated. In the same moulded part the lights casing and mounting can be moulded. Because the housing of the rear light can be integrated in the rear mount the cost price for the rear light will be quite low. Integrating the rear light in the rear mount is good opportunity to reduce part count and assembly time.

For the rear light to work also a rear light glass needs to be moulded from polycarbonate or a similar transparent plastic. Depending on the construction also a reflector and of course a wire to connect the light will be needs to be added.
The design of the rear light has not been worked out in detail. Only the outer shape has been defined.

Cost price
Below an indication of the costs for a possible integrated rear light:
- Rear light glass 2,-
- Rear light reflector 1,-
- Rear light LEDs 1,-
- Rear light wire 1,-

*Rear light*

**Mounting bolts**

In total seven bolts are needed to mount the wheel cover and mounting strap to the frame. For these bolts it has been chosen to use M5 bolts with a hex head. These are already used in other part of the bike, and having less variation in bolt sizes obviously beneficial for assembly time. For the sliding connection on the left side of the bike and for attaching the top mount also M5 hex bolts are used.

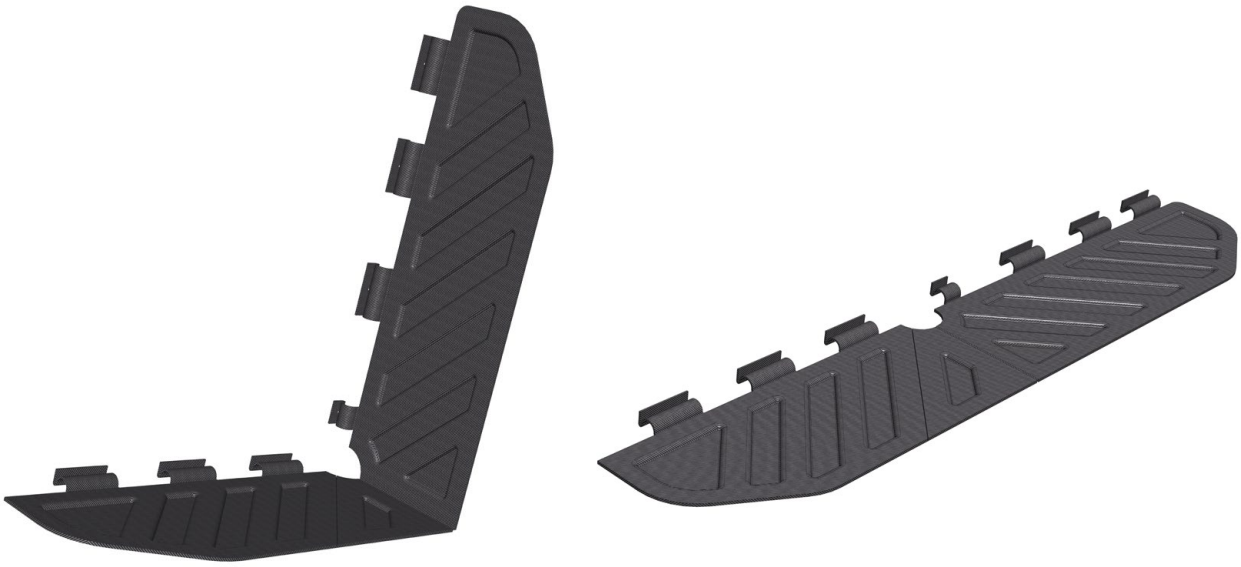
In hindsight M5 is quite big for the sleek aluminium frame, and maybe it would be better to change this to M4 bolts.

The top mount will be bolted to the bike's frame using M6 hex bolts. These are the same bolts which are now used for the mounting of the rear carrier strip. Also the mounting point of the frame at the rear carrier mounts are attached using M6 and self-locking nuts, like used for the rear carriers nowadays.

*Cost price*
The mounting bolts will be bought in bulk and will probably cost around 0,10 euro per pieces. In total this would come down to about 1,30 for the mounting bolts.

*Frame and top mount with all bolts*

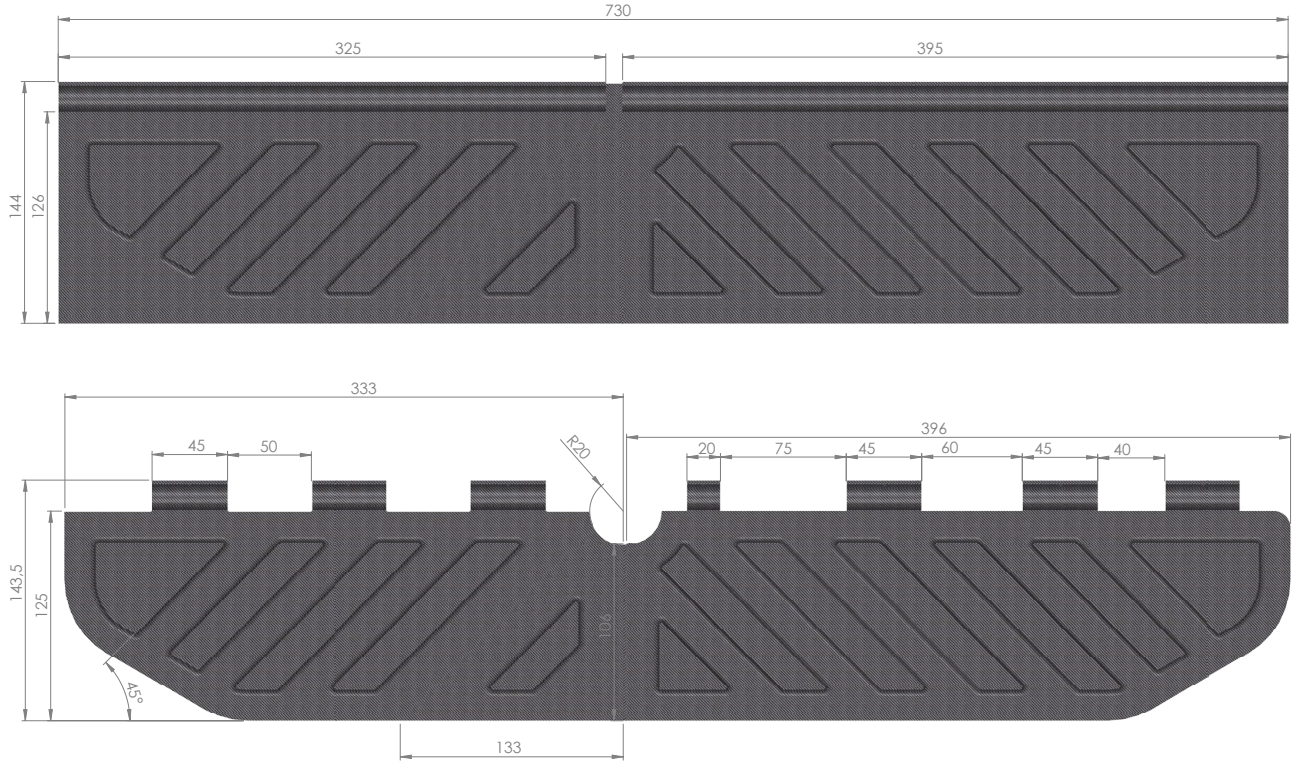
# Final design - Folding part



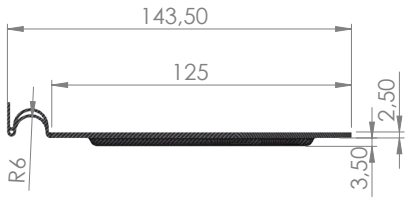
*The folded part as on the carrier and folded flat*

The folding part is the largest and arguable the most important part of the product. Folded out measures 750 by 145 mm and is about 15 mm high. The part will be made by thermoforming, more specific Mechanical thermoforming. In this process on both sides of the product a mould is used to obtain the required shape.

The folding part will be made from one sheet of plastic which will fold by using a sort of living hinge design. This is not the typical living hinge design as in injection moulded parts but a type of thicker living hinge which can be integrated into the thermoforming process. This way the folding part can be made from one sheet of plastic and no difficult hinge designs are needed..




*Untrimmed and trimmed part*



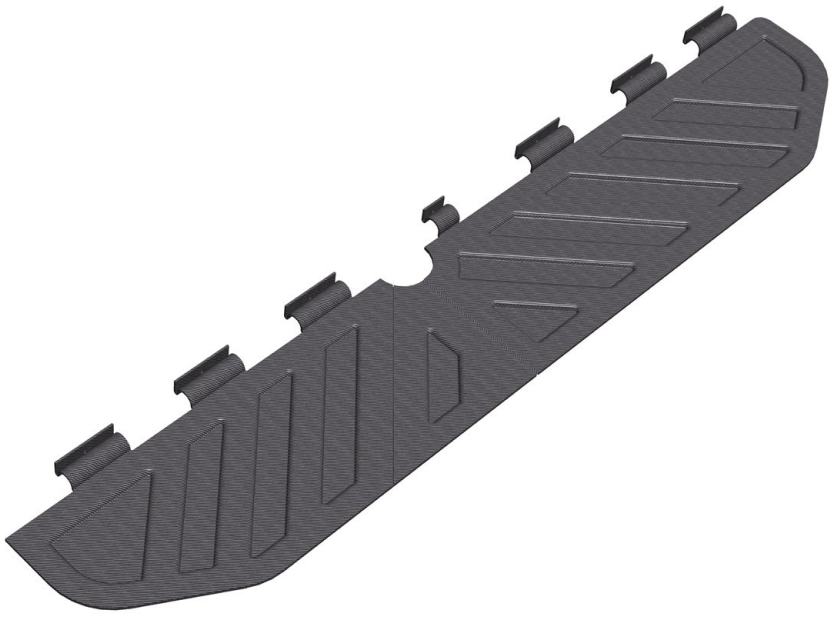

*Side view*

Making the carrier by thermoforming means the parts should be unloading from the mould. With the chosen hinge mechanism this is possible. The thermoformed parts will need to be trimmed in the exact right form after thermoforming. Also the holes for the rubber shock absorbers will need to be made afterwards.

*Finishing*
The finishing of the carrier parts will be made by using textured thermoforming sheets. These can be purchased in many surface finishings, for example with a carbon like texture, a suede texture or a leather like texture. For the standard design a carbon-like finishing has been chosen.

These textured sheets are available in different plastic types, from ABS to Polypropylene. Since the design also features a living hinge, the material polypropylene has been selected. Polypropylene handles elastic deformation quite well and does not quickly show signs of fatigue after repeated elastic deformation, which is the reason it is the most used material for living hinges. It is also quite impact resistant, which is also a benefit for the laptop carrier design.

*Cost price*
The mould costs for the thermoformed parts have been calculated using the information of a thermoforming manufacturer, namely Batelaan Kunststoffen B.V. Using their online calculator the mould costs would be 2.418 euro for the dimensions of the carrier part. Because in this price the living hinge forming and complexity of the mould are not included this amount is doubled in order to account for this. This results in a mould price of around 5.000 euro, which comes down to 0,50 per part with a production of 10.000 parts.



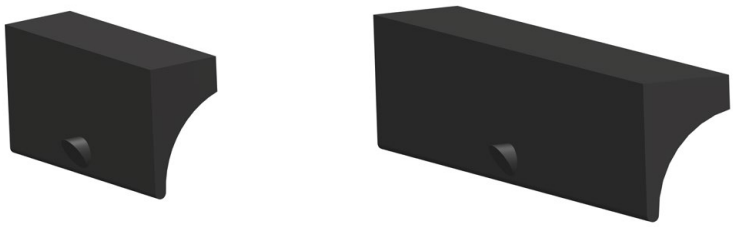
*Finished part*

Also the trimming of the frame hinges and post-processing needs to be considered. For trimming and post-processing 2,- euro per piece will be calculated. The sheet material costs is depended on the applied texture. As no reliable information about the costs of these sheets available this has been estimated as well based on the costs of textured sheet material. The costs are estimated at 2,- euro per part. Combining all costs leads to a cost price of 4,50 euro for the folding part.

**Shock absorption blocks**

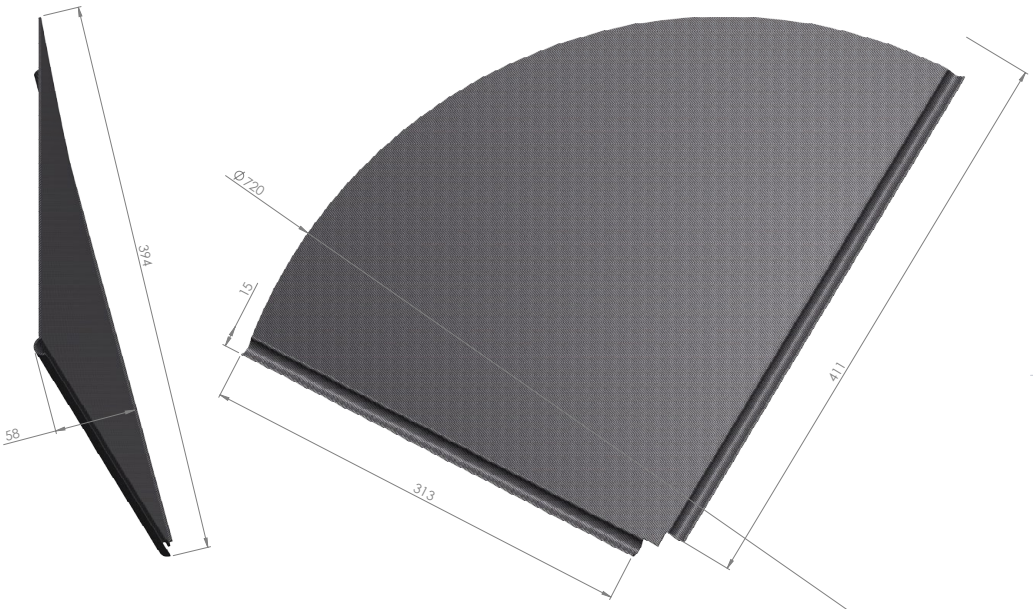
The shock absorption blocks will be made from a synthetic rubber, for example a elastomer like Styrene butadiene rubber (SBR). The blocks will be made by Compression Moulding. This allows for lower mould costs and as the blocks do not have a very complex shape this process is well suited.

*Cost price*
As it is a small part tooling costs will be low and the total price for the 7 shock absorption blocks is estimated at 2,- euro.



*Rubber absorption blocks*

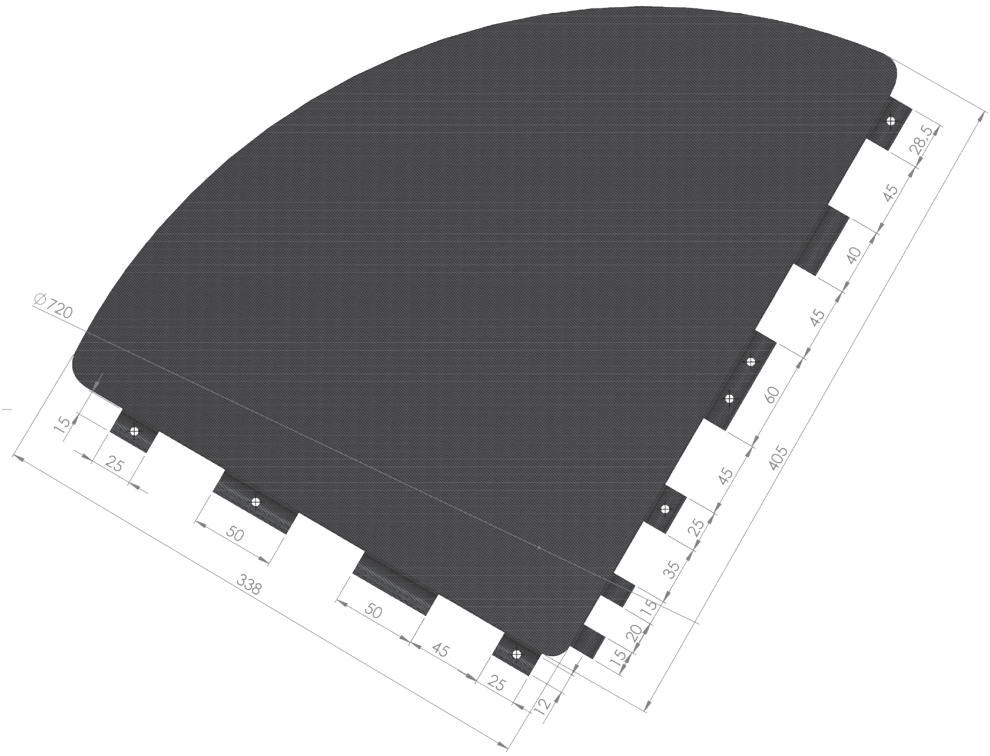
# Final design - Wheel cover




*Untrimmed wheel cover*

The wheel cover is one of the largest parts in the design. It is also a complex part, featuring several mounting holes and being attached to both the carrier's frame and the mud guard. Furthermore it has a double curved surface as it connects the rotated frame with the mud guard.

The wheel cover will also be made by thermoforming. This way this relatively big parts can be made in a cost-effective way. As the wheel cover forms one volume with the folding part it will be made from the same material, Polypropylene. Also it will have the same surface finishing, in this case a carbon fibre like texture.




*Trimmed with dimensions*

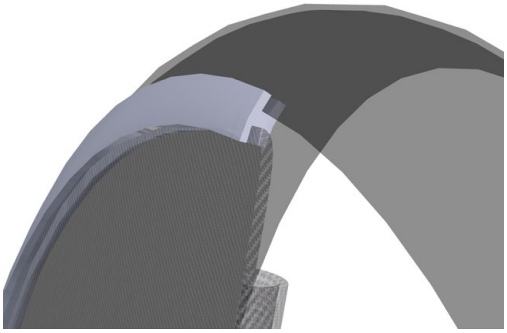
*Cost price*
Using the dimensions of the wheel cover the mould costs are estimated at 2080 euro, using the same calculator of Batelaan Kunststoffen B.V. This results in a cost price 0,20 euro per part (with 10.000 as a production number). For the trimming of the part and other post-processing an amount of 1,50- euro per part is estimated. Like for the carrier part the material costs are estimated at 2,- euro.
This results in a cost price of 4,20 euro for the wheel cover.

**Wheel cover strip**

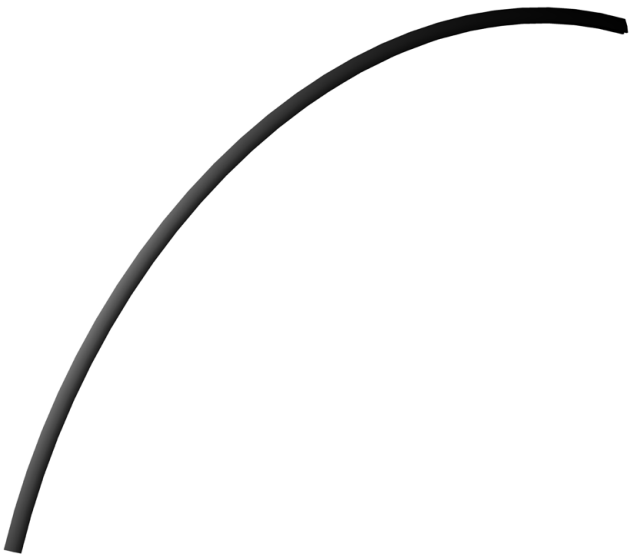
The wheel cover will need to be connected to the rear mud guard. This connection needs to be continues along the complete length of the wheel cover as gaps between the mud guard and wheel cover should be avoided to prevent dirt from the rear wheel reaching the bag.

In order to make this connection a rubber profile is clamped in between the wheel cover and the mud guard. This profile has a sort of H-form and form fits in between the wheel cover and the mud guard. This way it can be made by extrusion. The material will also be an elastomer like Styrene butadiene rubber (SBR).

*Cost price*
The cost price of extruded plastic parts is usually relatively low as tooling costs are low compared to other plastic shaping techniques. The cost price of the wheel cover strip is estimated at 1,- euro.



*Wheel cover strip in place*



*Wheel cover strip*

# Final design - Mounting strap

The mounting strap will be made from woven Nylon. It will be attached to the frame with the same bolts that also secure the wheel cover. In order to do this the mounting strap will need to be reinforced at the connection point to the frame by folding the strap and sewing it together.

**Mounting hook**

The hook of the mounting strap will be made from bent RVS. This way it will be rust-free and durable. The mounting hook will be covered with a rubber layer in order to protect the bicycle frame from scratches.

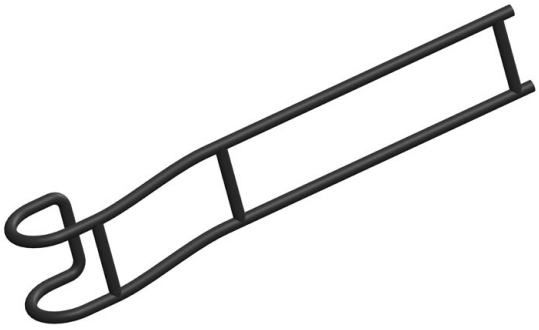
**Cover mounting hook**

The top of the mounting hook will get a leather cover. This is the point were the elastic mounting strap is attached to the hook and where the user handles the hook in order to secure his bag.

For the mounting strap and the mounting hook are estimated as follows:
- Mounting strap 2,-
- Mounting hook 1,-
- Cover mounting hook 2,-

*Complete mounting strap*

*Mounting strap*



*Mounting hook*

*Cover mounting hook*

# Final design - Cost price

In the design criteria the cost price target was set at 40 euro. During the final design phase it was however tried to come to a lower cost price, as Gazelle put forward the desire to also sell the carrier design instead of just leasing it.

**Bill of materials**

| | |
|---|---|
| - Frame | 5,- |
| - Sliding mount | 3,- |
| - Top mount | 2,50 |
| - Rear mount | 0,75 |
| - Rear light glass | 2,- |
| - Rear light reflector | 1,- |
| - Rear light LEDs | 1,- |
| - Rear light wire | 1,- |
| - Mounting bolts | 1,30 |
| - Folding part | 4,50,- |
| - Wheel cover | 4,20,- |
| - Shock absorbing blocks | 2,- |
| - Wheel cover strip | 1,- |
| - Mounting strap | 2,- |
| - Mounting hook | 1,- |
| - Cover mounting hook | 2,- |
| | |
| Total | 34,25 |

By further optimization the cost price could possible be brought down even further. In the next stage of developing the laptop carrier manufacturers should be contacted to get more exact cost prices estimations.

In the cost price of the laptop carrier the costs which are saved by not mounting a normal rear carrier and a rear light are not included. If these costs would be subtracted the laptop carrier would be even less costly.

# Final design - Stress calculations

The load of the laptop bag is mostly subjected to the folding part, both a the bottom part and the top part. It is expected that therefore this part is most critical in terms of stress and deformation. In order to determine if the polypropylene part can withstand these stresses have been calculated by hand and additionally a couple of simulations has been made in SolidWorks.
Also the frame of the laptop carrier was simulated in SolidWorks.

**Bottom of folding part**

*Material properties*
Yield strength Polypropylene: 12-43 MPa
Ultimate tensile strength Polypropylene: 19.7–80 MPa

The stresses occurring in the bottom of the folding part have both been calculated manually and using SolidWorks simulations.
For this calculation it is assumed the complete load is placed on the bottom part of the folding part. This means a weight of 7 Kg will be subjected tot he bottom support part. In reality this is not the case as about half of the load is transferred to the upper part of the folding part and the wheel cover.

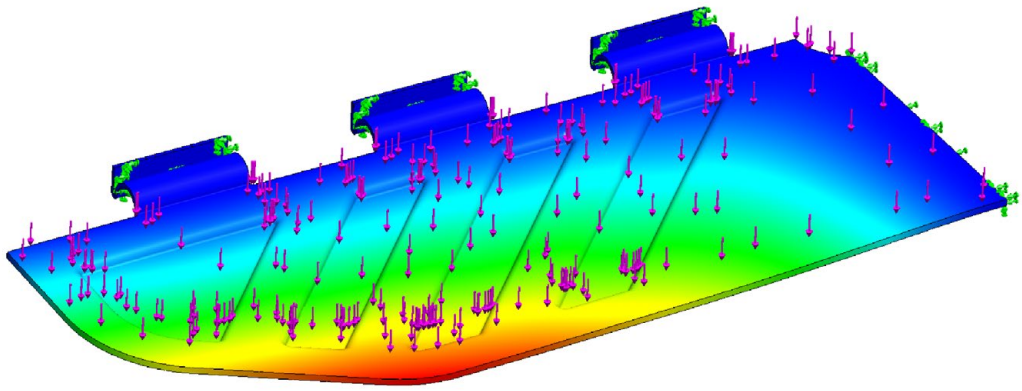
*Manual calculation*
The load is considered to be concentrated at a distance of 7,5 cm from the hinge, which is half of the maximum dimensions of the laptop bag. Using this value as a arm the bending moment on the hinge design can be calculated:
7*10*0,075 = 5,25 Nm

The diameter of the frame tube at the hinge point is 12 mm, which means the arm at the hinge is 6 mm. Using this arm the resulting force at the hinge can be calculated.
7*10*0,075/0,005 = 1.050 Newton

The surface area which has to withstand this load is the area of the three hinge parts combined:
3*45*1,4 = 189 mm^2

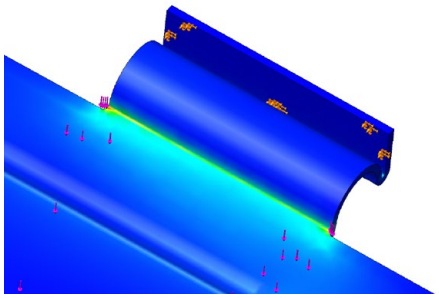
The resulting stress:
1.050 / 189 = 5,56 Mpa

This is well within the limits of the Polypropylene material properties.



*Large displacement in SolidWorks simulation*

*SolidWorks simulation*
When applying the same loads in Solidworks simulations the results were quite different.
The simulation resulted in a stress concentration of 56 MPa at the transition to the hinge. This has probably to do with the small radius at that point.
In order to reduce this stress concentration the transition to the hinge would need to be optimised geometry wise.



*Stress concentration*

Also the SolidWorks simulation lead to a quite large deformation of 10,6 mm. in the part. Although a little deformation and flexibility is not a problem this is a little too much. Luckily enough this simluation has been made with the complete load of the laptop. It needs to be further analysed how much of a problem deformation really is.

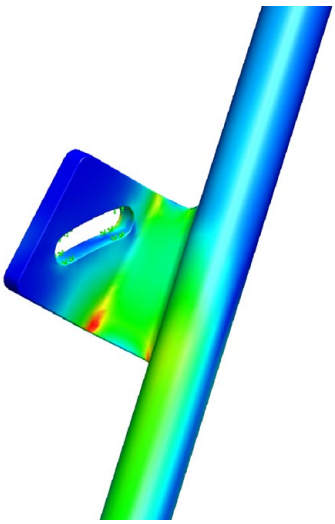
**Frame**

The frame was also simulated in SolidWorks as this is the part which needs to transfer all the loads to the bicycle's frame. As the frame is made from extruded aluminium it is not expected to be critical but still it was something to check.

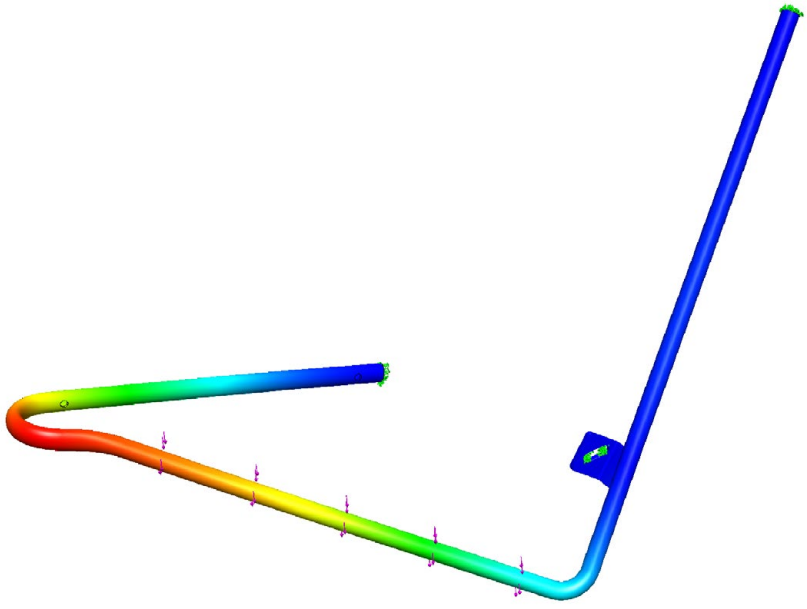
*Material properties*
Aluminium 6061-T6 yield strength: 240 MPa
Aluminium 6061-T6 ultimate tensile strength: 290 MPa

To account for dynamic loads a safety factor of 2 has been applied, which is a common factor for bicycle frame simulations. Additionally a safety factor of 1,5 was applied, resulting in a safety factor of 3. This means a load of 210 Newton will be applied to the frame. The load was subjected to the bottom part of the frame to make things worse.

The resulted stress of the simulation was well within limits with 146 MPa. The resulting deformation was quite high at 5,6 mm. Luckily like the deformation of the folding part this will not often occur in real life as the load will be better distributed over the frame. Also the safety factor of 3 means this high deformation will not happen easily in real life.



*Stress concentration at mounting point*



*Displacement of 5,6 mm in SoliWorks simulation*

# Evaluation

# Concept evaluation

The concept has been evaluated based on the mock-ups and renders of the final design.
Using the mock-ups the general working principles have been tested and with the renders the final styling and design has been evaluated.

The design has been evaluated under colleagues at Gazelle, of which many do fall in the target group. Many of them do have younger children and are thus young family men (or women). Among these colleagues a variety of travel means and distances are present. For some commuting by bike is not an option because of the distance, but part of them often commutes by bike.

In general the reactions to the concept were very positive. The idea to mount the laptop bag in a diagonal position was perceived as new and original. Also the way the carrier can be folded and the mounting were judged positively.
Some remarks were made about the material choices in relation to strength and durability. Especially during high dynamic loads there were doubts about the durability of the chosen materials.

**Recommendations**

*Stress tests*
Further stress testing needs to be done in order to test the feasibility of the design. Especially the dynamic loads on the carrier are a worry as the impact of road bumps or a high curb can be quite high. Also a fatigue analysis needs to be made, especially for the living hinge design.
Based on these tests some smaller adjustments to the design will likely need to be made.

*Material selection*
The materials for the parts have been defined, but not in complete detail. |Especially for the large plastic parts the surface finish needs to be investigated further. In cooperation with the company who will make the thermoformed parts a surface finish needs to be chosen. Also it needs to be seen if different surface finishes are possible.

*Production methods*
To make the design ready for production the production methods should be defined further. Next step in the process would be to contact manufacturers and see what the possibilities and prices would be exactly. Most likely the aluminium and plastic parts will be sourced from different suppliers.

*Fitting*
The fitting to other bikes in the Gazelle portfolio needs to be worked out further as well. The design will probably fit to the Gazelle Ultimate family and also other bikes do have the same kind of mounting point.

**Conclusions**

The carrier design is not ready for production yet. Some first steps in making the design ready for production have been made however and the design appears to be feasible.

The concept of the carrier design is new and original and in that sense quite innovative. Similar carrier design are not existing and the closest design is the 'Attaché mee' from Steco.

This means that Gazelle would have a unique proposition with this carrier design and when offered at the desired price point it would have a high market potential.

**Commuting**

The concept does make commuting by bike more attractive as it solves the luggage problem.
It offers an easy way to transport your laptop bag or backpack, which means one of the obstacles to commuting by bike is being solved.

**Target group**

The design will appeal to the target group because it is something new and original. Also its modern design will be appreciated and ease of use will probably be valued b the target group.

The choice to offer the concept as part of a lease construction was partly made in order to suit the target group. Having to pay a monthly fee and not having to worry about their bike will be a large befit for the target group. Also the inclusion of accessories like the laptop carrier in the lease construction will be appreciated by the target group.
Ideally they would also like to be able to customize the lease bike in the ordering process. If for example one could choose the colour of the bike and the colour of the laptop carrier in the order process this would be attractive to the styling sensitive target group.

# Process evaluation

In the research phase some time has been lost in choosing the right research type for the project. After the literature study a considerable amount of time was put in the making of an online questionnaire, which was not used in the end. It took until January to decide to mainly focus on interviews for the user research. If this decision would have been made earlier more time could have been spend on the interviews.
Mainly because of this the research phase did take a bit longer.

During the development of the design direction and early idea generation phase the project got stuck a little bit. In this phase I did not manage to come to conclusions and to make design decisions. For this reason I spend quite a lot of time in the formulation and development of the design direction, which resulted in a reduction of time for the concept development phase.
At this stage of the project he scope of it was still too wide and too vague. As a result many design ideas in multiple directions were developed without becoming concrete.

Because of the lost time in determining the design process and the first part of the idea generation there was little time left for concept development and final design. This meant less time could be spend to really work out the concepts and also in the development of the final design limited time was left.

Basically the first steps in the project did take longer than anticipated and resulted in the two month extension of the project. The main reason for this was the difficulties I had with making decisions and making things concrete.

In the end the finishing of the final design needed to be rushed a lot. This is the reason not all things in the final design have been worked out completely.

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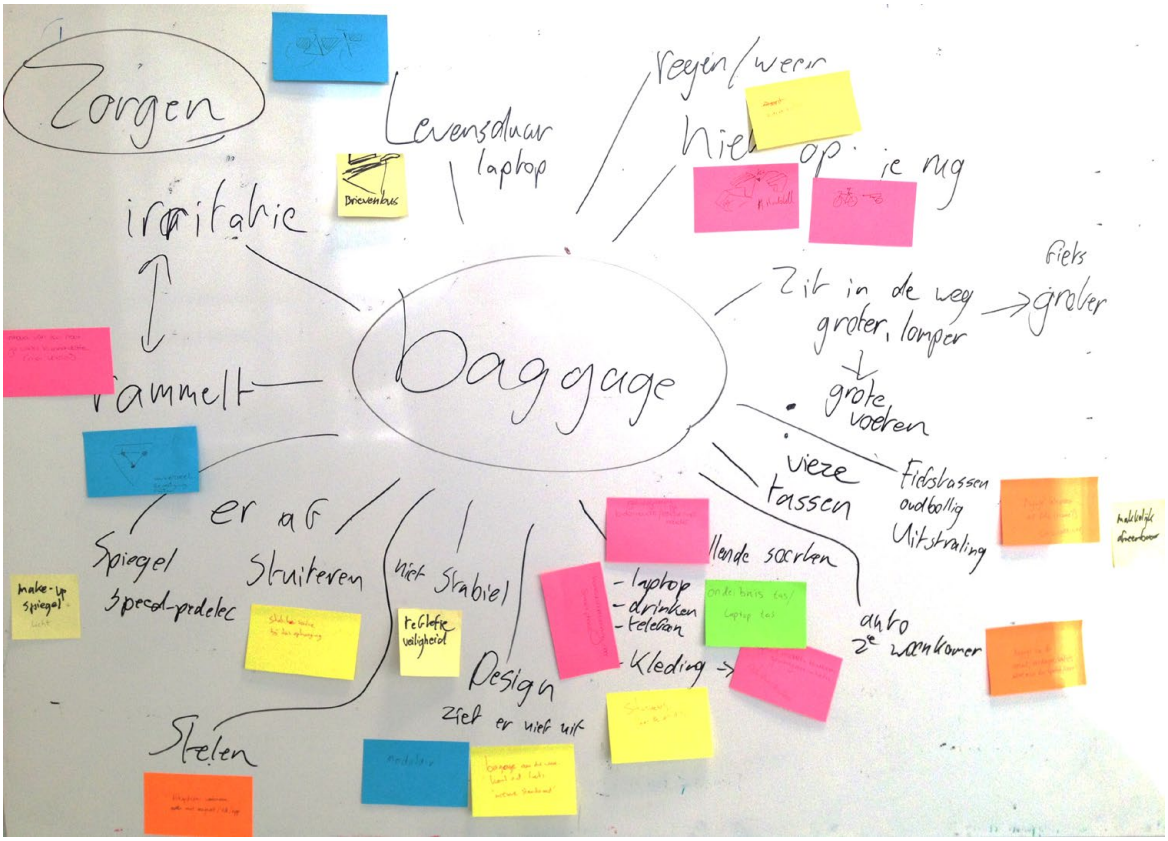
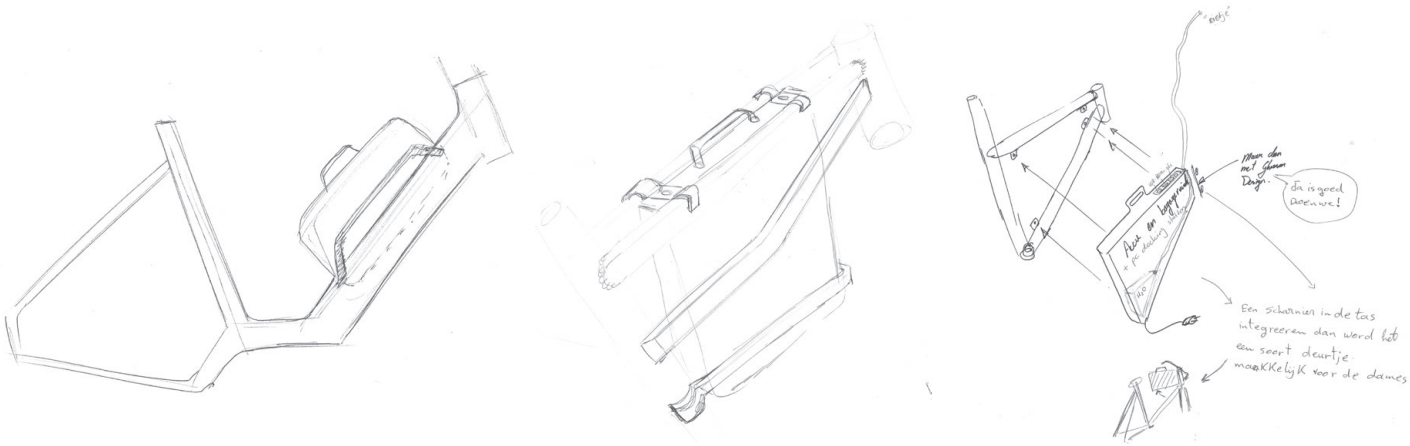
# Appendix 1 - Brainstorm session




*Mind-map problem analysis*

On Thursday 23th a brainstorm session with part of the innovation team was organised. Goal of this session was to first present the project to the team and afterwards have a small brainstorm session with the team. In this brainstorm session first the baggage problem was analysed. The result of this can be seen in the mind-map above. Based on this ideas were generated, first in a group session and afterwards using individual brainstorm techniques. In the individual part the participants all came up with different ideas to integrate a bag inside the frame (shown below).



*In-frame bag*