Exploring the transformation of a PSS into an SPSS through co-creation

Graduation Report | Luuc van Tiel | Strategic Product Design

TU Delft

Swapfiets

Exploring the transformation of a PSS into an SPSS through co-creation

June, 2019

Author

Luuc van Tiel

Education

Delft University of Technology
Faculty of Industrial Desing Engineering
Strategic Product Design

Chair

Sylvia Mooij
Prodduct Innovation Management

Mentor

Phil Brown
PhD in Circular Product Design

Company

Swapfiets

Company Mentor

Luuk de Leeuw
Product Manager, Team Bike

Preface |

Three years ago, I worked at Swapfiets as a bicycle mechanic. In that time, Swapfiets was growing and operations started to take shape. I still have good memories of the group of colleagues I worked with and the fun we had while working. Now, Swapfiets has grown from a Delft based company to a scaleup, operating in four countries with over 125.000 customers. I am happy to say that, despite the immense growth, it is still a treat to work at Swapfiets. The mindset of making it happen and having fun while doing so is still clearly present.

The project has brought me a lot of memories which I am sure I will remember and for which I am grateful. This project would not have been possible without the founders of Swapfiets, who helped me to define the challenge and gave me the freedom to take on the challenge in my way. Thank you Martijn, for your enthusiasm and participation in this project. I know your schedule is fully booked, however you always took the time for our discussions. Thank you Luuk, for your support throughout the whole project. Our meetings always gave me new insights and moreover: were a lot of fun. Thanks for believing in me and your supportive attitude, especially during the sessions.

This report would definitely not have been the same without Sylvia and Phil. Thank you both for believing in me. I can genuinely say that I learned a lot during this process (or methodology?). Thank you Sylvia, for your spot-on analyses and how you challenged me to get the best out of myself. Thank you Phil, for all our conversations, discussions and coffee breaks. You always asked the right questions to get me going and was always available to answer my questions.

My thanks to Fronteer, for allowing me to use their methodology and supporting me in executing it correctly.

I want to thank my family for their unconditional support throughout this project. Sophie, I want to thank you for your personal support throughout this project and always cheering me up when needed.

I am excited to present you this report. Enjoy the read!

Luuc van Tiel

Executive Summary |

This report contains a graduation project for the Delft University of Technology's master programme Strategic Product Design in collaboration with the company Swapfiets.

The goal of the project was to revise the material flow of the bicycle frames and simultaneously adapt a methodology that Swapfiets can use for future material flow improvements.

Swapfiets is founded four years ago by three students of the Delft University of Technology. Swapfiets offers bicycles as a service: customers pay a monthly fee to get a Swapfiets bicycle and whenever something is wrong with the bicycle, Swapfiets makes sure the bicycle is repaired or replaced with a working bicycle. Swapfiets' product service system (PSS) has proven to be very successful and Swapfiets scaled up from 160 paying customers to 80.000 customers within one year.

Rapidly scaling up has brought many new challenges to the company. Two of such challenges form the subjects of this research: 1) What can Swapfiets do with the bicycle frames, when they are at the end of their lifetime? And 2) How should the methodology for revision of the material flow be set up?

The current material flow of the bicycles leaves room for improvement. The bicycle is not designed from a lifecycle perspective, but it is optimised to increase the maintenance efficiency and prolong its lifetime. When the bicycles are not of sufficient quality to be used anymore, they are grinded in half and disposed as waste. However, the bicycle frames could also be treated as circular supplies, by recycling, refurbishment or reuse. Besides creating circular supplies from waste, the frames' raw materials could also be recovered and brought back in the material flow for procurement.

Reasons for Swapfiets to revise the material flow are diverse. The current material flow is unsustainable and can directly harm the brand value, on which Swapfiets builds strongly. Furthermore, it is economical unbeneficial, since the depreciated value of the frames are turned into direct costs when thrown away. Closing the material loop can add economic and brand value to the PSS.

However, there is no methodology in place at Swapfiets to revise the material flow of the bicycles. The current way of working is not long term focused. Comparing Swapfiets' PSS to other PSSs described in literature, shows that a closed material loop is a common success factor for PSSs. A PSS with a closed material loop is referred to as a sustainable product service system (SPSS). Optimising the lifecycle to create an economic benefit is one of the main drivers to develop an SPSS.

No methodology is yet developed to transform a PSS into an SPSS. However, barriers to overcome and success factors to develop an SPSS are extensively described in literature. To create a successful SPSS, the project vision should be flexible, the network should be reconfigured and managed strategically. A methodology that has the capabilities to fulfil these requirements is co-creation. Co-creation is the joint development of concepts by the firm, its network and other external participants.

For co-creation, the network is reconfigured by inviting a mixed set of participants. However, little research is done to link different sets of participants to the quality of the outcome. This research is exploring that gap, by organising two co-creation sessions with two sets of participants. The first set of participants are operating in the same sector as Swapfiets: inter-sector actors. The second set of participants are actors who have similar PSSs, but in different sectors: cross-sector actors. The two sets of participants are posed with the same question: how to keep the bicycle's frame longer in the loop?

The results of the research are separated in two categories: outcome and process. The direct outcomes of the sessions are three concepts for each session. Inter-sector co-creation shows a more technical focus and concepts can be implemented in the mid- or long-term. Cross-sector co-creation shows a customer centric focus and the concepts can be implemented in short-term.

Both sessions show how interactions between all actors open windows for collaborations. Inter-sector actors are more interested in possible business partnerships, while cross-sector actors are eager to create in-kind collaborations.

The co-creation process causes actors to find common ground. Inter-sector actors are more precautious in sharing information or experience, since they considered Swapfiets as a potential competitor. This was not the case for cross-sector actors, who share very specific information about their own companies.

For Swapfiets, this project has generated six possible solutions to improve the material flow. Three of them are elaborated on in this thesis, supported by strategic roadmaps. Furthermore, it has proven how co-creation can help Swapfiets to innovate their material flow. Involving external participants can bring the knowledge and experience Swapfiets lacks. A participant selection tool is developed, to support Swapfiets in inviting the right participants to get the desired result.

Reading Guide |

The report is separated in four phases. Before going in-depth, the company and the assignment for this project are introduced in chapter 1. After the introduction, the project diverges by analysing Swapfiets, the market it operates in and the trends in society. From that point, the project converges by selecting a methodology suitable for the problem context. In the third phase, execution, the selected methodology is used to solve the posed problem. In the last phase, deliver, all insights are gathered and translated into solutions.

Throughout the report, conclusions are highlighted by a blue box around the text.

Conclusion

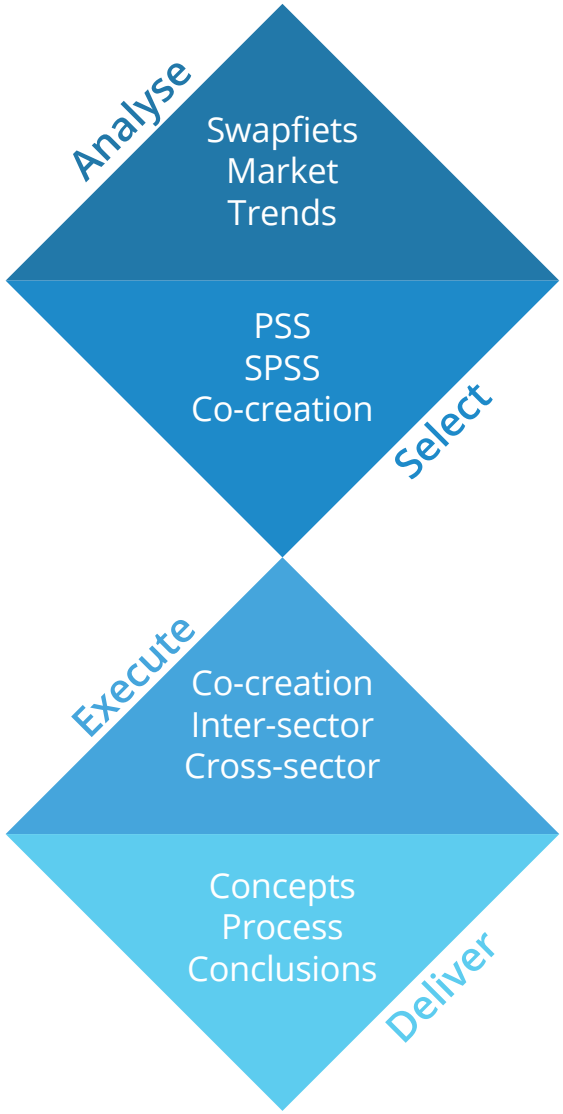


Figure 1 - The four phases of the report

0 | Content

1 | Introduction

This report is the result of the graduation project of the master programme Strategic Product Design at the Delft University of Technology. This project is executed in collaboration with Swapfiets, which is founded four years ago by three students of the Delft University of Technology. Since then, it has grown rapidly into a company that is currently providing more than 125.000 customers with a bicycle and the accompanying service.

This first chapter introduces Swapfiets and the assignment executed in this project.

1.1 | Swapfiets

Swapfiets is founded four years ago by three students of the Delft University of Technology. They observed the bad state of the student's bicycles in the city, what often leads to dangerous situations. Their solution: your bicycle, as a service. So they created a system to provide the service; a product service system (PSS). The product service system (Figure 2) is fairly simple; a customer pays a monthly fee to make use of a bicycle. It starts by ordering a bicycle, a 'Swapfiets' (name of the bicycle), and planning a delivery date. The bicycle is delivered by car, an electrical bicycle with a trailer or can be picked up at a local Swapfiets store. Whenever there is a problem with the bicycle, the customer calls Swapfiets or arranges an appointment via the app. Then, there are three options; either an employee goes to the customer to apply an easy fix, the bicycle is picked up by car and is swapped with a working bicycle, or the customer can go to the local store to swap the bicycle.

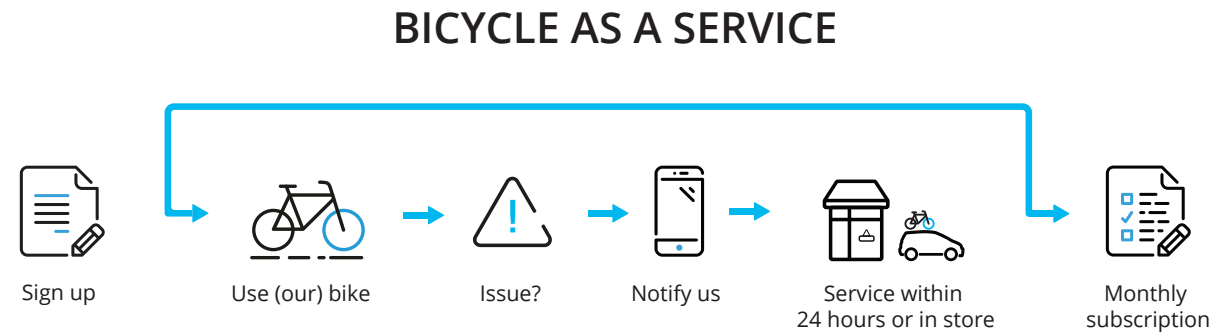


Figure 2 - Explanation of the subscription model (source: Swapfiets)

From start-up to scale-up

It all started with repairing old bicycles from scrapyards to a decent bicycle (Figure 3). To make the bicycle recognisable, they were fitted with a blue tire in the front. Nowadays, this is the well-known trademark for Swapfiets. Another trademark are the small cars with four bicycles on the roof, for deliveries and pick-ups (Figure 4). This also derives from the early beginning of Swapfiets, when they borrowed a roof rack to deliver bicycles with an old car (Figure 3).

Figure 3 - Swapfiets' assets in the first months. The first car (left) and the first workshop (right) (source: Swapfiets)

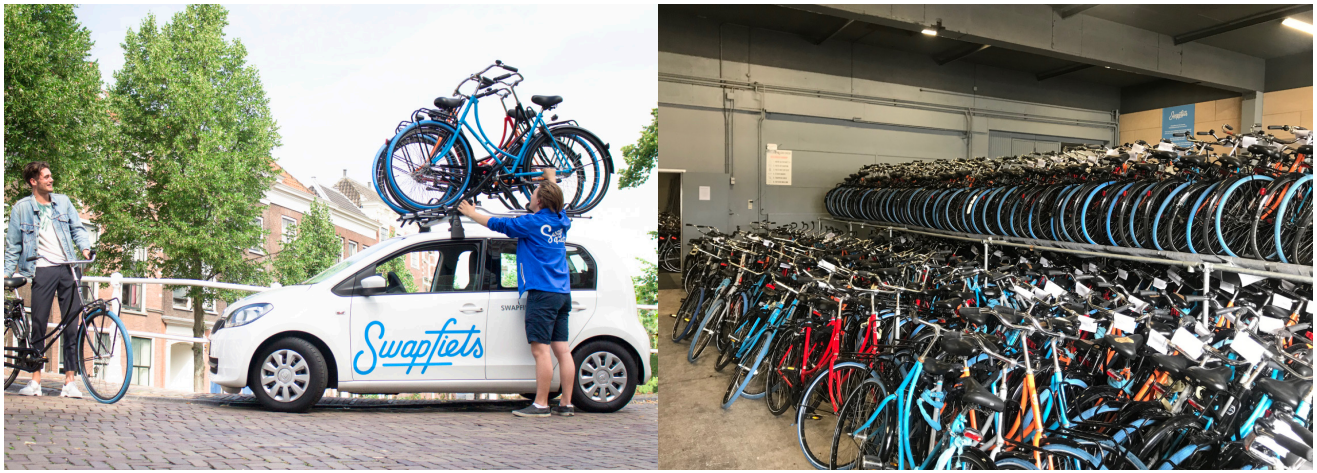


Figure 4 - The current branded car with four bicycles on the roof (left) and a current warehouse (right) (source: Swapfiets)

The start was very successful and Swapfiets grew to 160 paying customers within six months. Figure 5 shows the increase of customers (riding customers) together with the growing demand (orderbook). From that point on, the founders started to attract attention from investors to make further growth possible. Eventually, a deal was made with an investor. Due to confidentiality, more information about the investor cannot be shared in this public report.

Due to the investment, Swapfiets grew rapidly (Figure 6). Next to the growth, Swapfiets was able to design and produce its own bicycle. Within four years Swapfiets expanded from providing subscription bicycles in one city to 35 cities, in four countries. Nowadays, there are over 125.000 customers. Swapfiets operates in the Netherlands, Denmark, Germany and Belgium.

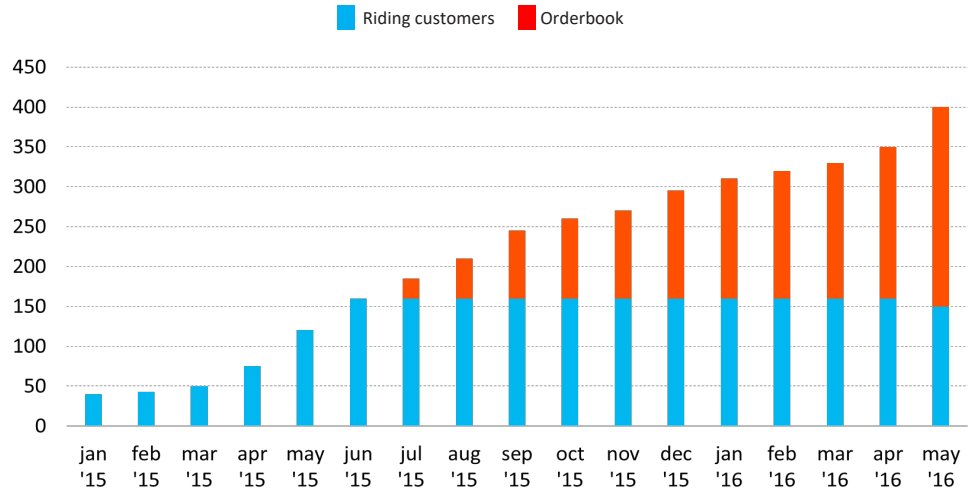


Figure 5 - Graph of number of subscriptions in the first year, combined with the orderbook (source: Swapfiets)

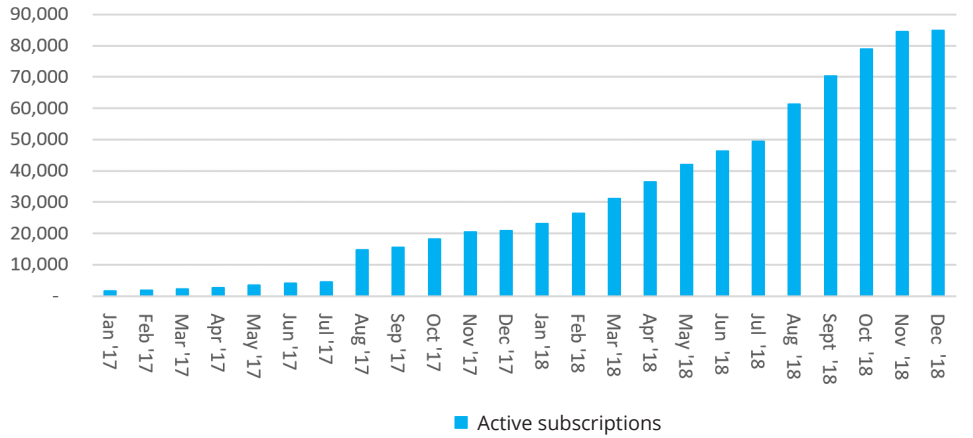


Figure 6 - Graph that visualises the fast growth from 2017-2018 (source: Swapfiets)

1.2 | Problem Definition

The immense growth has led to new challenges for Swapfiets to solve. Next to keep on growing and increasing efficiency of the processes, another unsolved challenge surfaced: the bicycles' material flow. Swapfiets has designed its own bicycle to optimise the ease of maintenance. The bicycles in use are brand new and will be kept in use within the service until they are not of high enough quality anymore. The challenge Swapfiets faces is: what should be done with the bicycles when they are degraded to this level?

For now, the solution is to throw them away and reuse the parts that are still of sufficient quality. Swapfiets is eager to improve the material flow, since it might create added value of the bicycles, even after the depreciation period. However, Swapfiets does not have a methodology to revise the material flow, which is an addition to the material flow challenge.

So there is a clear distinction to be made between two problems for this project. First there is the problem on what to do with the bicycle frames and second, there is no methodology in place to approach the first problem. This concludes in the following two questions:

1. What can Swapfiets do with the bicycle frames, when they are at the end of their lifetime?

2. How should the methodology for revision of the material flow be set up?

Figure 7 -Bicycle graveyard in China (source: Wired)

1.3 | Assignment

Since Swapfiets does not have a methodology in place to tackle such problems, there is a need to develop one. This methodology should be tailored to fit the organisation, so that it can be used for future material flow improvements. A methodology is introduced and adapted, with the first problem as the subject for testing and evaluating the selected methodology.

Adapting an approach, together with the problem definition, leads to the assignment for this project:

Adapt a methodology to revise the material flow of a product service system.

1.4 | Approach

This graduation project is set up and conducted over a period of six months. To create a clear representation of the process, the approach is divided in four phases (Figure 8). Each phase is executed sequentially and building up on the foregoing phases.

Currently, there is no process in place to revise the material flow. This thesis will select and execute an existing methodology to investigate how that methodology can help Swapfiets in developing a solution. Where needed, the methodology will be tailored to Swapfiets' organisation. The approach for this project is based on the double diamond model (UK Design council, 2005).

It starts by analysing the context of the project, followed by the selection of an appropriate methodology for Swapfiets. This methodology will be used in the execution phase, to find solutions for the posed challenge. Finally, these concepts together with an adaption of the used methodology will be tailored to the organisation in the deliver phase.

Analyse

An analysis of the company context is made to emphasise with the organisation and to find possible solutions to the problem. This analysis is thus divided in an internal and external analysis. The internal analysis will highlight the company its core values, strengths and the context of the problem. The external analysis is focused on trends and market developments.

Select

Within the context of the assignment, the methodology selection is made in the select phase. Literature is reviewed to find a suitable methodology for the assignment and for Swapfiets.

Execute

The third phase is about the execution of the selected methodology. The outcomes of the execution are evaluated and discussed. The methodology itself is evaluated on how it fits the context.

Deliver

This phase is about what the outcomes of the execution imply for Swapfiets and how the methodology could be used in the context. It concludes with recommendations for the future.

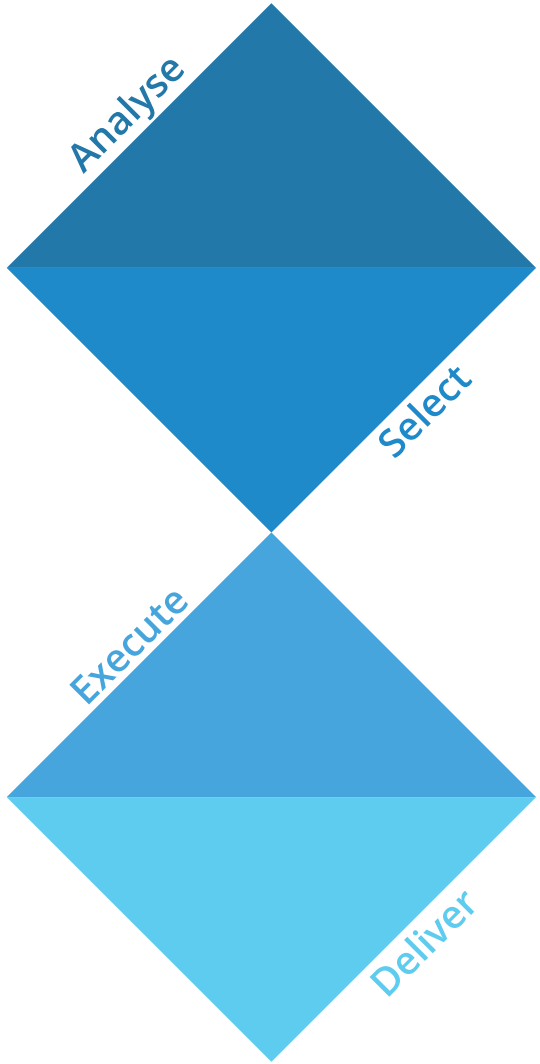


Figure 8 - The four phases of the project (own figure; based on UK Design council, 2005)


CB39
CB37
SWAPFIETS
FIETS

2 | Analysis

The analysis phase is separated in the internal and external analysis. First, the internal analysis is made to empathise with the organisation. Thereafter, external influences are examined to review the impact they might or will have on Swapfiets.

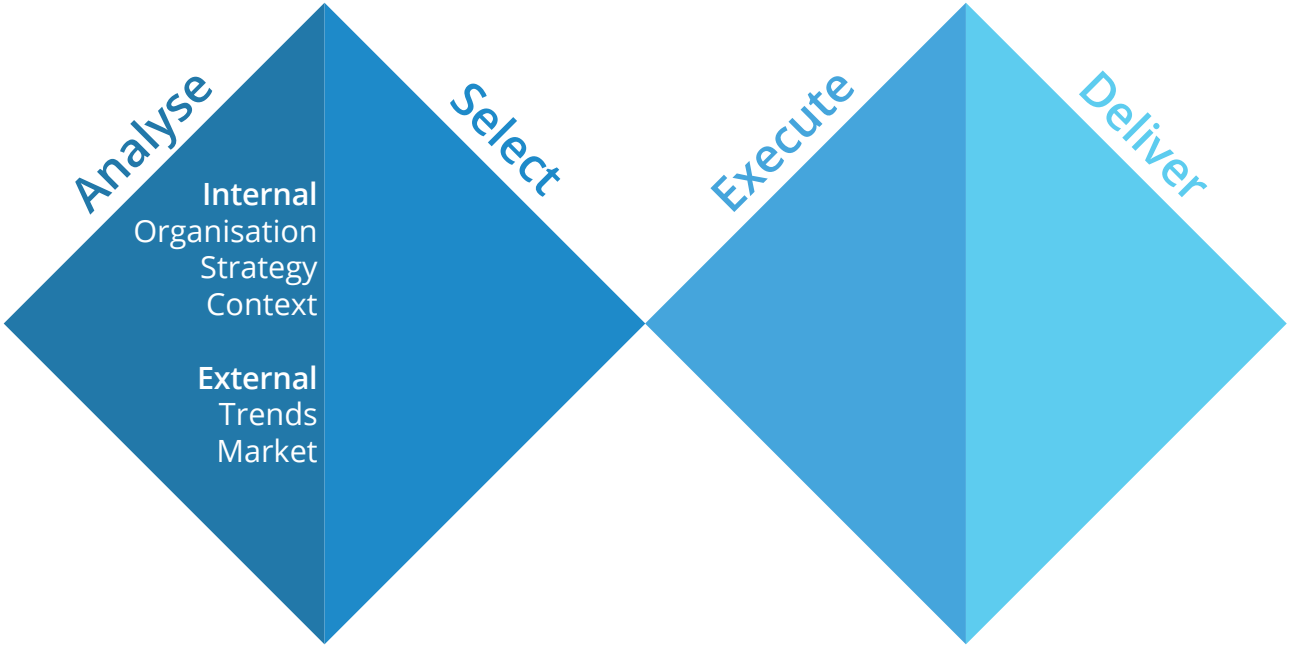


Figure 9 - Phase 1: Analyse (own figure; based on UK Design council, 2005)

2.1 | Internal Analysis

To empathise with the organisation, an internal analysis is made. The organisational structure is discussed to show the perspective from which the assignment is executed. To be able to fit the methodology to the organisation, the strategy, ambition and goals are described. To assess how the solutions fit the brand, the brand values and perception are discussed. Lastly, the problem context is elaborated, to create more background information about the arguments for the assignment.

2.1.1 Organisation

Due to the growth, the organisational structure has been a subject to change multiple times in the previous years. The headquarters moved from Delft to Amsterdam, to create more workspace and to be better reachable. The organisation is divided in five departments (Figure 10): sales, operations, finance, products and human resources. Each team is managed by a member of the management team, which in turn is managed by the general manager. The management team reports to Pon via the supervisory board.

Process wise changes are communicated to regional and city managers, who supervise and instruct the operational level employees; mechanics and swappers (delivering and picking up the bicycles).

Improving the material flow of the bicycles is a challenge for *Team Bike*, which is a sub team of the products department. Team Bike consists of a member of the management team, a product manager, two logistic planners and a quality supervisor.

Swapfiets innovates from a top-down approach. Improvements and changes are communicated from the top-layer towards the operational level employees. Team Bike hardly ever involves this level of employees in projects, what has led to frustrations among mechanics (interview 4).

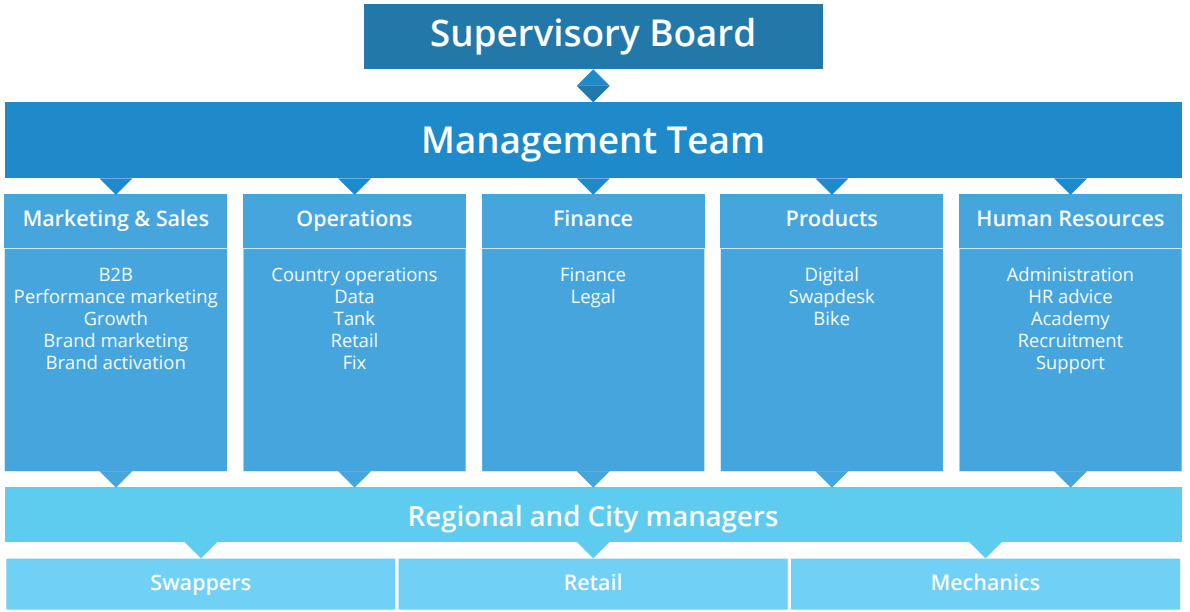


Figure 10 - Organogram Swapfiets (own figure; based on interviews and internal documents)

2.1.2. Ambition

Swapfiets foresees a world where nobody has to worry about a bicycle. In this world, the bicycle is the most common way of human transportation. People will use the bicycle to go to school, to commute, to do the grocery shopping and to just go for a spin. Customers of Swapfiets will not have a moment without a bicycle whenever they are in need for it.

Swapfiets provides the system for people not to worry about their bicycle. From the first bicycle with training wheels to an electrical supported bicycle, Swapfiets will provide you with whatever bicycle you need. Through their supreme service, customers will not even notify the process of 'swapping' the bicycle. Their ultimate ambition is:

"A blue tire in every bike rack. Everywhere."

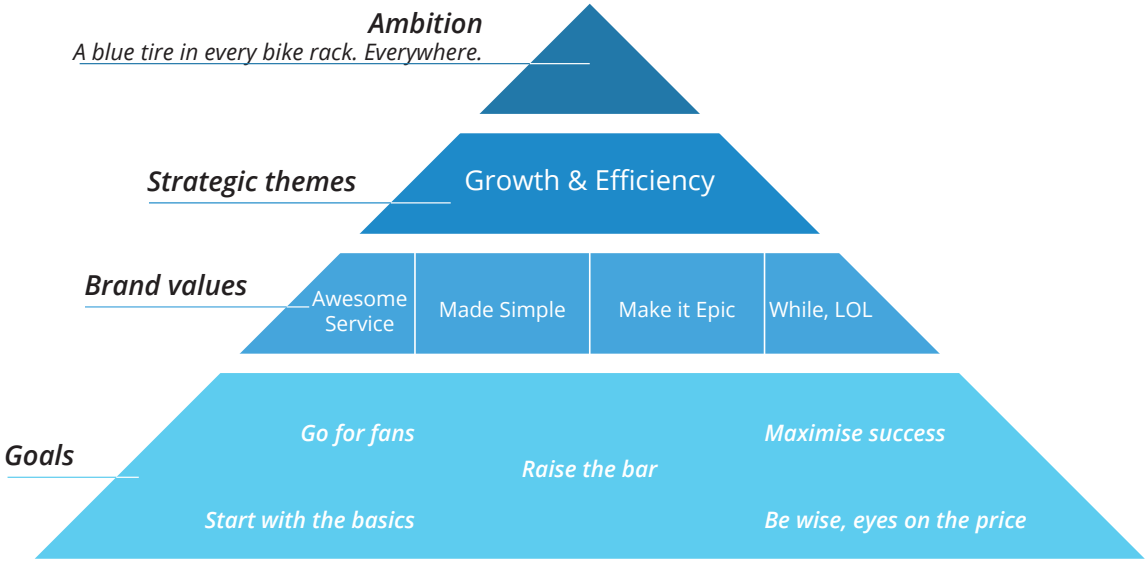


Figure 11 - Visualisation of the ambition, strategy, brand values and goals (own figure; based on interview 1 and internal documents)

2.1.3. Strategy

Due to the growth of Swapfiets the strategy is adapted continuously to the conditions. Within these shifts, there are however two main focus point derivable; *expansion* and *optimisation* (Figure 11). In 2017, the preparations for expansion started by creating a copiable concept for a warehouse with mechanics, a store design, marketing materials and training for new employees. Doing so, Swapfiets created the strength to penetrate a new city as quickly as possible. From the start of 2018 Swapfiets was fully focused on growth. Due to the preparations in 2017, Swapfiets created a first mover advantage.

After rolling out to so many new cities in 2018, the focus is shifting from expansion to optimisation. Along with the growth, many new challenges arose. Currently, Swapfiets is not profitable yet, due to inefficiencies throughout the organisation (Interview 2) and a declining growth. Swapfiets recognises the main challenge to be more efficient in all processes. Processes to be more efficient are for example: communication streams, customer service, optimising deliveries and pickups, stocks and logistics. This change in focus is needed for Swapfiets to become profitable in the future.

Sustainability is not included as a goal in the strategy, since it is fully focused on growth and becoming profitable. However, the potentiality and advantages of creating sustainable solutions is recognised within the company (interview 1). The influence of sustainability on the brand value and on the financial is recognised and elaborated upon in chapter 2.1.5 and 2.1.6.

2.1.4. Goals

To execute the strategy, goals are set for 2019 (Figure 11). There are four goals set to support Swapfiets' strategy (interview 2). First of all, everything should be created with the scalability and reliability kept in mind; *start with the basics*. Secondly, Swapfiets expects its employees to be focussed on the customers and wants them to challenge themselves and the company: *raise the bar* and *go for fans*. Lastly, employees are encouraged to maximise success by increasing efficiency and including long term profitability in solutions: *maximise success* and *be wise, eyes on the price*.

2.1.5. Brand Values

The PSS Swapfiets offers is focused on service. Not only towards customers, but also internally this is communicated strongly. It cannot be stressed enough that service is key, since it is the added value of the PSS Swapfiets offers. The bicycles are considered to be only a small part of the system (Figure 12).

The changes in strategy throughout the past years have not influenced the brand values, on which Swapfiets builds strongly (Figure 11). Supporting the strategy, the brand values play a leading role in building and maintaining the customer relation. These values supplement each other and all together reflect the focus on customer loyalty. The values are self-explaining and recur in every department of the company:

Awesome Service

Swapfiets wants to deliver an awesome service; it is important the customer feels special and experiences the service as a treat. Swapfiets wants to be that friend you call when your bicycle is broken.

Made Simple

No complicated conditions, no hassle. Everything should be as easy as possible for the customer.

Make it Epic

Take that extra step to give the service an extra touch. Ordinary moments will not be memorized, special moments will.

While, LOL

It is very important to have fun at the working place. Not only because it makes the work environment more fun, but it also directly leads to a more cheerful service.

Figure 12 - Core beliefs Swapfiets (source: Swapfiets)

2.1.6 Brand Perception

The brand name is very valuable to the competitive advantage Swapfiets wants to achieve. Since the whole service is about relieving customers from any problem with their bicycle, the customer relationship is key. To improve and maintain the customer experience, there is a weekly survey amongst 2000 randomly picked, new, existing and leaving customers. In this survey, the customers are asked to rate the service on a scale from one to five and give feedback about the service. The average all time score is 4.68, based on almost 40.000 reactions. Even when only taking customers who are ending the contract into account, it shows a positive appreciation of 4.71.

They are not only getting positive feedback from customers (Figure 13 and 14), but there is also a lot of positive media attention. Newspapers are picking up the fast growth Swapfiets is going through and with every new city entered, more and more international attention is gained.

Swapfiets is already, perhaps wrongfully, perceived as a sustainable alternative for buying a bicycle. In Denmark sustainability already is a driver for customers to buy a subscription (interview 32). Next to this, it is also being notified in media as a sustainable company.

Many marketers are using sustainability in their campaigns to attract the 'green' audience. However, using these terms but not acting upon those promised values is called greenwashing (Furlow, 2010). With sustainability not included in the strategy and no process in place to ensure it, Swapfiets cannot promise its customers to be more sustainable than the traditional model. Swapfiets does not use sustainability actively in marketing campaigns, it does however emphasise sustainability in interviews. When the future shows that Swapfiets is not sustainable, society will question the corporate honesty, which directly influences the main focus of Swapfiets; an excellent customer relationship. In that case, Swapfiets' brand value is endangered.

Lastly, there is the influence of choices made by the management. To reach budget targets, the price is increased from €15,- to €16,50 for the original model. Next to the price increase, the minimal contract term is raised from one month to three months. Both decisions directly affect the customer's perception of the brand, since it is less flexible (interview 31). Such changes highlight how decisions made at management level directly influence the brand perception.

Figure 13 - public appreciation of a customer (source: Instagram)

Figure 14 - Swapfiets conceived as sustainable company (source: Instagram)

2.1.7. Problem Context

The assignment is to adapt a methodology to revise the material flow of the bicycles. To be able to revise it, the current life cycle is analysed and areas for improvement are set forth. First, the product's design and financial aspects are portrayed. To understand the influence of the PSS around the bicycle, the life cycle is analysed from a system perspective.

Bicycle design

The challenge is focussed on the model 'Original', since it is the vast majority of the fleet (Figure 15). The second model is the 'Deluxe', a more advanced bicycles with two hand brakes and three gears. In February 2019, there are 80.000 Originals on the road, against 20.000 'Deluxes'. Due to the close ties with Pon, Swapfiets has designed its own bicycle and changing parts is relatively easy. The bicycle is designed for efficient maintenance and it is optimised to prevent the need for maintenance (Figure 15).

The Original is based on an iconic Dutch designed bicycle; the grandma bicycle ('Omafiets' in Dutch). This popular design is used as a start, from which optimisation began. First, the bicycle is designed to prevent defects. There is no carrier in the back, so a customer cannot carry someone on the back of the bicycle. This prevents damaging the rear wheel. Next, the battery powered lights are replaced with the so-called Reelights- magnetic powered lights- which are always switched on. A third major improvement are the special tires on the bicycles. These top notch tires have multiple anti-flat layers, so that the customer will not get a flat tire easily.

Furthermore, the bicycle is designed to increase the maintenance efficiency. The bicycle itself is kept as simple as possible. Every part attached to the frame has its own thread point, so each part can be replaced without having to remove other parts. The chainguard is kept open, to make it easier to replace the chain, a sprocket or the chainguard itself. Another example are the pedals, which are exchanged with more expensive models, to prevent damage to other bicycles during transport.

The bicycle is thus designed to prevent and optimise maintenance. However, the full life cycle is not taken into account in this design. When designing the bicycle, the end of life was neglected, so there is no purpose for the bicycle at that point in time, except for being thrown away. Aurich et al. (2006) describe how designing not only for maintenance, but also for refurbishment can increase the economic and ecologic performance.

Figure 15 - The model 'Original' and its modifications (source: Swapfiets)

Financial

This chapter contains confidential information about the financial background of Swapfiets. It builds up financial arguments why Swapfiets should solve the challenge.

The PSS Swapfiets provides is capital intensive since Swapfiets owns a bicycle for every customer.

The depreciation of the bicycle is taken into account, what results in a rest value. That rest value would turn into direct costs when no action is taken. These costs can be saved when the bicycles can be reused or refurbished, but it should counterbalance the rest value.

The costs sheet for the whole bicycle is analysed, which shows that the bicycle's frame and fork are the most expensive parts. This supports the argument for this project to focus on the frame and fork.

Furthermore, a sensitivity analysis is made. The analysis determines how different independent values affect the customer lifetime value. The customer lifetime value is a prediction of the net profit of an entire relationship with a customer. A sensitivity analysis is also referred to as a 'what-if simulation'; it predicts the influence of a change in a single variable on the customer lifetime value. By improving the material flow of the bicycles, two factors are considered to be most influenced: investment per bicycle and economic lifetime. The analysis shows that recovering the bicycle frames can be economical beneficial; it influences the customer lifetime value greatly.

System

To better understand the areas for improvement of the material flow, the current material flow is analysed. The bicycle's lifecycle is described from raw materials until it, eventually, becomes waste (Figure 19).

It all starts with raw materials, sold to manufacturers. At this moment, Swapfiets has a whole factory specially equipped for the production of the bicycles. When finished, the bicycles are shipped to a central point in the Netherlands, from where they are distributed to all operational cities. Once at location, access to the bicycle handed over to a customer, from which point the service element begins. When broken, the bicycle is repaired by mechanics. When mechanics consider the bicycle its quality not sufficient anymore and it cannot be fixed, it is grinded in half and thrown away.

Maintenance is key to keep the bicycles in the loop as long as possible. Broken parts are replaced with new ones and thrown away. When a better part is implemented in the design, the old bicycles will be updated as soon as they go through maintenance. Each bicycle that leaves the warehouse should meet the most recent design. Minor paintwork damages can be restored by using the matching paint, available at the workstations.

Eventually, there comes a point where the bicycle frame is not recoverable by easy fixes anymore and it must be thrown away. Swapfiets does not have another solution than to detach the still usable parts and to separate the waste materials in containers. It differs slightly per city, but the containers are in general collected by waste disposal services. The materials are then either reprocessed to usable materials or disposed to landfill.

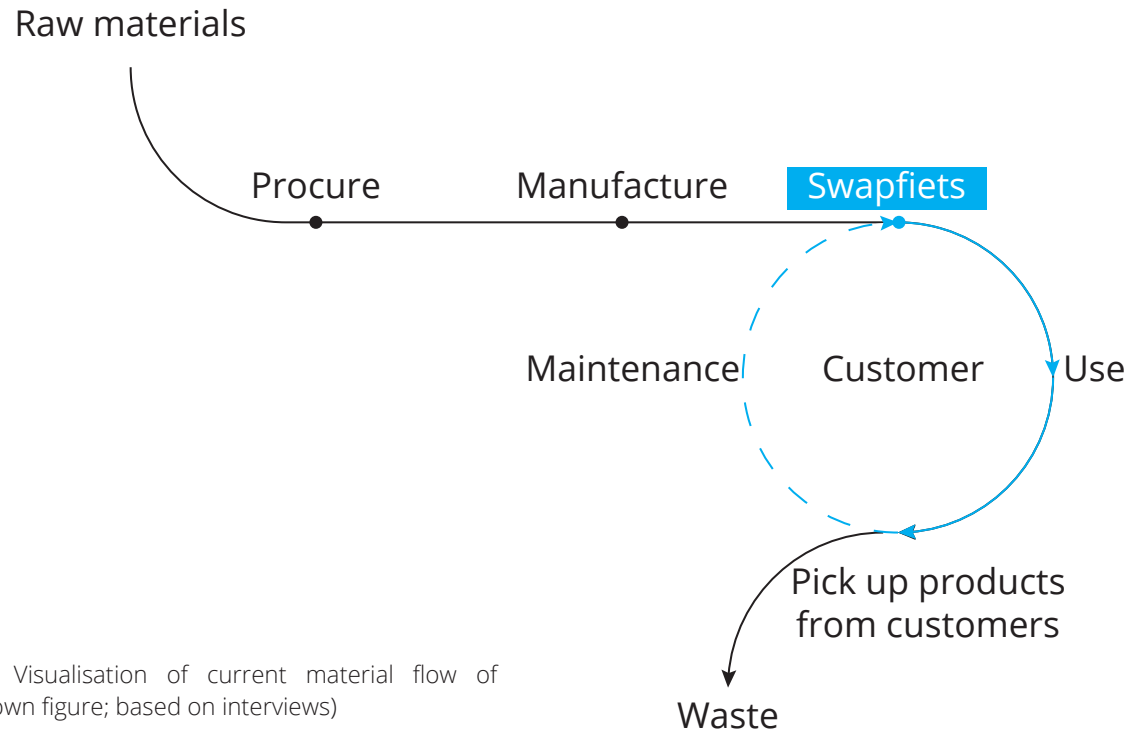


Figure 19 - Visualisation of current material flow of Swapfiets (own figure; based on interviews)

The current system reveals possible solutions to the posed problem. There are multiple ways possible to bring back materials into the material flow (Geissdoerfer et al., 2017). Based on the circular economy model, a closed loop material flow is visualised in Figure 20. For Swapfiets, areas for improvement are the collection of parts for remanufacturing and gathering remaining elements for resource recovery, to be reprocessed for procurement. Next to these missing elements in the current system, the model also emphasises the importance of maintenance to prolong the lifetime (Geissdoerfer et al., 2017).

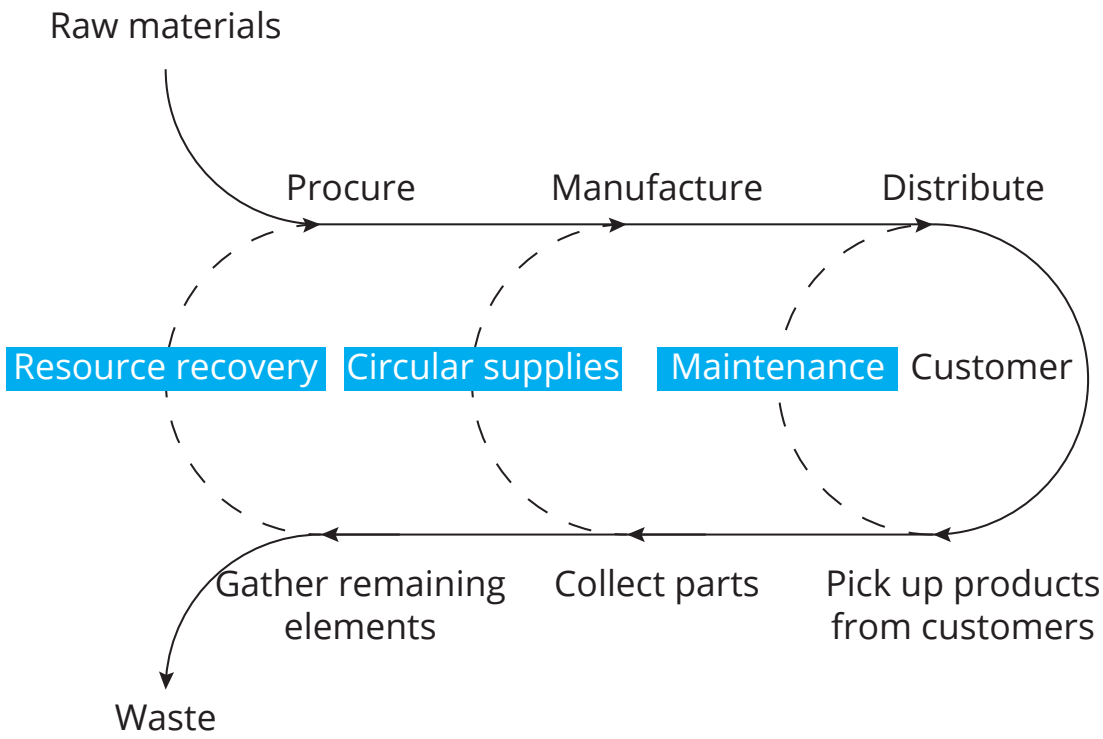


Figure 20 - Visualisation of closed material flow (own figure; based on Geissdoerfer et al., 2017)

2.1.8. Conclusion

The strategy and ambition are very progressive and are focussed on growth. Swapfiets builds strongly upon their brand name, it is considered as the differentiating factor. Less attention is paid to the bicycle itself. It is designed for efficient maintenance and to prevent defects. Although sustainability is not included as a goal in the strategy, it is recognised as a valuable possibility to increase the brand value.

However, the material flow shows a clear area for improvement. There is a limit to what extent the bicycles are recovered. When considered nonrecoverable, they are turned into waste. The financial analysis shows how decreasing the environmental impact could increase the economic value of depreciated bicycles.

When no action is taken, the material flow remains not optimised for sustainability. Whilst Swapfiets does not actively use sustainability in marketing, it does use it in interviews. This can directly affect the brand value, since Swapfiets could be accused of greenwashing. When the material loop is closed, it could be used in marketing.

Accumulating, solving the challenge would increase the brand value and possibly create a positive economic impact as well.

2.2 | External Analysis

External influences can affect the urge of solving the challenge. It also examines if there is a proven concept that could support Swapfiets improving the material flow. The external analysis shows the trends in society and the market. It also gives an understanding of the market Swapfiets is operating in.

2.2.1 Trends

Until recently the socioeconomic system is based on the linear economy, where products were used and disposed. Predominantly virgin materials enter the beginning of the value chain. The European Union faces clear challenges regarding the use of resources, such as "today in the EU, each person consumes 16 tonnes of materials annually, of which 6 tonnes are wasted, with half going to landfill" (Union, 2014). Whilst the era of cheap resources are over, businesses are facing higher material costs. Due to those developments, the EU has designated resource-efficiency as one of the flagships of the 2020 Strategy (Tukker, 2015). A playing field is being created, where innovation and resource efficiency are rewarded (Union, 2014). Where the use of carbon has been the key subject for politics, it is now shifting towards to the use of resources in general. The amount of materials directly used (9 billion tonnes) in the EU economy can be reduced whilst increasing production and competitiveness. Each year 2.7 billion tonnes of waste is thrown away. It is highly needed to use waste as a resource to be fed back into the economy, thus a focus shift towards re-use and recycling is inevitable (Union, 2014).

Mobility as a service

The servitization of society has become a well-known trend and many companies are shifting their focus on selling a service instead of selling a product alone. This shift is shown in the bicycle sector as well as an early shift for renowned car manufacturers. The larger cities are flooded with sharable bicycles, such as the Mobikes. There are other mobility service providers, such as Greenwheels, which has a fleet of 1700 sharable cars throughout the Netherlands ("[Zo werkt Greenwheels]", 2019).

Not only in the industry, but also in the political environments signals arise that show a shift towards a full servitization of mobility. The Dutch ministry of Infrastructure and Water Management has set her future target to solve the increasing problem of mobility in the Netherlands; traffic jams are increasing and predictions are that they will be increasing the years to come. One of their initiatives is a clear signal for the future: Mobility as a Service (Hietanen, 2014). This program focusses on decreasing the amount of cars per capita and increasing efficiency within the mobility sector. This means there will be a need for mobility as a service, socially and politically driven.

Brand value

With these shifts going on, the customers' choice is being influenced as well. Drivers for companies to improve the additional value of their products are increasingly not only dependent on the return of investments, but also on sustainability indicators. This is not a value directly related to a currency, but related to the brand appreciation by customers.

One of the drivers for sustainability can be reputation and brand value. Sustainability can be used for marketing purposes, strategic partnerships and acquiring new funds which all can contribute to a higher brand value.

Since the customer relationship is considered as the most important aspect in the service of Swapfiets, increasing the brand value by adapting more sustainability goals can be a value-adding element (Wagner & Schaltegger, 2004).

2.2.2. Market

Competition

Swapfiets is competing with several other bicycle providers (Figure 21). In the Netherlands, there are 22.9 million bicycles. This saturated, traditionally linear, market is however entered by multiple PSSs. Competitors of Swapfiets are categorised in *direct* and *indirect* competitors.

Direct competitors are competitors with a comparable degree of ownership. Since the customer practically owns a Swapfiets, it is competing with the traditional bicycle market. Swapfiets has approximately 100.000 bicycles in the Netherlands, thus a market share of 0.5%. This is still increasing, but the traditional bicycle brands remain the biggest competitor. Then there are copycats, copying the service on a local level. An example of this is Boogle, based in Groningen, offering a bicycle subscription to a lower monthly fee (€14,50 compared to €16,50 for a Swapfiets subscription). Those competitors remain small, but can pose a threat to Swapfiets, when more local competitors arise.

Secondly, there are *indirect* competitors, who also offer PSSs. Such competitors offer different forms of PSSs, all for temporary use. Where Swapfiets customers behold a bicycle, services such as Mobike and Donkey Republic distribute pay-per-use bicycles throughout cities. A customer can use any parked bicycle whenever they want and leave it whenever they are at their destination. The total fleet of these services remains under 10.000, but is still expanding to other cities in Europe.

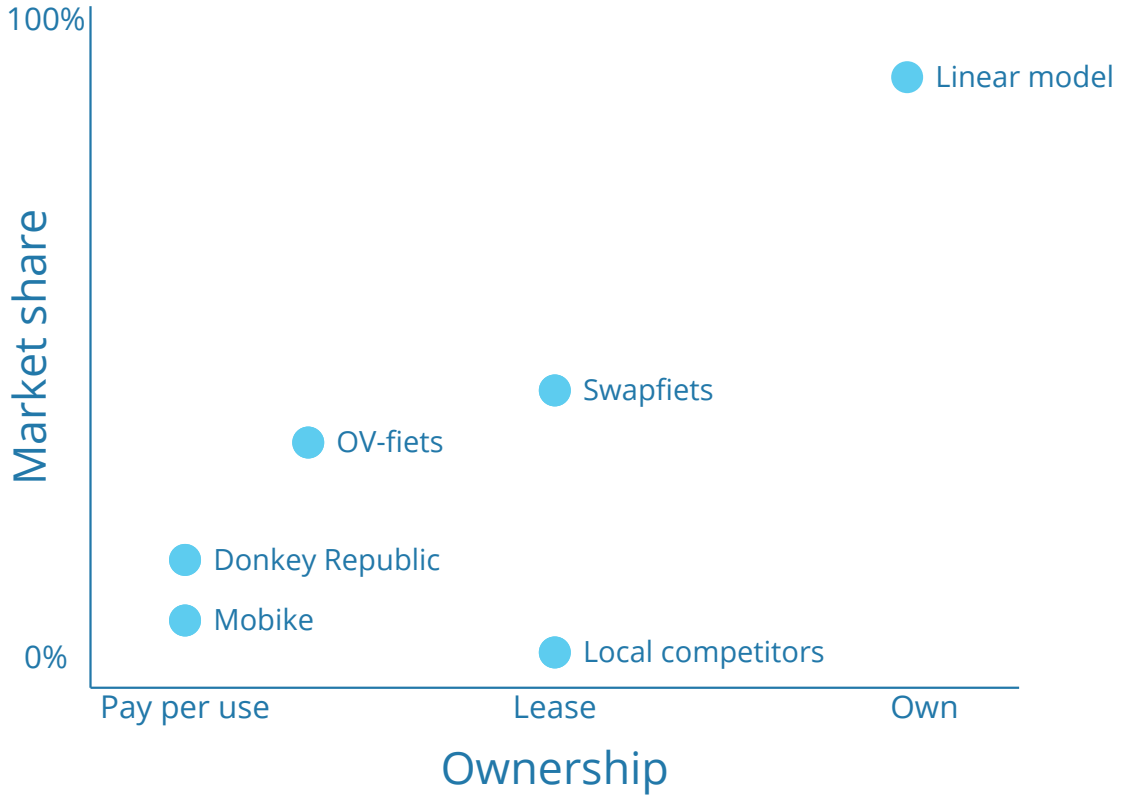


Figure 21 - Visualisation of competitors, evaluated on level of ownership and market share (own figure; based on research)

Pioneers

There are some companies which are reacting to the societal and political shift, mostly on a smaller scale. Those companies are referred to as pioneers, since they are the first movers, the first ones that see a business in developing trends (Barney, 1991).

The Upcycle is a Amsterdam based upcycling company and designs products with the waste of bicycles. It is a small-scale idealistic company with a small retail store in Amsterdam. For them, it is about decreasing waste and reusing it for products.

Roetz Bikes has a different perspective; instead of creating different products, they create new bicycles out of waste (Figure 22). It is a larger scale company which produces over 3000 bicycles a year. By now, they have reached an impressive circular percentage of 40%, but they strive towards a 100% circular product ("[Ons verhaal]", n.d.).

One of Roetz' partners is OV-fiets, the pay-per-use bicycle, provided by the Dutch National Railway Company (Figure 23). This service oriented company owns 15.000 bicycles located on 300 stations in the Netherlands. The ambitious goal of a circular bicycle is not met yet, but they have reached an impressive percentage of 70% circularity. Together with Roetz, OV-fiets has optimised its bicycle to close the lifecycle. 70% of the components can be reused for a new lifecycle, by choosing the right materials and lifecycle optimised design (Eilers, n.d.). They have proven the business case behind a circular bicycle. The usage of their bicycles increased from 200.000 to 500.000 rides within one year.

Figure 23 - OV-Fiets bicycles (source: OV-Fiets)

Figure 22 - Refurbished bicycle, Roetz Bikes (source: Roetz Bikes)

2.2.3 Conclusion

The external analysis underpins drivers for Swapfiets to improve the material flow. First, there is a societal and political shift towards more sustainable solutions. Political measures have not surfaced yet, but are very likely to do so in the future. Again, the societal shift highlights how the brand value can be damaged when Swapfiets does not offer a sustainable solution.

Furthermore, the increasing number of services in the bicycle sector is a menace to Swapfiets' position. The service is easy to copy on a local level and different forms of PSSs are gaining traction. Enhancing the competitive position can be done by improving the material flow, since it is a differentiation factor.

There are pioneers who have proven the business case behind closing the material flow. Swapfiets' challenge is to test such a business case at scale, while the growth keeps on going.


Swapfiets
SWAPFIETS.NL
Swapfiets
PJ-620-D

3 | Selection

The aim of this phase is to select a methodology that helps Swapfiets to improve the material flow. To achieve this goal, literature is reviewed to find common challenges for PSSs and ways to overcome them. The link between a closed material flow and a sustainable PSS (SPSS) is made. Swapfiets' performance is then compared to the findings in literature. The phase is concluded by defining an appropriate approach to the challenge.

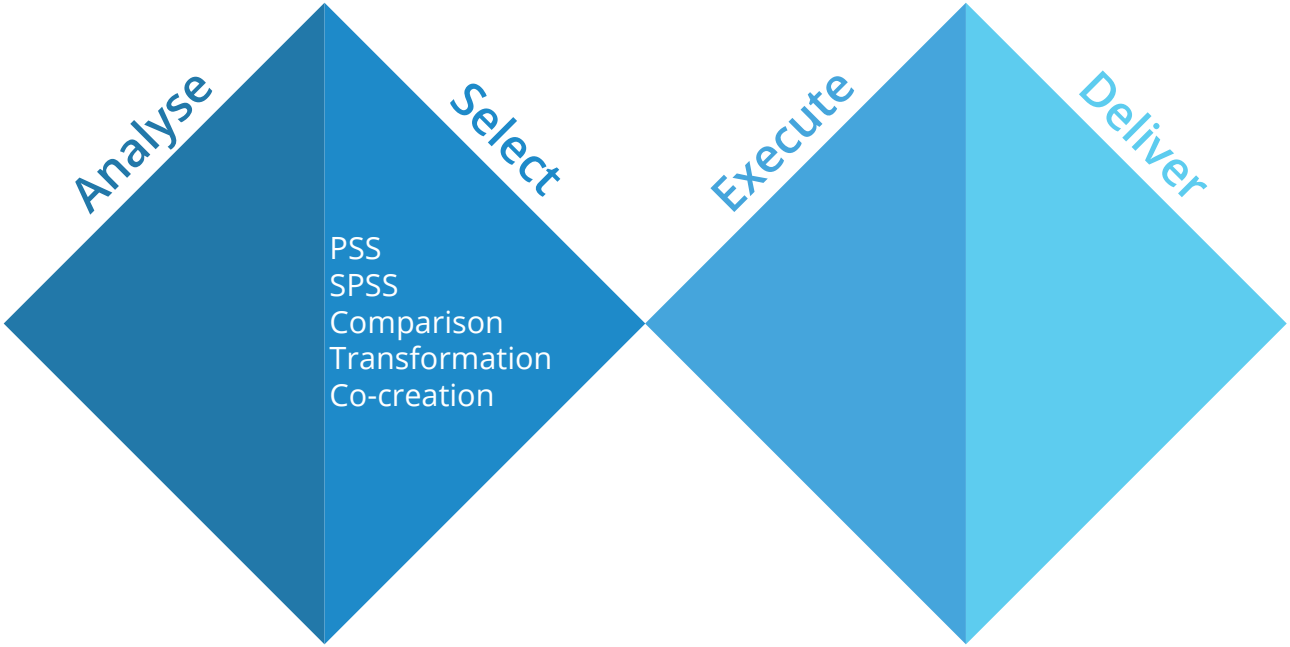


Figure 24 - Phase 2: Select (own figure; based on UK Design council, 2005)

3.1 | PSS

A product service system (PSS) is a business model where a company or multiple companies deliver an integrated product and service combination. The PSS offers a mix of both products and services capable of fulfilling user's needs (van Halen et al., 2005). Swapfiets, together with manufacturers and suppliers, offers bicycles as a service. The product remains in the ownership of Swapfiets and the customer is ensured of a working bicycle, thus benefits from the service element. There are PSSs that do offer a shift in ownership of assets, but it is not applicable to the PSS Swapfiets offers. For this thesis, the definition of a PSS is restrained to:

"an activity which has some element of intangibility associated with it. It involves some interaction with customer or property in their possession, and does not result in a transfer of ownership. A change of condition may occur and provision of the service may or may not be closely associated with a physical product" (MacDonald and Payne, 2006, p. 19).

PSSs can be divided in three different categories; product-oriented, use-oriented and result-oriented services (Tukker, 2004). In general, a PSS is a network configuration forcing a collaboration between the service provider, product supplier and the service module providers (infrastructure, logistics, etc.) (Annarelli, 2016). Tukker (2004) describes the potential environmental each category can make. A product-related service can have a positive impact, when maintenance prolongs the lifetime compared to the traditional model and the material loop is optimised (Tukker, 2004).

Since the rise of PSSs, they are considered as promising business models for meeting both economic and environmental goals. Up until ten years ago, services generally escaped the critical concern of decreasing environmental impact, compared to the traditional model (Mont, 2002). That has been changing since PSSs are more widely implemented in different sectors and not (yet) proving themselves to be both economic and environmental beneficial (Tukker, 2004). At the same time there is a clear call in literature for assessment methods or tools, which assess both environmental and economic impact a PSS makes (Doualle et al., 2015).

So there is a clear observation that a PSS hold potential to be both economic and environmental beneficial, but more and more doubt about how to realise both is raised. Together with the lack of the right assessment methods, the sustainability aspect of PSSs is not proven yet.

Nonetheless, much research has been published regarding the development of a PSS, analysing multi-sector cases to find common barriers, drivers and success factors. A comparison of litrature is represented in Table 1. Based on PSS design methodologies and case studies, common ground between PSSs is found. As Swapfiets is already an established and operating PSS, a comparison is made to the findings in literature in chapter 3.3.

Table 1 – *comparison of six papers, describing the common barriers, drivers and success factors*

		Mont, 2002	*Manzini & Vezzoli, 2003*	*Tukker & Tischner, 2006*	*Baines et al., 2007*	*Sundin et al., 2008*	*Annarelli et al., 2016*
Barriers							
	Acceptance from customers	X	X	X	X	X	X
	Shift in companies' culture	X	X	X	X		X
	Acceptance from stakeholders	X			X	X	X
	Regulative frameworks	X		X		X	X
	Socio-technical regime	X	X	X	X	X	
Drivers							
	Differentiation	X			X		X
	New market development						X
	Positive environmental impact	X	X	X	X	X	X
	Best utilisation of assets		X				X
Success factors							
	Increased capability for innovation	X	X	X	X		X
	Improved product design	X				X	
	Closed material loop	X				X	X
	Customer centric		X				X

3.1.1 Barriers

The barriers found in literature are challenges PSSs face in order to become successful. The barriers are mainly coming from two perspectives; the customers and the business.

The first barrier, *acceptance from customers*, is the challenge to shift from a traditional product to a service-oriented product. Since the ownership of a product shifts to the service provider, the product is not an object the customer identifies himself with anymore (Tukker & Tischner, 2006).

Second, the *shift* from traditional to service results in new challenges to the service provider itself. New capabilities concerning internal organisation, communication and integration of the customers' point of view need to be developed (Annareli et al., 2016 and Manzini & Vezzoli, 2003).

In comparison with the traditional model, PSSs require a larger extent of multidisciplinary teams (Sundin et al., 2008). *Acceptance from stakeholders* includes all actors directly involved in setting up a PSS; manufacturers, suppliers and the service provider.

The shift in ownership also forces a new perspective for manufacturers and other suppliers of the system. It forces the system to involve all stakeholders in (re)designing the product and the service system (Mont, 2002). Where traditional models focus on delivering a product, PSSs deliver a function. The product fulfilling this function require a shift in responsibility from only delivery to the use phase (maintenance, updates, etc.) and end of life phase (remanufacturing, reuse, recycle, etc.) (Baines et al., 2007).

Regulatory frameworks can become limiting boundaries for PSSs (Annareli et al., 2016). Since the PSS remains the owner of the product, it will also remain responsible for it. Changing regulatory frameworks can endanger the PSS, for example by extra disposal regulations.

Acceptance from the *socio-technical regime* as a barrier originates from the conventional mindset. Besides acceptance from stakeholders within the PSS, there is a need from external stakeholders as well. Such stakeholders are financiers and authorities, which are more likely to have a precautious mindset (Tukker & Tischner, 2006).

3.1.2 Drivers

PSSs are often used as a business model to *differentiate* from the established market competition. For saturated markets, it is difficult to gain market share as a newcomer. Since PSSs offer more than the product only and products can more easily be modified to respond to customers' changing demands, it is a way to differentiate (Mont, 2002). For example when a customer has a basic bicycle, but due to moving, he needs a more comfortable bicycle. Swapfiets can in this case offer a bicycle with gears. Another example is the need for baskets on the front of the bicycle; some customers wished to have such baskets, so Swapfiets extended the service with optional baskets. By integrating products and service, an added value is presented to the customer (Baines et al., 2007).

PSSs provide a high level of customisation, allowed by the service components, which can create a new market on itself (Annareli et al., 2016). Customisation implies that a product-service combination is developed and improved to meet specific customer demands. When customisation is possible on a high level, it can create a total new product and thus a *new market*.

For some companies, the potential *positive environmental impact* is a key driver in developing a PSS. By widening the system and internalising

3.1.3 Success Factors

environmental variables, more components of it can be optimised (Manzini & Vezzoli, 2003). This is one of the main drivers for Bundles, a PSS for domestic appliances. Bundles incorporated all environmental variables into its PSS to stimulate the environmental awareness of customers. The customer pays less, when less negative environmental impact is made.

For other companies, creating a PSS implies to incorporate industrial processes of production. Industrial processes are then made more efficient to be economical beneficial, what often generates a positive environmental impact as well.

Shifting the ownership from the customer to the service provider, there is an advantage in *using the assets* in the most efficient way. Through optimising processes, the service provider can increase the usage of its assets, which is cost reducing (Manzini & Vezzoli, 2003).

Instead of focussing on products, PSSs focus on the final need, demand or function to be fulfilled. This enhances the degree of freedom to find improvement options enormously compared to the traditional model(Tukker & Tischner, 2006). Since PSSs are not product focussed, they provide a higher degree of freedom to innovate by changing the provided product. It is also in the benefit of the PSS to improve the quality of the provided product, since it remains the company's asset. This *increased capability of innovation* is considered to be a success factor. For example, Swapfiets changed the lights fitted on the bicycle from battery to magnetic powered lights. This decreases the maintenance costs for Swapfiets, since batteries do not have to be replaced anymore. At the same time, it ensures customers of a working light, thus less chance on a fine and increased customer safety.

In close relation to that success factor, the relationship between the service provider and the manufacturer is the second success factor. Not only changing the product, but *improving* upon the provided product creates a successful PSS (Sundin et al., 2008). Thus, by having a good relationship with the manufacturer, increases the degrees of freedom to iterate upon the provided product.

Again, because of the shift in ownership, it can be beneficial for PSSs to *close* the *material loop*. By integrating the life cycle into the PSS and product design, values, such as economic, environmental and social can be enhanced. As well as for the second success factor, the relationship with the manufacturers needs to be close, since the involvement and responsibility in the life cycle is extended (Mont, 2002). In this way, recycle or refurbish processes can be designed and set-up. Ideally, it could lead to completely closed material cycles.

PSSs are designed to meet the final needs of the customers, which implies that a successful PSS is *customer-centric* (Baines et al., 2007). Products in a PSS are in this way of higher quality in two ways: 1) the product itself, since the service provider benefits from better products, and 2) customer satisfaction, since the service element fulfils all needs involved with the product. So a PSS should be customer-centric to create a market or to differentiate itself.

3.1.4 Conclusion

Different drivers for companies to develop a PSS are defined. Drivers most often recognised in literature are best utilisation of assets and differentiation. A positive environmental impact is broadly discussed and the potential is agreed upon. Closely related to the environmental potential is the success factor of creating a closed material loop. The potentiality of the environmental impact a PSS can have originates from the shift in ownership. It is expected to be economically beneficial to create a closed material loop, since the service provider remains the owner of the asset. However, no PSS is evaluated to make use of this potential by closing the material loop. To close the material loop, a close relationship with the manufacturer is needed, which builds upon the *increased capability for innovation* and an *improved product design*.

So, to utilise PSS success factors, the material loop should be closed and there must be a high degree of freedom to innovate the product. PSSs with a closed material loop engage with the potential environmental impact, thus approaching a sustainable product service system (SPSS).

3.2 | SPSS

Realising a closed material flow is closely related to realising a sustainable product service system (SPSS). Described by Mont (2002), the paramount goal of PSSs is to minimise the environmental impact by closing material loops. In other words, to use the potential of positive environmental impact of a PSS, the material cycle must be closed. To create a SPSS, not only the material flow should be closed, but environmental impact throughout the product cycle should be minimalised as well (Roy, 2000). Possible strategies to decrease the impact are: low-impact materials, reducing the amount of materials used, cleaner techniques for product manufacture, decrease the amount of packaging and optimising the life of the product (Roy, 2000).

For this research, SPSS is defined as:

"an offer model providing an integrated mix of products and services that are together able to fulfil a particular customer demand (to deliver a 'unit of satisfaction'), based on innovative interactions between the stakeholders of the value production system (satisfaction system), where the economic and competitive interest of the providers continuously seeks environmentally and socio-ethically beneficial new solutions" (Vezzoli et al., 2015).

Unfortunately, there are few examples of PSSs designed on a life cycle basis (Mont, 2002). Vezzoli et al. (2015) finds this to be true, since no successful SPSSs have been identified. Just as for the design and development of a PSS, drivers, barriers and success factors for creating a SPSS can be found in literature. Since a SPSS is a PSS with a focus on sustainability, the list is very similar as described in Table 1. Only additional factors and factors that are emphasised concerning the development of a SPSS are shown in Table 2. These factors are listed below. Due to the lack of successful SPSSs, the success factors are mainly focussed on ways to overcome the remaining barriers.

Table 2 – *comparison of eight papers, describing the common barriers, drivers and success factors for SPSSs*

		Roy, 2000	*Manzini & Vezzoli, 2003*	*Mont, 2004*	*Aurich et al., 2006*	*Baines et al., 2007*	*Ceschin, 2013*	*Tukker, 2015*	*Vezzoli et al., 2015*
Barriers									
	Network reconfiguration	x	x	x	x	x	x	x	x
	Product design influence and perspective	x		x	x	x	x	x	x
	Consumer's behaviour		x	x		x	x	x	
Drivers									
	Optimising the lifecycle creates an economic benefit	x	x		x		x	x	x
	Regulatory changes	x	x	x		x	x		x
	Improved competitiveness		x	x	x	x	x	x	x
	Best utilisation of assets	x		x	x	x	x		
Success factors									
	Cooperation with suppliers	x		x	x	x	x	x	x
	Reconfiguration of stakeholders	x	x	x		x	x	x	x
	Flexible project vision		x		x	x	x	x	x
	Strategic partner management					x	x	x	x

3.2.1 Barriers

Network

For developing a SPSS, network involvement and engagement is even more important. To do so, SPSSs are forcing new understandings of relationships between partners and new innovative networks (Vezzoli, 2015). Relying not only on the internal knowledge, but also involving external partners is important (Vezzoli, 2015). This network should be broad, including not only actors directly linked to the PSS, but also other relevant actors from other domains (Ceschin, 2013).

To decouple environmental impact from economic growth, service providers are required to extend their involvement and responsibility from making a product available to phases of the life cycle that are usually outside the buyer-seller relationship (Baines et al., 2007). For a closed material loop, Manzini describes the main innovation for a successful development as *stakeholder reconfiguration* (Manzini & Vezzoli, 2003). This means that the network should collaboratively be reconfigured, with a change in responsibilities, such as the shift of the life cycle perspective.

Product design

A major limitation to product-service providers is the lack of *influence on the product design*, since they most often buy their products from a third party manufacturer (Tukker, 2004). This limits the degree of freedom in optimising the product for a closed loop.

To create a sustainable product, it should be designed from an eco-design perspective (Roy, 2000 and Aurich et al., 2006). This enlarges the possibility for creating a strategy to remanufacture products, so that both economic and environmental benefits can be achieved (Sundin et al., 2008).

Lifecycle design of products however causes a major disadvantage; since it is a total redesign of a product, a long development time is caused (Kemp & Hoogma, 1998). When the full PSS should be redesigned with added environmental consideration, the time to market is even more lengthened (Mont, 2002).

Customer

Another barrier to become sustainable for a product-oriented PSS in specific. Tukker (2015) describes how leasing often leads to less careful behaviour by the user, since the PSS provider remains the owner of the product. Less careful behaviour in PSSs makes it a less sustainable solution compared to the traditional model. For example, renting a bicycle owned by a PSS can create less careful behaviour compared to when it was the possession of the customer. This leads to a shorter lifetime and is thus less sustainable (Tukker, 2015).

3.2.2 Drivers

Since the assets remain in the ownership of the service provider, the product core must be *optimised concerning the lifecycle* (manufacturing, usage and remanufacturing) (Aurich et al., 2006). So it is an economic benefit to take the lifecycle into account for developing a PSS (Manzini & Vezzoli, 2003).

External drivers to develop sustainable solutions often come from *regulatory changes* (Roy, 2000). Although environmental innovation is often not rewarded at the company level, governments are more and more overcoming the barriers to implement appropriate policies to create corporate drivers (Ceschin, 2013).

With PSSs, producers become more responsible for their product–services in case material cycles are closed. Producers are encouraged to take back their products, upgrade and refurbish them and use them again. (Mont, 2002). It must be emphasised that there is still a lack of regulatory drivers (Baines et al., 2007), but it is one of the flagships of the 2020 strategy of the European Union (Tukker, 2015). Those findings stress the possibility of new law enactments.

Lastly, a driver recognised in literature is the possible *improved competitiveness* through improved environmental performance (Mont, 2002). This can improve the relationship between the customer and the PSS (Sundin et al., 2008).

3.2.3 Success Factors

Few successful SPSS are captured and presented in literature (Baines et al., 2007), the success factors are mainly focussed on overcoming the abovementioned barriers.

Firstly, *cooperation with suppliers* is key to develop ways to close the material loop (Mont, 2004). A PSS has the possibility to gather data regarding the product in use, which can be used for redesigning the product efficiently (Sundin et al., 2008).

Besides suppliers, the network of actors involved to develop a SPSS is paramount. A heterogenous group existing out of outsiders and actors that directly influence the system should be created (Ceschin, 2013). In order to create such a network and thus enabling life cycle thinking, Manzini and Vezzoli (2003) described the need for *stakeholder reconfiguration*.

When a competent network is formed, the project vision should be widely shared (Kemp & Hoogma, 1998). Thus aligning and converging expectations of the network is key for developing sustainable solutions. To create the coherence in this complex network, strategic partner management is a critical factor (Vezzoli et al., 2015). Moreover, the challenge proposed to the network could shift along the way, so the *project vision* should be flexible (Ceschin, 2013). The accumulation of a shared and flexible project vision emphasises the importance of *strategic partner management*.

3.2.4 Conclusion

To create an SPSS, the network configuration needs to be reconsidered and the quality of the relation between the actors plays an important role. In this way, the product design can be optimised from a lifecycle perspective. When redesigning the product to close the material loop, the consumer's behaviour needs to be taken into account, since it is different from the traditional model.

For a company to develop an SPSS, multiple drivers can be found. By optimising the material flow, the lifetime of the products are extended and can create an economic benefit. Furthermore, regulatory changes can force a company to review its environmental impact. Becoming more sustainable can also lead to an improved competitive position, since it can be a differentiation factor.

To overcome the barriers two categories of success factors are found: stakeholder network and project management. The stakeholders need to be reconsidered and reconfigured, since a broader set of knowledge and capabilities is needed for creating a closed material loop. To create an SPSS, the project management is key; going through the (re)design process, the challenge can change along the way and all stakeholders need to be aware of and involved with that variable element.

3.3 | Comparison

Swapfiets' PSS is assessed on how it copes with the barriers, drivers and success factors. Multiple sustainability assessment methods exist (Doualle et al., 2015 and Abramovici et al., 2014) as well as economical assessment methods (Qu et al., 2016). However, there are few studies analysing one or more aspects of PSSs: the economical and environmental should be updated (Annarelli et al., 2016). Because of this lack of assessment methods, Swapfiets' PSS will be directly compared to the barriers, drivers and success factors found for PSSs and SPSSs. In this way, opportunities for Swapfiets to become an SPSS can be identified. Remaining barriers and success factors to overcome those can be identified.

To create a clear overview of Swapfiets' current status concerning its PSS and relation to SPSS, all factors are listed and compared to Swapfiets in Table 3. The barriers, drivers and success factors will be discussed subsequently.

Table 3 – *comparison of how Swapfiets copes with **relevant** factors for PSSs (italic text) and SPSSs (regular text) combined (+: means Swapfiets is performing well on that specific factor, -: means Swapfiets does not meet that specific factor and ±: means the factor is a point for discussion)*

		Swapfiets
Barriers		
	Regulative frameworks	±
	Network reconfiguration	±
	Product design influence and perspective	±
	Consumer's behaviour	±
Drivers		
	Differentiation	+
	Potential for environmental impact	-
	Optimising the lifecycle creates an economic benefit	+
	Regulatory changes	±
	Improved competitiveness	±
Success factors		
	Increased capability for innovation	+
	Improved design	±
	Closed loop	-
	Customer centric	+
	Cooperation with suppliers	+
	Reconfiguration of stakeholders	±
	Flexible project vision	±
	Strategic partner management	±

3.3.1 Barriers

As an established PSS, Swapfiets has already overcome most of the barriers. However, there are four factors to be discussed: *regulative frameworks*, *network reconfiguration*, *product design influence* and *perspective on consumer's behaviour*.

At this moment Swapfiets meets all legislations regarding environmental impact, mainly because there is a lack of strict regulations for corporates (Union, 2014). However, the European Union also estimates that by 2050, a four to tenfold of increasement in resource efficiency is needed, which has significant requirements to be met by 2020 (Union, 2014). With an eye on the 2020 strategy of the European Union, companies should expect and actively respond to changes in the regulatory environment. For Swapfiets, this change can imply a radical change in their system. Since Swapfiets' resource efficiency is not optimised yet, it would not meet future requirements as sketched by the European Union.

Swapfiets has already built up a strong network of actors to sustain the PSS. They are closely involved with their investors, customers and suppliers, but mainly with the manufacturers. Because of the investment, Swapfiets directly came in close contact with bicycle producers and parts suppliers. This collaboration means that Swapfiets has its own manufacturer, thus redesigning the bicycle is possible, but does require resources in terms of financial and time. However, to close the material loop, Swapfiets does not have the knowledge internally, so a reconfiguration of the network is needed to acquire the knowledge and experience.

Within the definition of Tukker (2006), a use-oriented service provider buys its goods from a third party, limiting the influence on the design process and thus innovating the product. For Swapfiets this is not the case, since they design the bicycle themselves and have third parties to produce them. This increases the degrees of freedom in developing the bicycle further. There is however a mismatch in the perspective from which it is designed, to close the material loop. Swapfiets has designed the bicycle to improve the efficiency for maintenance and endurance, but not taking the end of life into account. So the design perspective should be on optimising the lifecycle as well, to facilitate a closed loop (Aurich et al.,2006).

Lastly, it is still being tested by Swapfiets how the consumers' behaviour influences the lifetime of the bicycles. Tukker (2015) states that leasing leads to less careful behaviour, since the consumer is no longer the actual owner of the product. Swapfiets has implemented product improvements to make it more robust, but no bicycle is at its end of life yet. This makes it not yet possible to draw conclusions on the consumers' behaviour its influence on the lifecycle of the bicycle.

3.3.2 Drivers

There are many drivers a company can have to develop a PSS or an SPSS. For some companies it is about strengthen its strategic position, by developing new markets or differentiating from an existing market. For both PSSs and SPSSs, utilisation of assets is seen as a common driver, since it improves the companies' efficiency regarding the use of resources. For PSSs this means a cut in the costs and for SPSS it adds an environmental incentive. For Swapfiets to improve the material loop, not all drivers are applicable to its current strategic decisions. There is a distinction to be made between the drivers for creating a PSS and those for an SPSS.

Swapfiets created the PSS to differentiate from the existing and saturated market, by improving the utilisation of the bicycles and adding a service component. The environmental impact is not integrated in the strategy and no steps have been taken to create this impact.

Internal drivers to improve the material flow are mainly financially, since the product will still have a book value at the end of its life. By closing the material flow, this accounting value could be transformed into cash value, since it would be used again for other purposes or within the PSS.

External influencing factors are the competitive advantage Swapfiets has and regulatory drivers. As described in chapter one (SF analysis), the current concept can be duplicated at a local level, which endangers the competitive position. By differentiating the PSS from competitors, Swapfiets could reinforce this position. Second, as described before, the regulatory framework Swapfiets operates in is favourable at this moment, but is expected to change in the near future.

3.3.3 Success factors

As described before, no successful SPSS is recognised in literature, which hampers identifying success factors. However, potential success factors are described, mainly as responses to barriers in creating an SPSS. Swapfiets has already proven itself successful on some levels, but there is still room for improvement to meet the other factors.

Due to the customer centric setup of the PSS and the data collected in the past years, Swapfiets was able to cooperate with its suppliers to innovate the bicycles, by improving the design.

However, it does not have a closed material loop. The potentiality that goes hand in hand with a PSS is there, but the challenge is how to make use of it. To improve the material flow, the bicycle design needs to be reviewed together with a reconfigured set of stakeholders. For this project to succeed, a flexible project vision is needed, since it might change during the process of solving the challenge. With this variable project challenge, the management of the reconfigured set of stakeholders is key.

3.3.4 Conclusion

Since the main prerequisite for an SPSS is to have a closed material loop, the challenge of improving the material flow points Swapfiets towards taking steps in transforming the PSS into an SPSS.

Paramount for this process is the focus on reconfiguring the involved stakeholders, to involve the right knowledge and experience for a successful solution. Furthermore, a flexible project vision enhances the chance of success.

3.4 | From PSS to SPSS

To make the first step to transform the PSS into a SPSS, a methodology to do so is sought. However, no methodology yet is designed to make a transition from a non-sustainable PSS to a sustainable-PSS (Reigado et al., 2017). This finding is supported by multiple authors, described in Appendix C.

This general concern in literature generates a new challenge for Swapfiets. Since no methodology is described in literature and Swapfiets has not developed one, another methodology should be adapted or developed to improve the material flow. That methodology should support reconfiguration of involved stakeholders with the right knowledge and experience. This methodology should also be able to handle a flexible project vision.

It has been commonly agreed that designing and developing a SPSS is a co-creation process between the manufacturer, service provider and customer. However, it has been noted that such methodologies have not been evaluated in real time contexts (Vasantha et al., 2012). For this challenge, answers need to be sought for outside the existing network of stakeholders, since reconfiguration is needed. With this increased scope and complexity of the challenge, co-creation is introduced as a suitable methodology.

3.5 | Co-creation

Multiple definitions of co-creation can be derived from literature (de Koning et al., 2016). However, they all agree on the fact that it is the practice of collaborative development of future strategies. These strategies can aim to develop products, services, visions, processes, partnerships and many more possible outcomes. For this research co-creation is defined as:

'*Co-creation involves the joint creation of value by the firm and its network of various entities (such as customers, suppliers, distributors). Innovations are thus the outcomes of behaviours and interactions between individuals and organizations*' (Perks et al., 2012, p. 4).

Co-creation can be seen as a form of open innovation, since knowledge is willingly shared in creative sessions, rather than kept for oneself. It can bring many benefits to companies, such as an enhanced engagement of employees, an improved stakeholder commitment and an increased speed to market (Dong et al.,2008). Next to these benefits, it has proven to create new interactions between individuals leading to new perspectives and ideas (Frow et al., 2015). Companies do not have much choice but to collaborate in the form of co-creation to create a competitive advantage (Lee et al., 2012).

To innovate services in complex and quickly changing markets by co-creation, networks are particularly important (Perks et al., 2012). With relation to these networks, Perks et al. (2012) describe them as ecosystems, that require adaptability and agility to respond to changes within the network and the challenge that is posed to it. A co-creation network is "simultaneously innovative and efficient, agile and scalable" (Adler et al., 2011). These statements suggest that co-creation could be used as a method to solve the challenge.

3.5.1 Actors

To involve the right actors for co-creation, the identification and selection of qualified participants is stressed in literature (Füller et al., 2011). However, researchers disagree on what a qualified participant is.

Frow et al. (2015) proposed a co-creation framework, represented as a morphological field for co-creation design. Within this framework the co-creation motive, co-creation form and engaging actors are linked. The framework could assist companies in selecting the right actors for a co-creation form. The research describes how it is set-up and how it is used from one single case perspective. However, no comparison is made to define the effect of selected actors on the result of the co-creation sessions. So the framework helps in aligning the co-creation motive with the co-creation form and the engaging actors, but it does not present if the outcome met the co-creation motive. Furthermore, as the research point out itself, additional research could extend the work from the perspective from other actors, focusing on cross-industry co-creation.

In addition to abovementioned research, van de Poel (1999) showed that outsiders trigger radical innovations and set off processes of transformation of technological products. Outsiders are defined as people who do not share the rules that guide further development of a technology. Rules as such are for example design criteria related to the technology. Outsiders will not follow the same design criteria as people working on that technology. They are more likely to bring up secondary effects that contribute to a wider perspective on solutions. Secondary effects are effects a solution might generate on social, technical or environmental level. These effects are translated into desirable design criteria. In other words, people who are not working in the same sector can increase the chance of finding a radical innovation as an answer to the solution.

In contradiction to those findings, Sundin et al. (2009) state that there should be no competitive relationship between participating companies, since there would be no trust nor sharing of knowledge. However, PSSs with similar challenges are more eager to engage in co-creation. Sundin et al.(2009), as well as previous mentioned studies, do not present the connection between partner selection and the quality of the output of the co-creation sessions.

Vargo et al. (2008) found that co-creation is not limited to internal resources of a PSS, but that value is added through the integration of internal resources with all external resources that can contribute to the system its well-being. This finding is extended by Perks et al. (2012), who emphasised competitors as stakeholder in co-creation as well.

So there is a gap, which this research wants to explore. A comparison is made between actors who are likely to have the same kind of challenge and actors who are in the same competitive sector. Two co-creation sessions with different sets of actors are organised to gain insights about the difference in added value delivered.

3.5.2 Changing Role of the Researcher

Using co-creation within research, directly changes the researchers' role compared to traditional research processes. This role shifts from observing only, to acting as a moderator, participating in discussions and providing input to the companies (Sundin et al., 2009). The researcher is then expected to lead, guide, provide scaffolds and offer a clean slate to encourage people at all levels of creativity (Sanders & Stappers, 2008).

Being a facilitator involves more than preparing and guiding a co-creation session. A facilitator should consider the implications choices have on the organisation (Santanen et al., 2004). Constantly filtering discussions and assessing them to fit the desired outcome and success factors requires an unbiased opinion. The presentation of new solutions and problems tend to unleash experience based solutions, which can cause the "stuck in a rut" syndrome, leading to a creative block (Santanen et al., 2004).

The co-creation experience is formed by a structured and fun session. The experience greatly influences the quality and quantity of the output (Füller et al., 2011). To create a good experience, the facilitator must act as a catalysator in discussion and recognise interesting angles. It is also about making sure everybody is comfortable and feels heard.

The facilitator role is to keep a strategic overview and taking all generated insights and opinions into account in further development of an idea or concept. It is about educating, speeding up and spreading the word (Nätti et al., 2014). Educating means equalising knowledge by sharing earlier generated insights and information in a structured way. Speeding up a process is referred to as catalysing, reducing the number of transactions to increase the efficiency. When concepts are being developed, the facilitator spreads the word to engage other stakeholders and make them a co-owner of the solution.

So, using co-creation inevitably increases the influence a researcher (as facilitator) has on the outcome of the co-creation sessions. To be able to compare the results of two sessions with different actors, the sessions need to be organised equally. For both sessions, the same challenge is presented and the programme (including time schedule) are exactly the same. The researcher will not give input on a creative level, but only encourage people at all levels of creativity.


SWAP
SWAP

4 | Execution

Two sessions are performed to compare the effect of different actors on the process and the results. To close the gap defined in the selection phase, a comparison is made between inter- and cross-sector actors.

To innovate the material flow of Swapfiets, multiple actors need to be involved. As described by Perks et al. (2012), innovations are the outcomes of behaviours and interaction between individuals and organisations. Since Swapfiets does not have the resources to revise the material flow internally, external actors are involved.

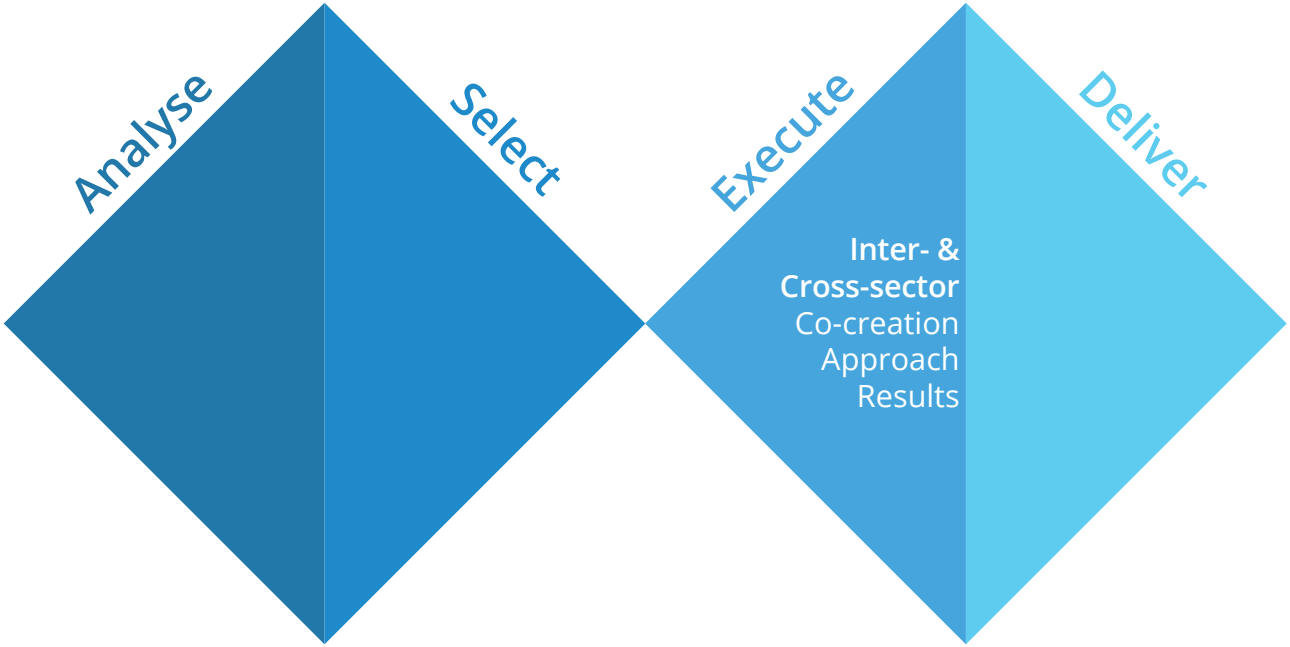


Figure 25 - Phase 3: Execute (own figure; based on UK Design council, 2005)

4.1 | Inter- and cross-sector co-creation

Invited participants range from close contacts to new contacts and are divided in two categories; *inter-sector* and *cross-sector* (Figure 26). *Inter-sector* actors are actors who operate within the same market, thus in the bicycle market. *Cross-sector* actors are companies operating in different markets, but with the same business model as Swapfiets. Such actors are likely to run into similar material flow challenges. Swapfiets employees who contributed to the sessions are from now on called the *internal actors*. All participants from other companies are referred to as the *external actors*.

To be able to compare the output of both sessions, the methods used to gather data and to find are described below. First, the context of the co-creation sessions is described. Then the process of actor selection is outlined. To gather the data required for conclusions, the data collection instruments and translation procedures are represented. Lastly, the co-creation process is explained.

After elaborating on the research approach, results are discussed by comparing inter- and cross-sector co-creation. Similarities and differences are outlined and the effects of actor selection is represented.

Context and setting of the study

Both co-creation sessions are executed in a large open room at the headquarters of Swapfiets. Within this room there is a whiteboard, projector screen, plenty of workspace and materials to assist in the creative process, such as markers and post-its. To comfort the participants, the facilitator has provided for healthy snacks and drinks, located in the same room. The whole session takes place within this room.

The challenge is the same for both sessions, which is: ***How keep the bicycle's frame longer in the loop?***

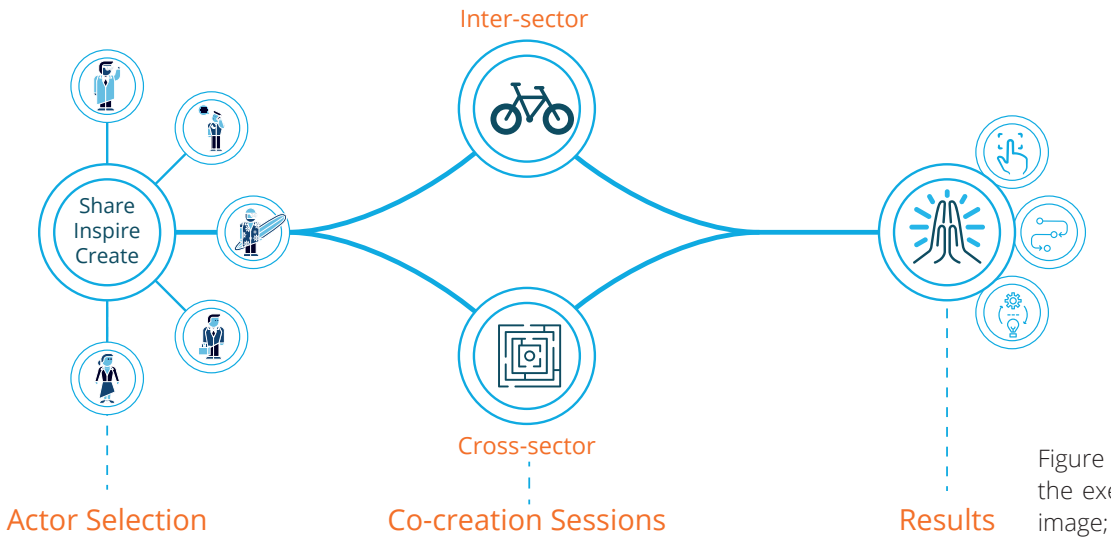


Figure 26 - Visualisation of the execution phase (own image; based on research)

4.1.1 Co-creation Process

The co-creation methodology used for this research originates from Fronteer Amsterdam. This creative strategy firm helps companies to innovate on multiple level, using self-developed co-creation methodologies (Pater, 2009). In collaboration with a Fronteer strategist, the session approach is chosen and adapted to the context of the challenge. During the preparation, execution and evaluation of the process, input and output is discussed with the Fronteer strategist. It must be emphasised that the author facilitated both workshops alone, but is experienced with the Fronteer methodology.

To generate insights and develop concept directions regarding the challenge, there is a clear need for two main steps. The first step is to diverge, to gather the most important insights, knowledge and experience about the challenge. The second step is to make choices in the created scope, to converge. For these two steps, Fronteer created the *Treehouse Session* (extensively described in Appendix E). This half day programme helps in accelerating the steps by offering manageable exercises to the participants.

A *Treehouse Session* is designed to involve external actors in solving the internal challenge. In this case, the challenge is to solve Swapfiets' problem. External actors are engaged to supplement the internal knowledge and experience. All actors are informed about the problem definition of the session beforehand. This is key, since external actors need a relation to the problem to participate. The session takes half a day and consisting of the following elements: *welcome*, *start*, *vision*, *challenge*, *opportunities*, *co-creation* and *advice*.

Since not all actors know each other, the *welcome* is meant to get familiar and to create a good atmosphere. At the *start*, the facilitator welcomes all actors and explains the programme of the day and the rules to create an open and creative atmosphere. The actors are then divided into groups to discuss their *vision* on what requirements a good solution should meet. Collaboratively, a product requirement list is defined, to set the purpose and scope of a possible solution.

At this point, the internal actors present the challenge for the session and provide the external actors with background information about the company. All actors will then be asked individually to come up with *opportunities* that could help solving the challenge. These opportunities will then be combined to jointly define interesting solution directions in *co-creation*. *Co-creation* is about translating solution direction into concepts that solve the posed challenge. At the end of the session, all participants are asked to share their insights of the session and give their *advice* to the internal actors.

Multiple worksheets are used throughout the session to support the actor creativity and to endorse interaction between them (Appendix D). The most important worksheet is the *concept worksheet*, used for translating a solution direction into a reasoned concept (Appendix D.1). It challenges actors to think through all aspects needed to realise their concept. Furthermore, it asks for a visual representation, so that it is easier to understand for others.

4.1.2 Actor Selection

Fronteer employs connectors, whose job it is to carefully select, contact and invite external actors for co-creation. Since this study is carried out by the author, selection criteria are derived from Fronteer its approach (Pater, 2012). To maximise the chance of successful sessions, three criteria are used to select actors: a *diverse* group of involved companies, ranging from small to large sized companies; senior employees with *experience* in their field and a relation to the challenge which creates a *willingness* to participate in the research (Frow et al., 2015). For every session, a *wildcard* is invited: a person who is familiar with creative sessions and has the capabilities to enhance the group's creativity (Pater, 2012).

The goal of separated actor selection is to evaluate the influence of: outsiders on triggering innovative ideas (van de Poel, 1999); cross-sector actors (Sundin et al., 2009); and inter-sector actors (Vargo et al., 2008 & Perks et al., 2012). To be able to compare inter- and cross-sector actors, two sets of groups, meeting the three criteria, are selected for co-creation.

4.1.3 Research Approach

To compare the sessions, data for analysis is gathered in multiple ways. The research process included two co-creation sessions. After the sessions, individual interviews with all actors- *internal* and *external*- are conducted to gather feedback about the co-creation process and additional information about the created concepts.

The sessions are recorded by multiple cameras, from all perspectives, so that interactions and behaviour can be reviewed afterwards as well. During the session, information is gathered by notetaking and physical worksheets used by the actors.

To translate the information into insights, the grounded theory strategy is used (Langley, 1999). The author documented all *observations* before, during and after the sessions. These observations are *categorised* to analyse the level of group behaviour and performance, instead of individual behaviour. The categories are then described per session to find *similarities* and *differences* between the two sessions. In this way, *connections* between actor selection and the effect on the outcome can be derived.

Concepts generated by the co-creation team are generally assessed by the team itself (Gardien et al., 2014). In creative processes it often occurs that the inventors often are influenced by the "stuck in a rut" syndrome, leading to biased judgements of the concepts (Santanen et al., 2004). To objectively judge the quality of the generated concepts, an *experienced* and *independent* judge is assembled. This judge is existing out of two Swapfiets employees, thus *experienced* with the company and goals it set to achieve. The created concepts are presented without mentioning details about in which session or by whom it was created. The judge did not contribute in any way to the process or its outcomes and is therefore *independent*.

Co-creation concepts are often judged on three criteria: *feasibility*, *viability* and *desirability* (Menold et al., 2016). These three criteria combine the impact a concept is ought to make and the resources needed to do so. They have become an integrated element in the design process and methodologies that steer towards an outcome that comply with these values (Gardien et al., 2014). When a concept meets all criteria and is thus feasible, viable and desirable, it is often referred to as the Innovation Sweet Spot, visualised in Figure 27 (Henderson, 2005). The concepts, created in co-creation, are judged on these three values, so that high potential concepts are highlighted.

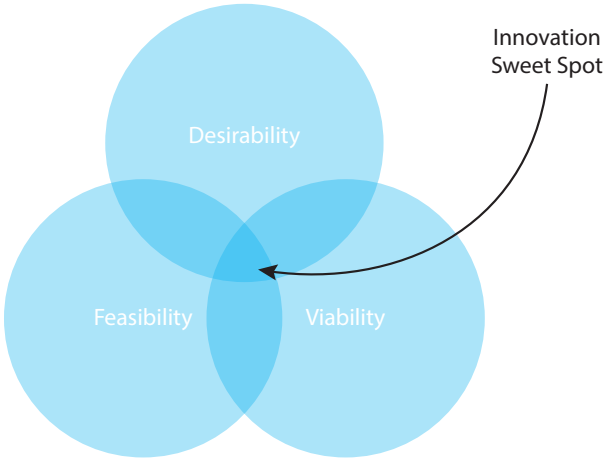


Figure 27 - The Innovation Sweet Spot; a balance between feasibility, viability and desirability (own figure; based on Henderson, 2005)

4.2 | Results

Both sessions are conducted successfully and produced three concepts each. To link the actor influence to the effect on the outcomes, categorised insights about the actor engagement, process and outcomes are described subsequently. Within every sector, similarities and differences between inter- and cross-sector actors are highlighted.

4.2.1 Actor Engagement

Table 4 represents the actors who participated in both sessions. The three criteria for both sessions are met, by involving *diverse*, *willing* and *experienced* actors. A *wildcard* is invited for each session, with a high level of creativity and willingness, to stimulate discussion.

Motivation to participate for all *cross-sector* participants was the resemblance of the challenge, which was shared before the session; these companies face similar challenges within their own PSSs. Additionally, for some actors it was the possibility to contribute to a more sustainable solution for Swapfiets, since increasing sustainability is in their core strategy, such as for Bundles and Super Power. Other participants imagined how Swapfiets could help them in return by sharing information on, for example, logistic challenges.

Inter-sector participants need more persuasion to participate, since they are more protective of their own experience and knowledge. For actor selection, pioneers described in chapter 2.2.2 are invited, since they are known for their innovative approaches towards creating a closed material loop. Swapfiets is considered a potential competitor by vastly all inter-sector participants, yet they also saw possibilities for partnerships in several ways. One company, Roetz, already offers a solution to the challenge of the session, so a possible collaboration was their main motivation. For others, possibilities to make use of Swapfiets' service in a business to business context was imagined; Hoge Veluwe and Yellow Bike. Lastly, the motivation for OV-fiets was to find similar challenges between their and Swapfiets' service and to possibly collaborate on solutions.

Although Swapfiets has a large network due to its ties with Pon, not many external actors came forth out of this network. This can be devoted to the *willingness* of these actors; no inter-sector member of the Pon network directs itself to the service element of bicycles. They are focussed on selling bicycles according to the traditional model and thus less interested in the material flow. Nevertheless, the personal network of the Swapfiets employees did generate valuable leads for this project.

Table 4 – *Participants of inter- and cross-sector co-creation sessions.*

Inter-sector		
Company	**Scale**	**Function**
Roetz Bikes	Medium	CEO & Founder General manager
Hoge Veluwe	Medium	Head operational management
OV-fiets	Large	Format manager Process manager
Yellow Bike	Small	CEO
Swapfiets	Large	Co-founder Product manager Service optimisation Logistic Planner Head of mechanics
Cross-sector		
Company	**Scale**	**Function**
Super Power	Small	Founder & CEO
Gerrard street	Medium	Co-founder Co-founder
Bundles	Medium	Brandmanager
Swapfiets	Large	Co-founder Product manager Service optimisation Visual creative Quality manager

4.2.2 Process

The co-creation methodology contributed to the collaboration between actors on multiple levels. It creates room for *conversation*, supports finding *common ground* and triggers *knowledge sharing*. All three elements occurred in both sessions, showing similarities and differences between inter- and cross-sector co-creation.

Room for *conversation* contributes to the general atmosphere during the sessions. The internal and external actors did not know each other upfront, so an introduction is put forward on the agenda. For both sessions an organised introduction contributed to a lower threshold to share thoughts. Throughout the session, the author ensured all actors felt comfortable to speak their mind. In addition, the worksheets required interaction as well.

Deliberately encouraging conversation is of more importance for *inter-sector* actors. Here, actors are more awaiting for others to share thoughts. The facilitator had to make a greater effort to keep conversations going, in contrast to *cross-sector* co-creation. During this session, the author was more often holding back than accelerating conversations.

Throughout both sessions, actors were constantly searching for *common ground*; similar challenges. Here however, a great difference between inter- and cross-sector co-creation also surfaces. With inter-sector co-creation, all actors are actively searching for similar challenges they face concerning the bicycles, e.g. 'how do you retrieve stolen bicycles?', 'how do you organise your spare keys?' or 'how often do you perform a full bicycle check?'. Many of these questions remained unanswered however, because of a more precautious attitude.

While at *cross-sector* co-creation, actors were focussed on customer experience, data collection and logistic challenges. Questions were openly put forward, such as; 'how do you inform customers about a delay in delivery?', 'in what way do you analyse your churn rate?' or 'how do you decide the quantity to pre-order your bicycles?'. These discussions were highly valued by the actors in this session and answers were often very open.

Knowledge sharing refers to information shared regarding the challenge. This element exclusively shows a difference between inter- and cross-sector co-creation. *Inter-sector* actors were known to have knowledge that could help solving the challenge. However, due to precautious behaviour, this knowledge is not shared explicitly. This can be devoted to the fear of potential competition and to dissimilar challenges. The fear of potential competition is most often observed during conversations between internal and external actors, who possess knowledge that is directly valuable to the challenge, such as Roetz and OV-fiets. External actors who rent out bicycles often have dissimilar challenges, since these bicycles are used in another type of system, e.g., Yellow Bikes sells their bicycles after use and has a different maintenance system.

In contrast to the *inter-sector* session, the *cross-sector* actors acknowledged not the technical knowledge contributing to solving the challenge. More focus was put upon thinking outside the box, to come up with unexpected and original solutions.

4.2.3 Outcome

The outcomes of the sessions are separated in two diverse directions; *concepts* and *collaborations*. First, the quality of the concepts created in the sessions themselves is described. Followed by different forms of possible collaborations as an outcome.

Concepts

The Fronteer methodology is applied in both session and six concepts are created in total (Appendix F). These concepts are evaluated by the judge on feasibility, viability and desirability. Besides these criteria, an open discussion is held to further examine the concepts and to find patterns in the different sessions.

Inter-sector Co-creation

Concepts, created during the *inter-sector session*, have a **technical focus**. For every concept, the bicycle is the key focus point and the level of details is very high. In this session, the following concepts are created:

Robust & Modular – Redesign of the bicycle; a frame to last. All weak spots of the bicycle are defined and redesigned into a bicycle that lasts. With a focus on modularity, it will also reduce the waste and increase the efficiency of repair.

Reframing – A central factory to remanufacture the bicycles. By designing a disassembly line and an assembly line, efficiency of refurbishment is increased.

Team-up! – A partnership to combine all fleets of the actors, to collaboratively set up a refurbishment flow. Further in time, this would transform into a partnership to collaboratively redesign the bicycle, combining all parties' data and experience. The ease of maintenance should be central.

Robust & Modular and *Reframing* clearly show the high level of technical details. Both concepts reconsider the bicycle design, improve the ease of maintenance and take the full material flow into account. It must be emphasised that the *Team-up!* concept is a direct result of the discussion possible partnerships between Swapfiets, OV-fiets and Roetz. Due to this extensive discussion, the concept sheet was not filled in at the end, but it is considered as one of the most valuable solutions by all participating actors. *Reframing* and *Team-up!* both are answers to the posed challenge, by improving the current material flow. *Robust & Modular* is a future focused solution, since it is a redesign of the bicycle, thus not applicable to the current bicycle design.

Figure 28 - Inter-sector co-creation session (source: own picture)

Figure 29 - Creation of Robust & Modular, during inter-sector co-creation (source: own picture)

Cross-sector Co-creation

The concepts created during *cross-sector co-creation* all show a **customer focus** to a greater or lesser extent. The level of technical details is low, but every concept is highly detailed in customer benefits. In this session, the following concepts are created:

APK-Go – an addition to the application which asks customers to check their own bicycle. If there is something noted that might break in the future, they are asked to swing by the Swapfiets store.

Old love does not rust – a guerrilla marketing campaign to provoke society to help in solving the challenge by an open contest.

Plug & Play – a split-up of the frame; a front and a rear part. When one of those is done, it can be replaced by another one. Decreases waste and creates nice colour combinations.

APK-Go and *Old love does not rust* are both involving the customer to great extent. *Plug & Play* takes into account what effect this solution will have on customers, by emphasising on possible colour combinations. None of the concepts are an answer to the posed challenge; *APK-Go* prevents defects by early detection, *Old love does not rust* sets out a contest to ask public support to solve the challenge and *Plug & Play* is a redesign of the bicycle, thus future focused.

Comparing the concepts of both sessions is divided in *focus* and *judgement*. The focus is about different types of solutions the concepts pose. Judgement on feasibility, viability and desirability show to what extent, and in what term, the concepts are realisable and how they fit the organisation.

The *focus* differs greatly between both sessions. Inter-sector co-creation shows a clear focus on technical aspects and how they would improve the material flow. These actors include the challenge into discussions throughout the session and multiple solutions to the challenge are posed. This is in contrast to cross-sector co-creation, where there is a central role for the customer. None of the concepts is a direct solution to the challenge.

Judging all concepts show differences between the session as well. In average, inter-sector co-creation scores higher on two out of three criteria; viability and desirability. A lower feasibility is devoted to the current resources, since Swapfiets does not have the knowledge or experience to implement any of the three concepts itself. Although *Reframing* and *Robust & Modular* are constantly in the top three of the judges, a cross-sector concept excels: *APK-Go*. This concept is highly valued by the judge, since it is considered very feasible with current resources, viable due to relatively low investments and desirable for both Swapfiets and the customer. Even though it is not a solution to the posed challenge, it does prevent larger defects and increases customer touchpoints.

Besides *judging* the concepts on the three criteria, the term in which the concepts could be implementable is discussed. Another difference between both sessions arises here. Inter-sector concepts propose mid- and long-term solutions, where cross-sector is more focussed on a short-term. The judge discriminates these terms as; *short-term*, realisable within a year; *mid-term*, realisable between three to five years and *long-term* to be realisable in approximately ten years.

Figure 30 - Cross-sector co-creation, prestentation (source: own picture)

Figure 31 - Cross-sector co-creation (source: own picture)

Collaborations

Both sessions showed that external actors are willing to collaborate with Swapfiets on two levels; as *business partners* or as *information partners*. A business partnership is a collaboration between two or more companies, where one is paying the other for its services. Information partners exchange information with each other.

During the *inter-sector co-creation session*, both forms of partnerships were discussed amongst multiple actors. As mentioned in the process section, there were actors -Roetz Bikes- with knowledge and experience that could help solving the challenge, but did not share it. Interviews afterwards show that those actors do want to help Swapfiets, but as *business partners*. This is underlined by the precautious attitude, described in the process section. The concept 'Team Up!' is a direct result of this mindset. The concept did however contribute to the contact between Roetz and Swapfiets and there is a possibility to become business partners.

Another actor, OV-fiets, who contributed to the 'Team Up!' concept as well, evaluated a possible collaboration with Swapfiets differently. This actor recognises many challenges Swapfiets faces and relates it to their own product. Swapfiets is not considered as a competitor, but as a possible *information partner*. Swapfiets and OV-fiets shared this feeling and information has been shared since.

Possible partnerships are discussed during the *cross-sector session* as well. Due to the more open atmosphere, all actors felt free to share challenges within their own PSS. These mentions caused discussions and often led to common grounds. Due to the form of the represented PSSs, all actors work a lot with data. During and after the session, multiple actors agreed to share data analytics tools and processes to improve the data by influencing customers. All possible discussed partnerships are *information partnerships*.

4.2.4 Conclusion

The findings support how selecting actors does influence the outcomes of co-creation. Abovementioned differences and similarities are visualised in Figure 32. To emphasise the contrast between both sessions, findings are categorised.

Inter-sector actors create concepts with a technical focus, ranging from mid- to long-term realisation periods. The process is more precautious, due to a competitive mindset, but also provokes discussions about possible business partnerships.

Cross-sector actors emphasise the customer experience by creating customer-centric concepts. These concepts are short-term solutions and relatively more feasible. Throughout the session, common ground is sought by openly sharing challenges per PSS. This results in the willingness to help each other in the form of information partnerships.

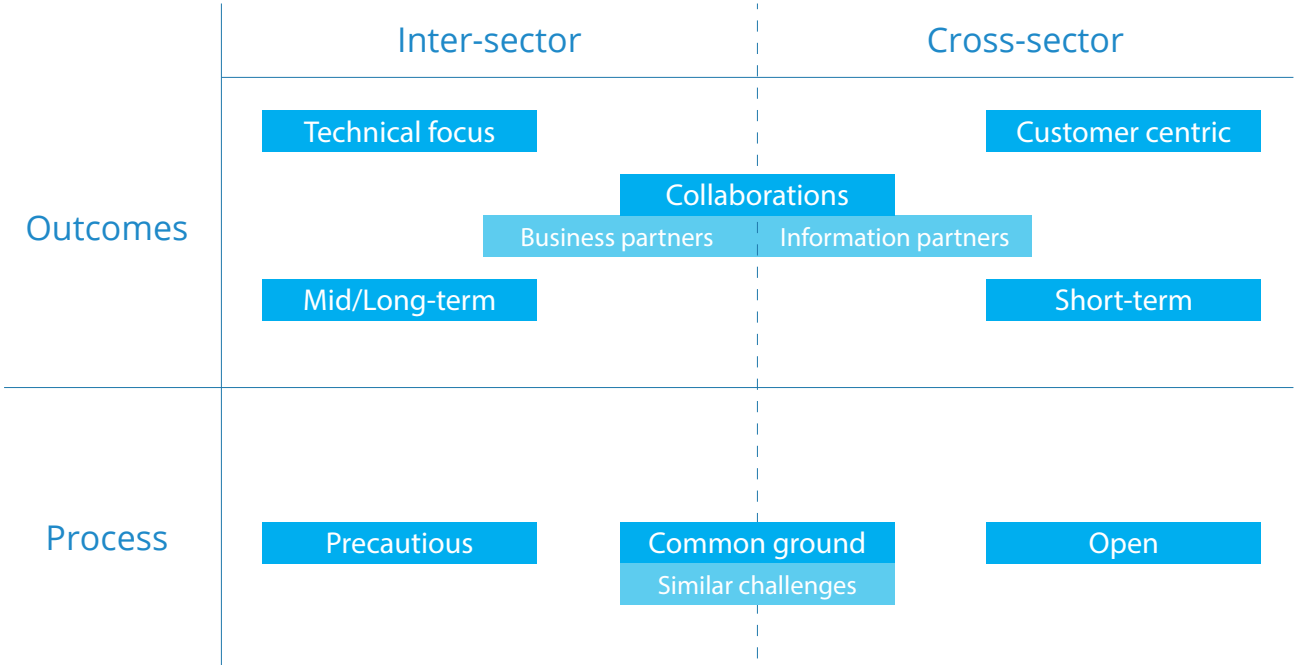


Figure 32 - Visualisation of results (source: own figure; based on results of co-creation sessions)

5 | Deliver

The deliver phase translates the results of the sessions into implications for Swapfiets. The results from the two sessions are divided in the process and concepts. The process should help Swapfiets to tackle future material flow challenges itself. The concepts are a step towards a solution for the material flow. Since the concepts are not implementable yet, the next steps are discussed.

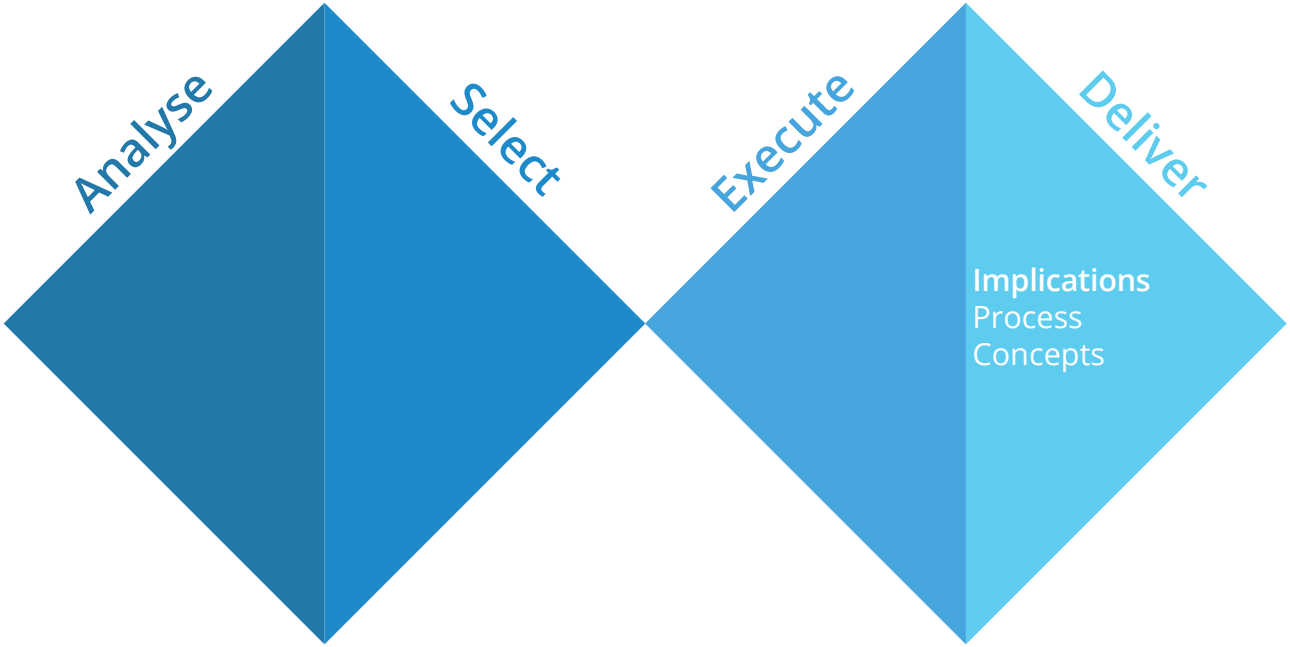


Figure 33 - Phase 4: Deliver (own figure; based on UK Design council, 2005)

5.1 | Process

The project assignment is to adapt a suitable methodology to close the material loop of the bicycle's frames. This approach should fit the organisation, so that future co-creation sessions to improve the material flow can be organised and conducted by themselves. The conducted research has shown how co-creation could help improving the material flow by: 1) ideas and concepts as a solution to a problem, and 2) collaborations on different levels. To organise such co-creation sessions, Swapfiets should take influencing factors into account. To do so, the influencing factors *actor selection* and *facilitation* are discussed. These factors should be contemplated to successfully use the *approach*.

5.1.1 Actor Selection

This study shows how actor selection directly affects the results of co-creation. Inter-sector actors tend to tackle the technical aspects of the challenge, whereas cross-sector co-creation leads to more customer-centric solutions.

Before selecting actors, the desired outcome of the session should be defined along three criteria:

1. *Knowledge gap* - the lack of knowledge and experience, regarding the challenge, within the organisation should be clear. This knowledge gap should then be abstracted to a point where it is clear whether it is a technical or human challenge.

2. *Time period* - the urge of the challenge should be clear; in what time period does it need to be solved.

3. *Degree of outsourcing* - It should be determined to what extend the solution may be outsourced; the need for a business or information partnership to solve the challenge.

By altering the parameters *knowledge gap*, *time period* and *outsourcing*, Swapfiets can decide whether inter- or cross-sector actors should be invited. However not tested in research yet, a combination of both actors can also be applicable to a challenge.

This selection tool is supposed to be used as a guidance, not as a binding decision tool. Swapfiets has to decide on the desired outcome and translate that into the three elements in Figure 34. These elements will then point towards a balance point for actor selection. Actors should be selected to meet the desired outcome per element. For example, there is a possibility that the *knowledge gap* is technical and the *outsourcing* is desired to be on a business level, but the *time period* is rather short. Two of the three elements will then point towards inter-sector actors, but the desired time period asks for direct implementable solutions and thus towards cross-sector actors. In this example, a mix between both actors could be selected, but a majority of the actors should be inter-sector.

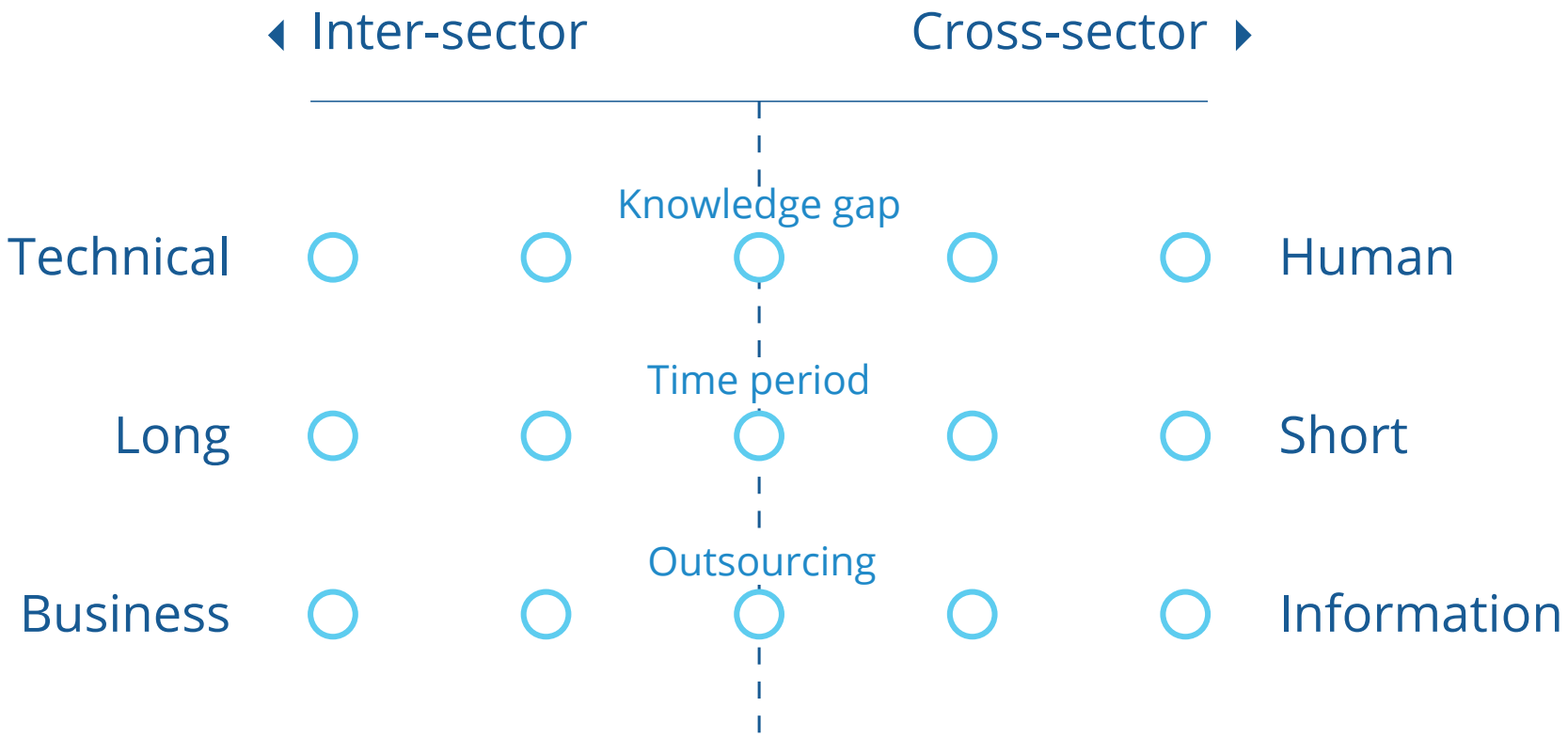


Figure 34 - Visualisation of supporting tool for actor selection (own figure; based on results of co-creation sessions)

5.1.2 Facilitation

Facilitating co-creation involves more than preparing and guiding a co-creation session. A facilitator should consider the implications decisions have on the organisation (Santanen et al., 2004). Filtering discussions and assessing them to fit the desired outcome requires an unbiased opinion. The presentation of new solutions and problems tend to unleash experience based solutions, which can cause the "stuck in a rut" syndrome, leading to a creative block (Santanen et al., 2004). Thus an unbiased facilitator is key to prevent premature termination of creative ideas and discussions.

The facilitator role is to keep a strategic overview and taking all generated insights and opinions into account for development of an idea or concept. It is about educating, speeding up and spreading the word (Nätti et al., 2014). Educating means equalising knowledge by sharing earlier generated insights and information in a structured way. Speeding up a process is referred to as catalysing, reducing the number of transactions to increase the efficiency. When concepts are being developed, the facilitator spreads the word to engage other stakeholders and make them a co-owner of the solution.

Thus, to facilitate co-creation sessions, one needs the abovementioned skills. All employees at Swapfiets will be connected to the project to some extent, which makes them biased. In co-creation, employees are in the position to improve their own well-being (Plé & Cácares, 2010). They can choose not to share their knowledge and experience, to protect their job or enhance their self-esteem and perceived status (Plé & Cácares, 2010). Especially managers, who often consider themselves as rational decision makers and follow steps with outcomes they can predict (Calabretta et al., 2016, p. 43). Innovations often involve risk-taking behaviour and uncertainties, which can be felt like a threat for managers. They often tend to protect their knowledge and position, which can harm the openness and transparency when facilitating co-creation sessions (Prahalad & Ramaswamy, 2004). Employees and managers are thus likely to be biased and thus not suited to fulfil the facilitation role.

Although employees are not suited to facilitate co-creation, co-creation can have a positive impact on the employees' engagement and satisfaction. Employees feel empowered when they are part of the decision making process and are expected to have a higher identification with their company (Zwick, 2004). Furthermore, participating in co-creation enhances the employee engagement. In this way, their professional aspirations are addressed (Ramasyamy, 2009).

Concluding, an unbiased facilitator should be external. In this way, the facilitator will not take personal benefits or disadvantages into account. Next to being unbiased, the facilitator should be educating, speeding up the process and be able to spread the word. Designers are known for having the right skillset and education to fulfil the role of facilitator. This skillset requires an empathic attitude, the ability to catalyse discussion, challenge creativity, visualise, summarise and reflect (Calabretta et al., 2016, p. 221-225). Next to this skillset, a designer's way of working includes translating mental associations into core criteria for the development of an intuitive outcome (Calabretta et al., 2017). Inspiring participants with those core criteria can reduce uncertainty and encourage the organisation to open up to innovative possibilities (Calabretta et al., 2016, p. 46). This does not mean that the external facilitator should be a designer. Anyone who interacts with others could have the right skillset (Isaksen, 1983).

It is however important that the facilitator applies this skillset to enhance creative problem solving amongst participants (Santanen et al., 2004). Such skills cannot be simply transmitted through books, lectures and videos (Isaksen, 1983). A person should have the right skillset and be trained to use it to facilitate creative sessions (Dym et al.,2005). So, a facilitator should be external, have the right skillset and be trained for creative facilitation.

5.1.3 Approach

The approach used for this project is tailored to Swapfiets, with the goal to support them to organise co-creation sessions themselves. Preparing, executing and following up on co-creation is divided in five phases; *define challenge*, *research*, *prepare*, *co-create* and *implement*. Per phase, the sources to support decisions are discussed. Each triangle in Figure 35, shows whether the phase is meant to converge or to diverge towards a solution.

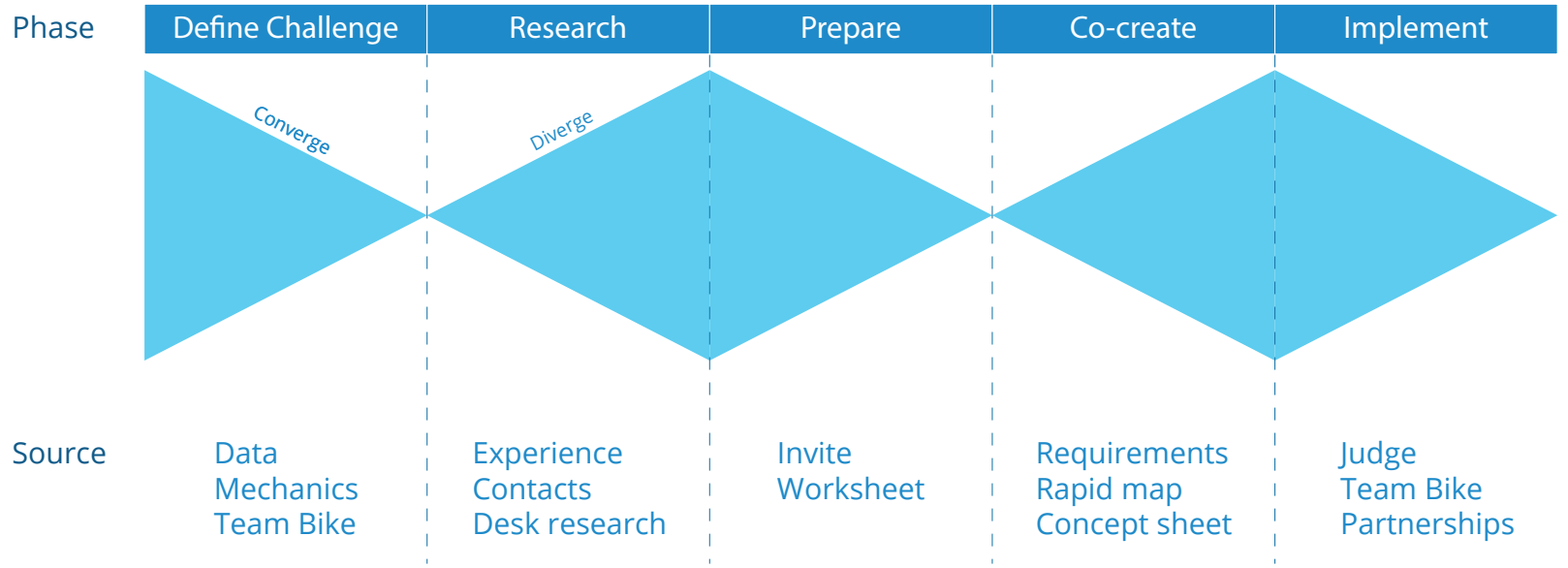


Figure 35 - Abstract visualisation of the Swapfiets co-creation approach (own figure; based on results of research)

The *define challenge* phase is the early beginning of the process. Here, the challenge that needs to be solved together with a desired outcome is determined. By using the rich set of *data*, parts that need improvement can be revealed. Current data can refer to efficiency improvements in maintenance, excessive costs due to faulty parts and material types thrown away in larger amounts. *Operational employees* are a rich source of insights, since they are working with the bicycle every day. Interviews showed how valuable insights are easily generated by, for example, work in the workshops for an afternoon. Their experience with and education about bicycles can be of great value to detect faulty parts, design improvements and increase maintenance efficiency.

Lastly, *Team Bike* has a key role in defining the challenge. Since this team is managing the bicycles at a strategic level, it is here where long-term goals can be defined. The whole team constantly receives feedback about all aspects of the bicycle, which include the material flow as well. Next to this, it is also the team that needs to be involved throughout the process, thus creating co-ownership of the challenge is important.

The *research* phase is where background information about the challenge is gathered. Possible solutions to the challenge and companies with comparable problems are examples of outcomes. Creating background information can be based on *experience*; again Team Bike and mechanics are valuable sources. The main source of information is Swapfiets' network *contacts*. The close ties with Pon, manufacturers and suppliers are of great value for gaining background information. Next to existing knowledge and experience in the organisation, *desk research* helps in finding possible solutions to the challenge.

The *prepare* phase is to meet all requirements needed for a successful co-creation session. First, with the knowledge gained in the previous phases, the challenge is revised and translated into one clear sentence. To increase the chance of valuable concepts, the *worksheets* are adjusted to fit the challenge. Leads discovered in the research phase are contacted and *invited* to participate.

The *co-creation* phase is where it all comes together. An extensive description is attached in the Appendix G, to support facilitation. The challenge is central in this phase and three methods are used to diverge and converge in the session. First, a list of *requirements* is jointly composed, by making use of model examples. This list is used to set a scope in which solutions have to fit. Then, internal and external knowledge and experience comes together in the *rapid map*. This method is based on individual brainwriting, where ideas for solutions are individually created. These ideas are meant to diverge possible solutions. From that point, clusters of ideas are formed and categorised. All actors jointly decide on interesting solution directions, which converges towards three solution areas. Finally, by filling in the *worksheet*, the selected solution areas are translated into visualised concepts. The visuals are supported by critical questions to enhance the feasibility, viability and desirability of the concepts.

The last phase, *implementation*, is dependent on the concepts created in co-creation. *Judging* on feasibility, viability and desirability helps identifying the most promising concept or concepts. From that base, further actions need to be captured. When a concept is not realisable yet due to a lack of knowledge, it must be examined whether a *partnership* is desired to close the gap. A *partnership* often shortens the term in which a concept is realisable, but might not be beneficial economically. When the urge is less, a task division for Team Bike can be made to gain the knowledge and experience to implement the concept independently. There is also the possibility that the needed knowledge is present. In that case, a task division for Team Bike should be made as well.

5.2 | Concepts

The co-creation sessions have produced six concepts in total, of which three are selected by the judge: *APK-Go*, *Reframing* and *Robust & Modular*. Each concept is elaborated and next steps are proposed in the form of a roadmap: a schematic overview of all sub-goals and contributing teams and partners. Each roadmap is divided in five elements: the product, Swapfiets, research and design (R&D), partners and technology.

For each concept it is key to form multidisciplinary teams to realise the concepts (Sundin et al., 2009). The concept must be developed from a multidisciplinary perspective, since it affects the whole PSS.

5.3 | APK-GO

All Dutch cars are required to have a 'general periodic inspection'. This inspired the actors who created APK-GO; a periodic check with the customer, to ensure the bicycle is in good shape. Twice a year, a customer receives a notification in the Swapfiets application. The customer is asked to report defects, even when it is not hindering the customer. When a defect is detected, the customer is asked to come by the store, to either get the bicycle fixed or to get another bicycle.

APK-GO (Figure 37) is focussed on prevention of real defects by detecting them in early stage. Doing so, Swapfiets could increase the lifetime of the bicycles. It is highly feasible, since Swapfiets has all the resources to create the concept itself. It is viable, because it is expected to increase the lifetime, but an investment of time is needed by Team Digital. The desirability is also very high for both the customer as for Swapfiets. For the customer, since it could avoid a bicycle to really break and thus prevent difficulties for the customer. It is desirable for Swapfiets, because it increases the amount of touchpoints in the service. This creates the chance for Swapfiets to increase the customer experience by 'epic service'.

It is thus a short-term solution, since it does not not fully solve the problem posed in the challenge. It does however increase the lifetime of the bicycles, what creates more time to realise a solution that completely answers to the challenge.

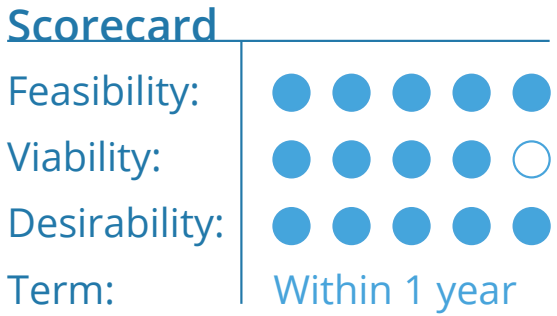


Figure 36 - Score card APK-Go, rated by the judge

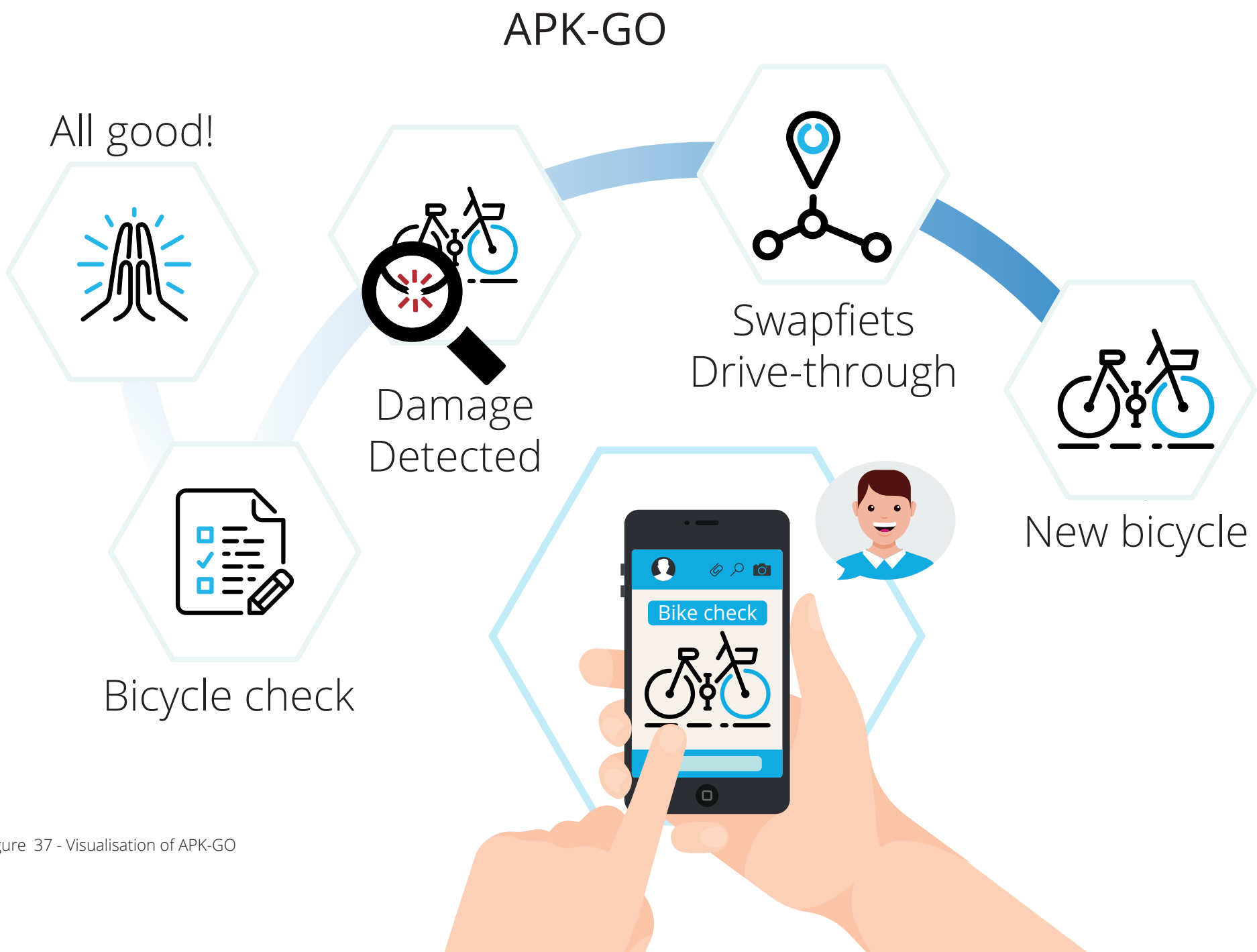


Figure 37 - Visualisation of APK-GO

5.3.1 Roadmap

The timespan in which APK-GO can be developed is approximately one year, divided in quarters. To develop the concept into a product, a few teams at Swapfiets play a role in research and design, supported by possible partnerships and technological developments.

Within the organisation of Swapfiets, Team Bike and Team Digital play a vital role in app development. Team Bike is responsible for data collection; what parts of the bicycle break often, but could be prevented by asking customers about the bicycle's status. To define and prioritise this list, Team Bike is supported by Team Data and the operational level employees. Team Data has the dataset and analysis tools to list parts that break most often. The operational level employees have field experience with how customers treat their bicycles and know how to prevent serious damages on the bicycles. The operational level is also important to involve during the testing phase, since APK-GO is meant to attract more customers to the Swapfiets stores. Team Digital is responsible to include the listed damages into a list of requirements for the application. Since Swapfiets already has an application, APK-GO is an extra function to be included. This shortens the design and development phase.

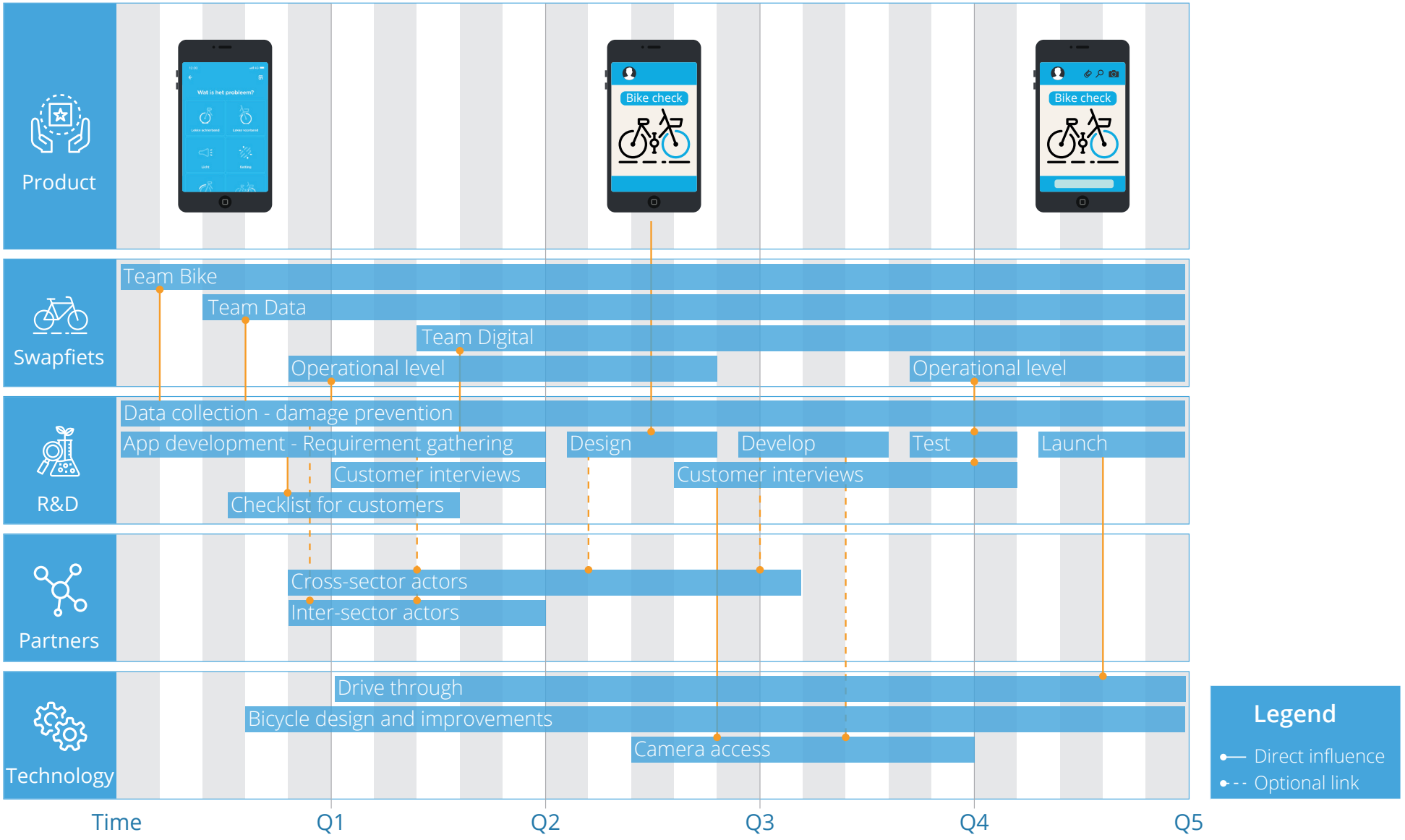
The main objective for research and design, is to develop and test the application extension. Data collection is important to keep the list of requirements for the application up to date and can be altered at any moment. The list of requirements is the basis for the application, it is important to verify this in early stage with customers, by conducting customer interviews. Customer interviews are furthermore important during the design and test phase, since they are the end users.

There are a lot of partners that may be involved during the development of APK-GO. For data collection, inter-sector actors can contribute to a comprehensive list. Later in the process, both inter- and cross-sector actors could contribute to the list of requirements for the application, since they might have experience in app-development. Cross-sector actors can support Swapfiets during the design phase, since they have proven to be customer centric.

The technological aspects for this project are the development of the drive-through, improvements for the current bicycle design and the possibility to use the camera for bicycle checks. The drive-through is meant to receive customers who are asked to preventive exchange the bicycle for another one. Together with the operational level, Team Bike is responsible for designing and developing the drive-through.

Throughout the development and after launching the application, more data is generated. This data can draw attention to parts that are faulty and thus might need to be replaced. This is valuable to Team Bike, since they can then improve the bicycles and prolong their lifetime. Lastly, there is an option to include camera access into the functionality, so that customers can share pictures of defects. It should however be verified with customers if there is a need for such functionality.

APK-GO


Product
Bike check
Bike check
Swapfiets
Team Bike
Team Data
Team Digital
Operational level
Operational level
R&D
Data collection - damage prevention
App development - Requirement gathering
Design
Develop
Test
Launch
Customer interviews
Customer interviews
Checklist for customers
Partners
Cross-sector actors
Inter-sector actors
Technology
Drive through
Bicycle design and improvements
Camera access
Legend
Direct influence
Optional link
Time
Q1
Q2
Q3
Q4
Q5

5.4 | Reframing

All parts of the bicycle are replaceable, except for the frame. Reframing (Figure 39) is changing that perception. By setting up efficient disassembly- and assembly-lines, refurbishment of bicycles becomes profitable. Bicycles with broken, damaged or rusted frames are collected and transported to a central warehouse. In this warehouse, a special refurbishment line is built to disassemble the bicycles. Usable parts are then sorted and redistributed to the assembly line. At the end of the disassembly line, only the frame is left. From that point, the bicycle is reallocated to the right refurbishment booth. Once refurbished, the bicycle is rebuilt again with the used parts.

The concept scores high on desirability, since it is considered as the most sustainable solution. Furthermore, it is also the only one that answers the challenge; it is a solution for the current bicycle frames. It is less viable, since it is expected to need a large investment to build the concept and to train employees. It could however create economic benefits. Not only the bicycle lifetime is increased, but it also adds to the brand value. The feasibility is high, since Swapfiets has all the assets to realise it, except for the knowledge about or experience with bicycle refurbishment. Researching and setting up the refurbishment factory would take approximately three years.

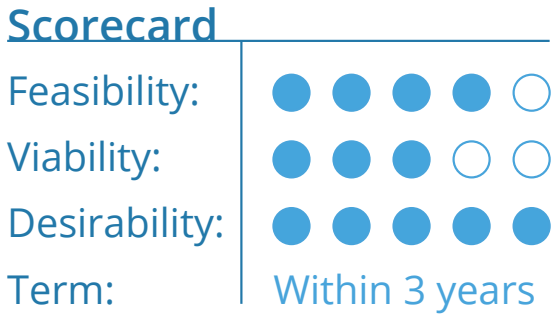


Figure 38 - Score card Reframing, rated by the judge

Reframing

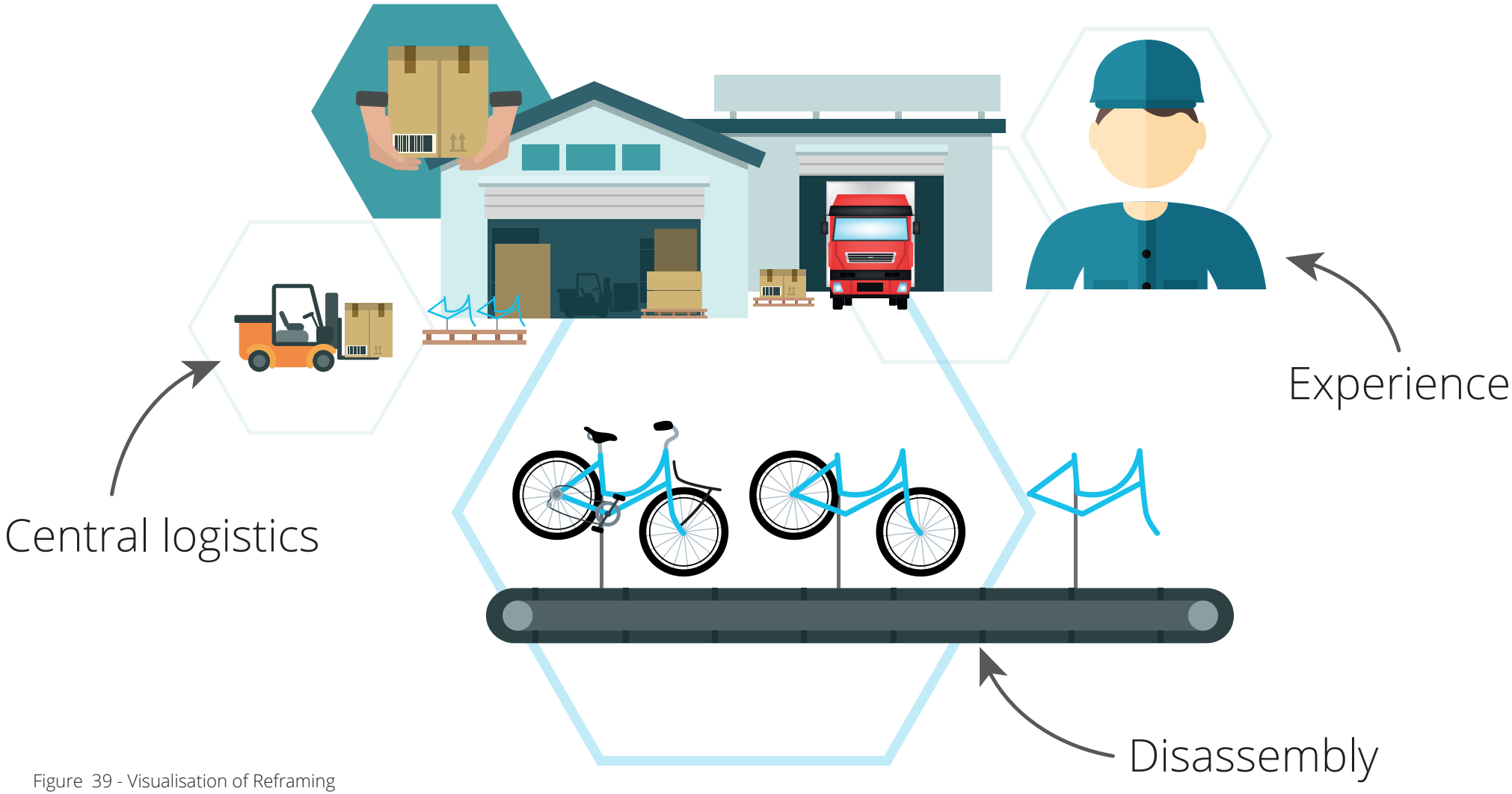


Figure 39 - Visualisation of Reframing

5.4.1 Roadmap

Collaboration between multiple teams is required to acquire the knowledge to further develop the concept 'Reframing'. The technological aspects and research and design play a key role to realise a refurbishment factory in three years. External actors can accelerate the development, but Swapfiets can choose to gain the knowledge and experience by themselves.

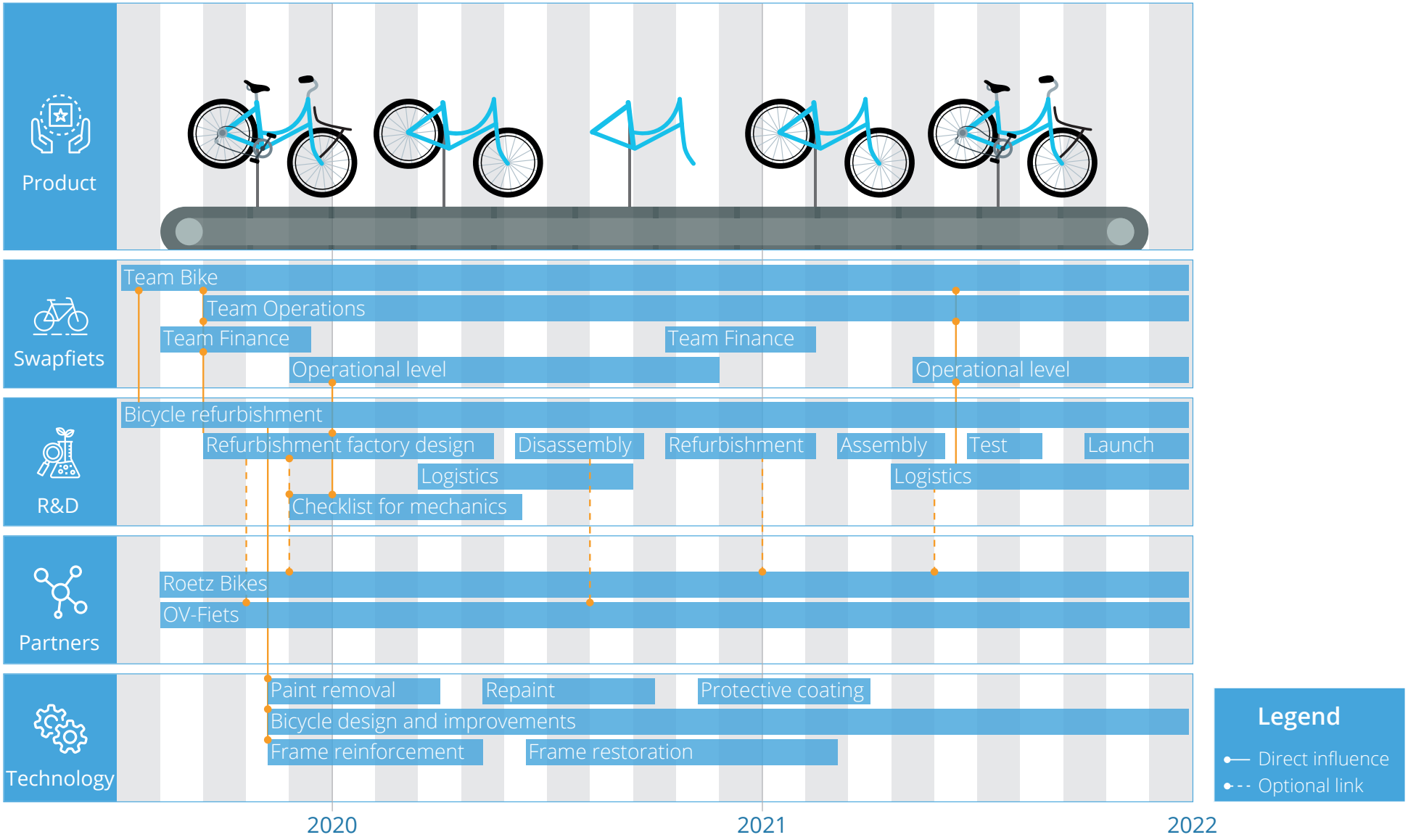
Team bike and Team Operations play a vital role in creating a feasible plan for a refurbishment factory. Team Bike is responsible to acquire technological knowledge for refurbishing bicycle frames. Team Operations is responsible for setting up the logistics flow: transportation from and to the refurbishment factory and efficient assembly- and disassembly-lines. This project is expected to be capital-intensive, thus multiple decision moments are scheduled for Team Finance. They are responsible to budget the factory and can decide whether or not to continue on the decision moments. The operational level is expected to give input for the checklist for mechanics and efficient assembly- and disassembly-lines.

The main question for this concept is: how to refurbish the bicycle frames? The answer to this question is key to develop a refurbishment factory. Designing such a factory requires a well-considered plan, so each step in the refurbishment cycle is a separate design phase; factory design, disassembly, refurbishment and assembly. Simultaneously to this design process, the transport logistics should be organised to create a smooth flow from warehouses throughout Europe to the refurbishment factory.

Swapfiets can decide to execute this plan by itself or it can, later in the process, decide to involve external actors for support. Roetz Bikes is known for their successful refurbishment factory, which could be scaled to Swapfiets' wishes. So Roetz Bikes could be involved as a partner to accelerate the process, since less research and development would be needed to design the factory. Besides Roetz Bikes, OV-fiets is known for the refurbishment of their bicycles, what can contribute acquire technical knowledge to refurbish the bicycles.

To be able to refurbish the bicycle, Swapfiets needs to acquire technical knowledge. First, knowledge is required to refurbish the paint; how to remove old paint, repaint and protect it with coating. Frames with more damage to it than just the paint, for example sagged rods, should be reinforced or restored. That needs specific technical knowledge Swapfiets does not have yet. As well as from APK-GO, Reframing can generate insights for improvement of the bicycle and thus prolong its lifecycle.

Reframing


Product
Swapfiets
Team Bike
Team Operations
Team Finance
Team Finance
Operational level
Operational level
R&D
Bicycle refurbishment
Refurbishment factory design
Disassembly
Refurbishment
Assembly
Test
Launch
Logistics
Logistics
Checklist for mechanics
Partners
Roetz Bikes
OV-Fiets
Technology
Paint removal
Repaint
Protective coating
Bicycle design and improvements
Frame reinforcement
Frame restoration
2020
2021
2022
Legend
Direct influence
Optional link

5.5 | Robust & Modular

Robust & Modular is a complete redesign of the bicycle (Figure 41). This newly designed bicycle is built to last. Each and every part of the frame is replaceable, what greatly decreases the waste of materials. Whenever a part is broken or rusted, it can simply be replaced with a new one.

Designing, developing and producing this bicycle is expected to be very costly process. The final product is also expected to be more expensive to produce than the current bicycle. Accumulating those factors lead to a low viability. When realised however, it could greatly decrease maintenance costs and the bicycles would last longer.

It is also slightly doubted whether it is feasible or not, since it is a complete redesign of the bicycle. But there is data and experience to pinpoint weak points in the current design, which increases the expected feasibility. Robust & Modular is desirable, because it would make it possible to develop a truly unique bicycle for Swapfiets that promotes sustainability.

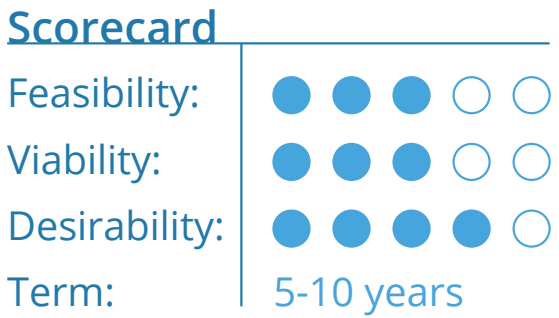


Figure 40 - Score card Robust & Modular, rated by the judge

Robust & Modular

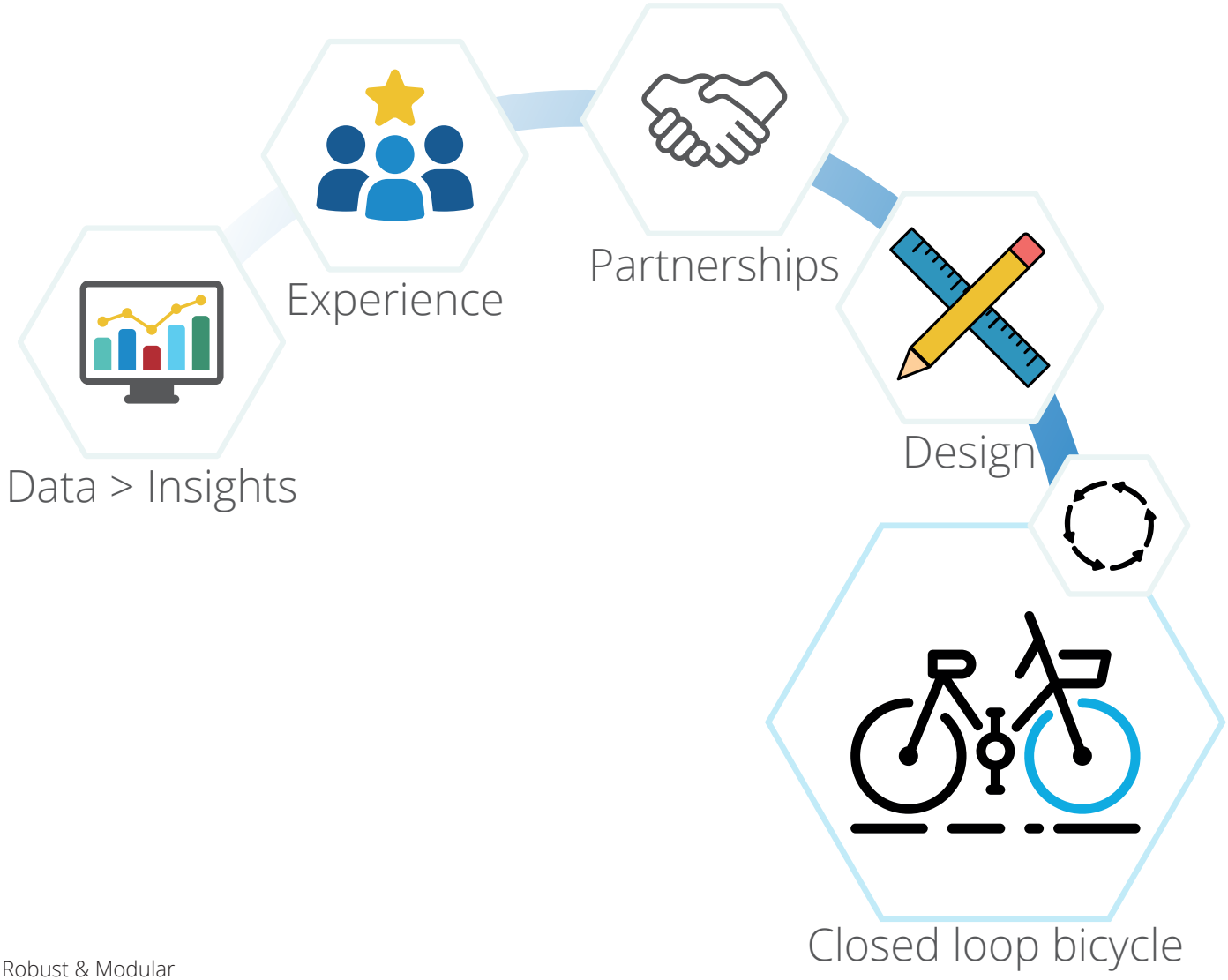


Figure 41 - Visualisation of Robust & Modular

5.5.1 Roadmap

Robust & Modular is a total redesign of the bicycle and thus a very time-consuming process. Each part of the bicycle is revised and improved where necessary. The frame will be fully modular to decrease waste and increase maintenance efficiency.

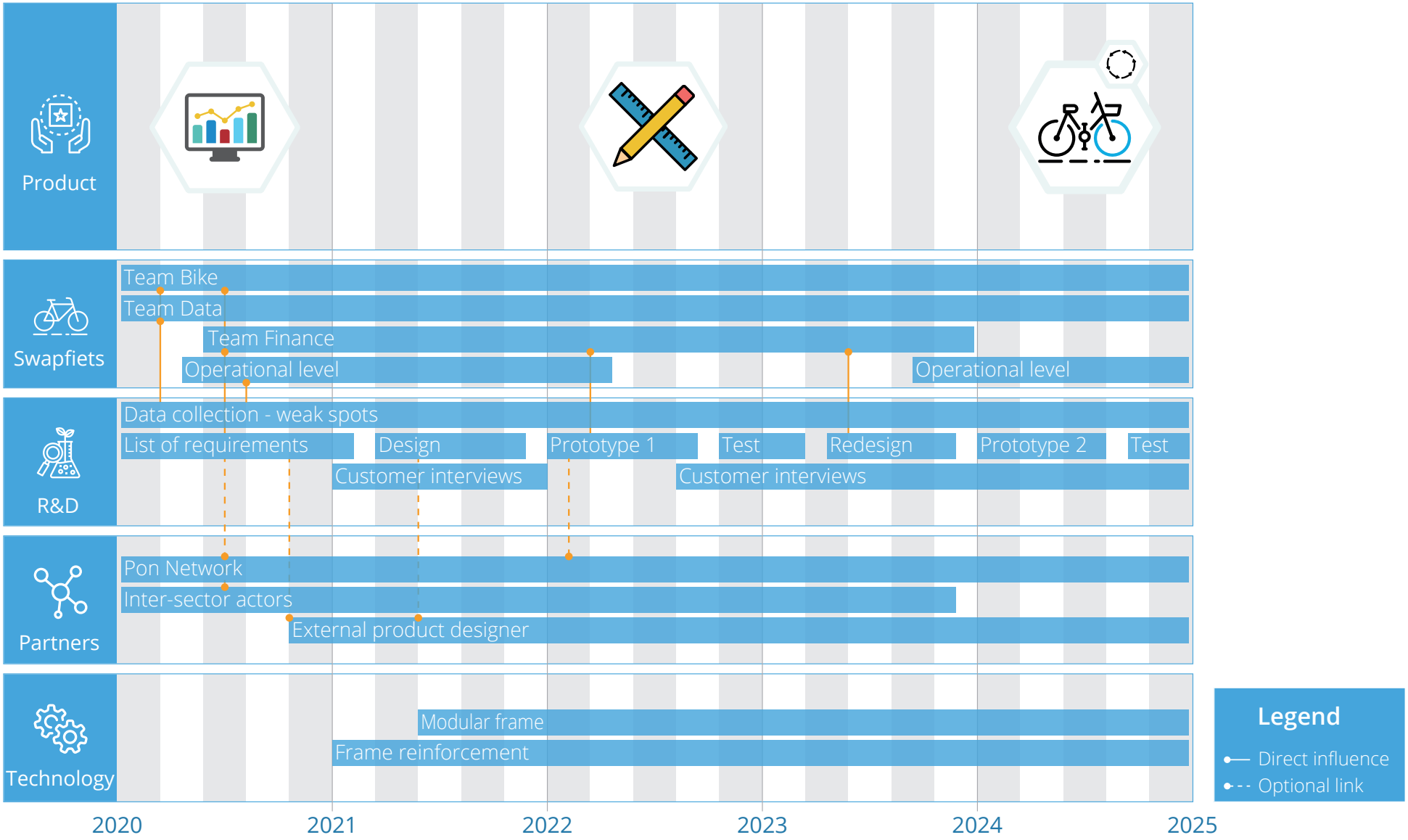
Team Bike, Team Data and the operational level are responsible for identifying the weak spots of the bicycle. These are translated and included into the list of requirements for the bicycle. Throughout this project, Team Finance remains closely involved to monitor the costs and the potential financial benefits. It should not be a goal on itself to redesign the bicycle, but should only be continued when the redesign is expected to be viable, feasible and desirable. Frequent evaluation moments are key to decide whether or not to continue.

For research and design, data collection is an ongoing process to ensure the redesign overcomes all known problems of the current bicycle. The development of the bicycle starts with setting up the list of requirements the design should meet. After this list is compiled, the following cycle should be repeated until the final design is realised: (re)design, prototype and test. The redesign is expected to differ completely from the current design, so customer interviews are necessary to foresee the impact on the customer experience.

For this project, collaborations are likely to be of added value. First of all, there is a lot of knowledge about bicycle design within the Pon network. Not only for designing the bicycle, but also for production, Swapfiets can consult this network. Furthermore, the inter-sector session has shown that there are multiple actors eager to collaboratively design a modular bicycle to close the material loop. When Swapfiets does not have the capabilities or resources to design the bicycle by itself, an external product designer can be employed.

The technology needed for a modular frame is all about enforcement of the frame. Since each rod will be a separate part, developing strong joints is a prerequisite. Production of a modular frame is also a long term technical challenge.

Robust & Modular




THE BLUE
CIRCLE

6 | Discussion and conclusion

Discussion

The aim of this thesis is multi-layered: 1) it examines how co-creation could support transforming a PSS into a SPSS by closing the material loop, and 2) makes out the effect of actor selection for co-creation on the quality of the outcome. To achieve this, two unvarying co-creation sessions are organised with two sets of actors; inter- and cross-sector. Figure 32 (page 71) reveals the differences and similarities between both sessions.

The co-creation process has shown how the agile approach contributes to: 1) creating new insights and ideas (Frow et al., 2015) and 2) involving and creating networks (Perks et al., 2012). This thesis refers to the developed ideas as concepts. The concepts are however not developed enough to be implemented, which puts extra emphasis on the word 'ideas' stated by Frow et al. (2015). Although the ideas created in co-creation are not ready to be implemented yet, co-creation can lead to an increased speed to market (Dong et al., 2008). Co-creation does support the creation of new networks, shown by the possible partnership results of this research (Perks et al., 2012). The co-creation process is very time consuming, mainly due to the preparation. This does not confirm the efficiency of the process, claimed by Adler et al. (2011). However, partnerships can help solving the challenge after the session and advance the created concepts into implementable solutions. So the partnerships developed in co-creation can create long-term benefits to both internal and external participants. This counter-balances the upfront costs and thus complies with Adler et al. (2011).

In contrast to findings of Frow et al. (2015), motivations for competitive actors to engage in co-creation were not about competitive pricing, but possible partnerships. This difference can be explained by the level of competitiveness between actors. This research involved indirect competitors in the same sector, where Frow et al. (2015) describe direct competitors in the same sector. Results also show a contrast to findings described by Sundin et al. (2009), who state that there should be no competitive relationship whatsoever, since there would be no trust nor sharing of knowledge . The results of this research show that competitors develop valuable results, thus knowledge is shared. It does however confirm the lack of trust to some extent, because the process is more precautious, so needs to be a consideration in design.

This research confirms how cross-sector actors are motivated by access to resources (Frow et al., 2015), in the form of information and method sharing. Although cross-sector actors do not have direct knowledge or experience with bicycles, results have proven that all external resources can contribute to the system its well-being (Vargo et al., 2008). Acknowledgements of the internal actors also confirm how external actors ignited new perspectives on innovating the product material flow (van de Poel, 1999).

Conclusion

Co-creation can support transforming a PSS into a SPSS; it supports making steps towards a closed-loop material flow, but requires preparation and good facilitation. It creates room for conversation, supports finding common ground and triggers knowledge sharing amongst actors. Due to its open form and unforced approach, concept directions do not necessarily directly solve the posed challenge.

Concepts created in co-creation show a high potential value. Ranging from short- to long-term solutions and from technical to customer focussed solutions, they are diverse. Co-creation has shown how feasible, viable and desirable concepts are created. However, only one out of six concepts directly answers to the challenge posed in the sessions. Others are focussed on temporary solutions (e.g., an application to prevent maintenance) or improve the material flow in other ways (e.g., a redesign of the bicycle). Furthermore, the concepts are not developed enough to be implemented. They all require further research and development.

Co-creation with external actors is meant to gather knowledge and experience the internal actors lack. In this area, it has proven itself to be effective. Through group interaction, it has led to new ideas and insights. Internal actors acknowledge how different external perspectives have influenced their mindset and how it created fresh ideas.

The influence of actor selection on the quality of the process and outcome is reflected in the results. Both on the outcomes as well as on the process itself. The concepts created by inter-sector actors show a technical focus and are realisable in mid- to long term. Cross-sector actors enhance the focus on the customer and concepts are short-term solutions. Both actors are willing to set up a collaboration, but in different forms. Inter-sector actors tend to create business partnerships, where cross-sector actors are more eager to create in-kind partnerships, to share information and analysis tools.

The process is influenced by actor selection as well. Inter-sector actors are more precautious in sharing knowledge and experience, due to possible competitiveness. Cross-sector actors are open in sharing approaches, challenges and knowledge. Finding common ground is key to the process for both sets of actors. Common ground benefits the general atmosphere, since actors are able to relate to each other.

Motivation for participation in co-creation differs between inter- and cross-sector actors. For inter-sector actors, it is the possibility to create business or information partnerships. Cross-sector actors are however motivated by the resemblance of the challenge.

Limitations

The research is conducted for Swapfiets, to improve the material flow of the bicycle frames. This directly is the main limitation: one case for one PSS. The results do not imply that co-creation supports other PSSs with similar or different problems with certainty.

A comparison is made between how inter- and cross-sector actors influence the quality of the outcomes and process. This comparison is based on only two sessions and future research is needed to confirm the findings.

Fronteer's methodology is chosen, since the author is experienced in applying it. There are other co-creation methodologies that could be better suited for transforming a PSS into an SPSS.

Lastly, no co-creation session is performed with a mix of inter- and cross-sector actors, due to the timespan of this project.

6.1 | Recommendations

Results of this project show the potential of the application of co-creation for Swapfiets specific and PSS's in general. The recommendations are therefore separated in two directions: practice and academic. Practice is focussed on the recommendations for Swapfiets and academic is focused on future research.

Practice

The co-creation sessions have generated insights on two levels; 1) process- how the methodology fits Swapfiets and 2) concepts- how Swapfiets can improve the material flow of the bicycle frames. These two levels are sequentially described below.

Process

When Swapfiets wants to organise co-creation sessions itself, there are two main recommendations: practice and get training. Using creative techniques enhances efficiency and fun. It also leads to new ideas that can be valuable for the organisation. Throughout the execution of this project, the author has organised multiple creative sessions with internal teams. All participants valued the sessions highly and think it helps in working efficiently.

The written approach can be used by anybody, however it needs practices. Start with smaller, internal groups and slowly increase the number of participants. It is also very helpful to get trained in using creative techniques.

However, as described in chapter 5, it is doubted if Swapfiets employees will be able to organise co-creation sessions with similar results. The importance of being unbiased as a facilitator should not be underestimated. During discussions, it is almost impossible, as a manager, to neglect the impact results of co-creation will have on your and your team's job. An external facilitator will provide a higher quality session, with an increased chance on valuable outcomes.

Concepts

The concepts created in co-creation are not ready to implement yet. Following up on all concepts would take a lot of time. If one concept should be further examined, it is Reframing. This concept is the best solution to the problem so far. It requires planning and testing, but it is realisable within 3 years. When it turns out not to be realisable by Swapfiets alone, a partnership with Roetz Bikes is the next best option. Roetz Bikes has the knowledge and experience to set up such a refurbishment factory.

The importance of solving the problem cannot be stressed enough. Although Swapfiets has a lot of urgent problems, closing the material loops should not be underestimated. Swapfiets builds upon its brand value, by putting the customer experience first. The customers' needs and wishes will change in the (near) future. Incorporating sustainability in the company's strategy will contribute to the brand value and can be a differentiation factor. Not only for the brand value, but it will also create financial benefits, since the rest value of the bicycles can be turned into usable assets instead of costs for waste. Lastly, regulations will change and companies will be forced to compensate their environmental impact to some extent. Creating a solution now will protect Swapfiets for such regulations and thus for unanticipated situations.

Academic

The research conducted for this project has shown interesting directions for future research. Two main subjects can be derived from the research: co-creation and creating an SPSS. The two sessions show how co-creation can support the development of an SPSS, but future research is needed to explore improvements and possibilities.

Co-creation

Involving external actors to gain access to their knowledge and experience has delivered a diverse set of concepts. The comparison between inter- and cross-sector actors shows the difference in outcomes. However, this research tested only one challenge within the context of one PSS. Future research could be done to find how actor selection influences the process and outcome in different PSSs and with multiple challenges. A possible partnership is considered as motivation for all participants in this research. Future work could investigate if inter-sector actors can also be involved in co-creation with a higher level of competitiveness and no chance on possible partnerships. Next to comparing two different groups, mixing up both inter- and cross-sector actors can generate valuable insights.

SPSS

The literature review shows a major gap: transforming a PSS into an SPSS. No methodology is developed to support transforming existing PSSs into an SPSS. Successful PSSs are described, but none is found that benefits from both economical and environmental potential impact. PSSs show a high potential to combine both impacts, but no supportive tool or methodology exists that utilises all success factors of an SPSS. Fronteer's co-creation methodology is used for this research, but there are many other co-creation methodologies that could support the transformation from a PSS into an SPSS. Future research could also examine how other methodologies than co-creation fulfil this goal.

References

Abramovici, M., Aidi, Y., Quezada, A., & Schindler, T. (2014). PSS sustainability assessment and monitoring framework (PSS-SAM)–case study of a multi-module PSS solution. *Procedia CIRP,* 16, 140-145.

Adler, P., Heckscher, C. and Prusak, L. (2011), "Building a collaborative enterprise", *Harvard Business Review*, Vol. 89 Nos 7/8, pp. 94-101

Annarelli, A., Battistella, C., & Nonino, F. (2016). Product service system: A conceptual framework from a systematic review. *Journal of Cleaner Production*, 139, 1011-1032.

Ansoff, H. I. (1975). Managing strategic surprise by response to weak signals. *California management review*, 18(2), 21-33.

Aurich, J. C., Fuchs, C., & Wagenknecht, C. (2006). Life cycle oriented design of technical Product-Service Systems. *Journal of Cleaner Production*, 14(17), 1480-1494.

Baines, T. S., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., ... & Alcock, J. R. (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: journal of engineering manufacture*, 221(10), 1543-1552.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.

Brancheanalyse Fietsen | RAI Vereniging. (z.d.). consulted on 12 januari 2019, link; https://raivereniging.nl/artikel/marktinformatie/branche-analyses/brancheanalyse-fietsen.html

Brown, T., & Katz, B. (2011). Change by design. *Journal of product innovation management*, 28(3), 381-383.

Calabretta, G., Gemser, G., & Karpen, I. (2016). *Strategic Design: Eight Essential Practices Every Strategic Designer Must Master*. Amsterdam, the Netherlands: Bis B.V., Uitgeverij (BIS Publishers).

Calabretta, G., Gemser, G., & Wijnberg, N. M. (2017). The interplay between intuition and rationality in strategic decision making: A paradox perspective. *Organization Studies*, 38(3-4), 365-401.

Ceschin, F. (2013). Critical factors for implementing and diffusing sustainable product-Service systems: insights from innovation studies and companies' experiences. *Journal of Cleaner Production*, 45, 74-88.

De Koning, J. I., Crul, M. R., & Wever, R. (2016, May). Models of co-creation. *In Service Design Geographies. Proceedings of the ServDes. 2016 Conference* (No. 125, pp. 266-278). Linköping University Electronic Press.

Dong, B., Evans, K. R., & Zou, S. (2008). The effects of customer participation in co-created service recovery. *Journal of the academy of marketing science*, 36(1), 123-137.

Doualle, B., Medini, K., Boucher, X., & Laforest, V. (2015). Investigating sustainability assessment methods of product-service systems. *Procedia Cirp*, 30, 161-166.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of engineering education*, 94(1), 103-120.

Eilers, S. (n.d.). How we make a new OV-fiets with 70% of the original material | Roetz-Bikes. Retrieved January 20, 2019, from https://roetz-bikes.com/nl_NL/blog/roetz-2/post/how-we-make-a-new-ov-fiets-with-70-of-the-original-material-5

Frow, P., Nenonen, S., Payne, A., & Storbacka, K. (2015). Managing co-creation design: A strategic approach to innovation. *British Journal of Management*, 26(3), 463-483.

Füller, J., Hutter, K., & Faullant, R. (2011). Why co-creation experience matters? Creative experience and its impact on the quantity and quality of creative contributions. *R&D Management,* 41(3), 259-273.

Furlow, N. E. (2010). Greenwashing in the new millennium. *The Journal of Applied Business and Economics*, 10(6), 22.

Gardien, P., Rincker, M., & Deckers, E. (2014). Innovating innovation: introducing the rapid co-creation approach to facilitate breakthrough innovation.

Geissdoerfer, M., Savaget, P., Bocken, N. M., & Hultink, E. J. (2017). The Circular Economy–A new sustainability paradigm?. *Journal of cleaner production*, 143, 757-768.

Henderson, A. (2005). The innovation pipeline: design collaborations between research and development. *interactions*, 12(1), 24-29.

Hietanen, S. (2014). Mobility as a Service. *the new transport model*, 2-4.

Holopainen, M., & Toivonen, M. (2012). Weak signals: Ansoff today. *Futures*, 44(3), 198-205.

Isaksen, S. G. (1983). Toward a model for the facilitation of creative problem solving. *The Journal of Creative Behavior*.

Kemp, R., Schot, J., & Hoogma, R. (1998). Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technology analysis & strategic management*, 10(2), 175-198.

Langley, A. (1999). Strategies for theorizing from process data. *Academy of Management review*, 24(4), 691-710.

Lee, S. M., Olson, D. L., & Trimi, S. (2012). Co-innovation: convergenomics, collaboration, and co-creation for organizational values. *Management decision*, 50(5), 817-831.

MacDonald M, Payne A (2006) Marketing Plans for Service Businesses. *A Complete Guide*.
2nd edition. Butterworth Heinemann Publications, Oxford. ISBN-10: 0-750-66746-X.

Manzini, E., & Vezzoli, C. (2003). A strategic design approach to develop sustainable product service systems: examples taken from the 'environmentally friendly innovation'Italian prize. *Journal of cleaner production*, 11(8), 851-857.

Menold, J., Simpson, T. W., & Jablokow, K. W. (2016, August). The Prototype for X (PFX) framework: assessing the impact of PFX on desirability, feasibility, and viability of end Designs. In *ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. V007T06A040-V007T06A040). American Society of Mechanical Engineers.

Mont, O. K. (2002). Clarifying the concept of product–service system. *Journal of cleaner production*, 10(3), 237-245.

Mont, O. K. (2004). Institutionalisation of sustainable consumption patterns based on shared use. *Ecological economics*, 50(1-2), 135-153.

Morelli, N. (2003). Product-service systems, a perspective shift for designers: A case study: the design of a telecentre. *Design studies*, 24(1), 73-99.

Morelli, N. (2006). Developing new product service systems (PSS): methodologies and operational tools. *Journal of Cleaner Production,* 14(17), 1495-1501.

Mourtzis, D., Fotia, S., & Doukas, M. (2015, September). Performance indicators for the evaluation of product-service systems design: A review. In *IFIP International Conference on Advances in Production Management Systems* (pp. 592-601). Springer, Cham.

Mourtzis, D., Doukas, M., & Fotia, S. (2016). Classification and mapping of PSS evaluation approaches. *IFAC-PapersOnLine*, 49(12), 1555-1560.

Nätti, S., Pekkarinen, S., Hartikka, A., & Holappa, T. (2014). The intermediator role in value co-creation within a triadic business service relationship. *Industrial Marketing Management*, 43(6), 977-984.

[Ons verhaal]. (n.d). Retrieved January 25, 2019, from https://roetz-bikes.com/nl_NL/ourstory

Pater, M. (2009). Co-creation's 5 guiding principles. *Fronteer strategy*.

Pater, M. (2012). Getting the best people for co-creation. *Fronteer strategy*.

Perks, H., Gruber, T., & Edvardsson, B. (2012). Co-creation in radical service innovation: a systematic analysis of microlevel processes. *Journal*

of Product Innovation Management, 29(6), 935-951.

Plé, L., & Chumpitaz Cáceres, R. (2010). Not always co-creation: introducing interactional co-destruction of value in service-dominant logic. *Journal of Services Marketing*, 24(6), 430-437.

Prahalad, C. K., & Ramaswamy, V. (2004). Co-creation experiences: The next practice in value creation. *Journal of interactive marketing*, 18(3), 5-14.

Qu, M., Yu, S., Chen, D., Chu, J., & Tian, B. (2016). State-of-the-art of design, evaluation, and operation methodologies in product service systems. *Computers in industry*, 77, 1-14.

Ramaswamy, V. (2009). Leading the transformation to co-creation of value. *Strategy & Leadership*, 37(2), 32-37.

Reigado, C. R., da Costa Fernandes, S., Saavedra, Y. M. B., Ometto, A. R., & da Costa, J. M. H. (2017). A Circular Economy toolkit as an alternative to improve the application of PSS methodologies. *Procedia CIRP*, 64, 37-42.

Roy, R. (2000). Sustainable product-service systems. *Futures*, 32(3-4), 289-299.

Sanders, E. B. N., & Stappers, P. J. (2008). Co-creation and the new landscapes of design. *Co-design*, 4(1), 5-18.

Santanen, Eric L., Robert O. Briggs, and Gert-Jan De Vreede. "Causal relationships in creative problem solving: Comparing facilitation interventions for ideation." *Journal of Management Information Systems* 20.4 (2004): 167-198.

Santanen, E. L., Briggs, R. O., & Vreede, G. J. D. (2004). Causal relationships in creative problem solving: Comparing facilitation interventions for ideation. *Journal of Management Information Systems*, 20(4), 167-198.

Sundin, E., Östlin, J., Rönnbäck, A. Ö., Lindahl, M., & Sandström, G. Ö. (2008). Remanufacturing of products used in product service system offerings. In *Manufacturing Systems and Technologies for the New Frontier* (pp. 537-542). Springer, London.

Sundin, E., Sandström, G. Ö., Rönnbäck, A. Ö., Sakao, T., & Larsson, T. (2009). Challenges for Industrial Product/Service Systems: Experiences from a learning network of large companies. In *CIRP IPS2 Conference: 01/04/2009-02/04/2009*. Cranfield University Press.

Tukker, A. (2004). Eight types of product–service system: eight ways to sustainability? Experiences from SusProNet. *Business strategy and the environment*, 13(4), 246-260.

Tukker, A. (2015). Product services for a resource-efficient and circular economy–a review. *Journal of cleaner production*, 97, 76-91.

Tukker, A., & Tischner, U. (2006). Product-services as a research field: past, present and future. Reflections from a decade of research. *Journal of cleaner production*, 14(17), 1552-1556.

UK Design Council (2005). The 'double diamond' design process model. *Design Council*.

Union, I. (2014). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. *Brussels. http://ww. w. xploit-eu. com/pdfs/Europe, 202020*, 20.

Van Halen, C., Vezzoli, C., & Wimmer, R. (2005). *Methodology for product service system innovation: how to develop clean, clever and competitive strategies in companies*. Uitgeverij Van Gorcum.

Van De Poel, I. (2000). On the role of outsiders in technical development. *Technology Analysis & Strategic Management*, 12(3), 383-397.

Vargo, S. L., Maglio, P. P., & Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European management journal*, 26(3), 145-152.

Vasantha, G. V. A., Roy, R., Lelah, A., & Brissaud, D. (2012). A review of

product–service systems design methodologies. *Journal of Engineering Design*, 23(9), 635-659.

Vezzoli, C., Ceschin, F., & Diehl, J. C. (2015). Sustainable Product-Service System Design applied to Distributed Renewable Energy fostering the goal of sustainable energy for all. *Journal of Cleaner Production*, 97, 134-136.

Wagner, M., & Schaltegger, S. (2004). The effect of corporate environmental strategy choice and environmental performance on competitiveness and economic performance:: an empirical study of EU manufacturing. *European Management Journal*, 22(5), 557-572.

Yuan, Z., Bi, J., & Moriguichi, Y. (2006). The circular economy: A new development strategy in China. *Journal of Industrial Ecology*, 10(1-2), 4-8.

[Zo werkt Greenwheels]. (2019). Retrieved March 6, 2019, from https://www.greenwheels.com/nl/prive/zo-werkt-het

Zwick, T. (2004). Employee participation and productivity. *Labour Economics,* 11(6), 715-740.