Increasing sustainability within the racking system industry

An exploration in how to achieve an environmental and business sustainable solution at Modul-System

Master's thesis in Product Development

Glen Bales
Bernard Fiedler

Department of Industrial and Materials Science
Chalmers University of Technology
Gothenburg, Sweden 2020

Master's thesis 2020

Increasing sustainability within the racking system industry

Glen Bales & Bernard Fiedler

Examiner & supervisor: Lars Almefelt
Company supervisor: Anders Carlsson

CHALMERS
UNIVERSITY OF TECHNOLOGY

Department of Industrial and Materials Science
Chalmers University of Technology
Gothenburg, Sweden 2020

Master of Science Thesis

Increasing sustainability within the racking system industry

Glen Bales & Bernard Fiedler

Chalmers University of Technology
SE-412 96 Gothenburg
Telephone +46 31 772 1000

Cover image: Modul-System's racking system in use
Printed by: Chalmers Digital Print

Contents

Acknowledgements

We would like thank our supervisor and examinor Lars Almefelt at Chalmers for all the great support throughout this project, especially his expertise within service innovation, which methods to use and how to structure the work in the best possible way. We would also want to thank our company supervisor Anders Carlsson at Modul-System for his support and guidance. Thanks to him we got a good insight into Modul-System and to the company's customers and partners. We are thankful for the treatment we got by the people at Modul-System, where we were warmly welcomed and got assisted throughout the project. The office they lent us, has been of great value, enabling us to at a moments notice to talk with anyone at the office.

Additionally, we would like to thank the rest of the people that contributed to the this project, such as the interviewees that took part in the customer analysis and the support from Chalmers, RISE and Högskolan Dalarna.

Glen Bales & Bernard Fiedler, Gothenburg, May 2020

Increasing sustainability within the racking system industry
An exploration in how to achieve an environmental and business sustainable solution at Modul-System
GLEN BALES
BERNARD FIEDLER
Department of Industrial and Materials Science
Chalmers University of Technology

Abstract

This project has had as a purpose to develop a new service concept for racking systems, used in light commercial vehicles, that meets the future needs for electrical vehicles (EVs) and results in a more sustainable service. It has been conducted by two students performing their master thesis at Chalmers University product development masters programme, in collaboration with the company Modul-System. Included in the report is a pre-study, exploring the literature around environmental sustainability, electric vehicles and outsourcing. The market, its trends and actors are analysed. An iterative concept generation phase is also conducted. The main focus has been in exploring and evaluating a broad spectrum of different business models, resulting in two concepts, Re-use and Optimise use, being produced and further detailed.

Re-Use is a business oriented concept, which through circular economy, aims to increase the racking systems' life span. It achieves this in two ways. Firstly, through re-use of racking systems for the first hand customer, moving the racking systems from a vehicle, that is going to be retired, to a new one. Secondly, through refurbishment and sales of used racking systems to a second hand customer, targeting the low price segment of the market. Emphasis on how to realise the refurbishment of the racking systems is included in the later stages of concept development.

Optimise use focuses on integrating hardware and software solutions, to increase the effective range of electric vans with racking systems installed. It also aims to increase resource utilisation efficiency. The main features are (1) a material management system, (2) a fleet management system adapted for EVs and (3) removable/mobile racking systems. The material management system aims to minimise the material that the customer brings to the work sites by integrating both physical and software solutions. The fleet management system includes new functions adapted for EV use that facilitates work optimisation from a fleet perspective and monitoring of individual vehicles/drivers. The removable racking systems will facilitate material exchange and allow the customers to charge their vehicles while they perform their work tasks.

It is also concluded that that the purpose of the project is fulfilled, but further analysis and development is necessary to fully implement the two concepts. A conclusive recommendation for how to proceed with the development of both concepts is thus lastly presented, including a pilot program for the Re-use concept and recommendations for future master thesis projects.

Keywords: Circular economy, Sustainability, Servitisation, Electric vehicles, Racking systems, Fleet management

Chapter 1

Introduction

In society there is a trend were environmental sustainability is highlighted. A Swedish study by Naturvårdsverket found that 86% of the Swedish population believes that societal intervention is needed to decrease climate change (Naturvårdsverket, n.d.). If a company has a sustainability profile it is becoming increasingly attractive to investors and consumers (Mcavoy, n.d.) (Whelan & Kronthal-Sacco, n.d.). Modul-System sees this trend and wants to help reduce the environmental footprint in society. They are already working on reducing the carbon footprint, by minimising the weight of their products, which are installed into light commercial vehicles (LCV:s). This is an important task but Modul-System also believe that they can do more to help alleviate the stress put on the environment and its eco-systems through innovating within their field.

LCV:s are commonly used among service companies. In the 1990:s a transition took place from using gasoline driven to diesel driven LCV:s. This was mainly a result of higher gasoline taxes which was favoring diesel as a fuel. Now, a similar transition is taking place. Air quality concerns have resulted in more restrictions on diesel vehicles in European cities and emission policies such as the European Parlament initiative (Directive, 2014/94/EU) are encouraging companies to use vehicles with alternative fuels (Morganti & Browne, 2018). Therefore, Electric LCV:s has been recognized as a clean option to its diesel counterparts (Morganti & Browne, 2018) and EU transport policy stipulates that the number of internal combustion (IC) vehicles generally should be reduced by 50% by year 2030 and completely gone by year 2060 (Wątróbski et al., 2017). Here, the company Modul-System want to follow the sustainability trend and adapt their products for electric vehicles.

1.1 Background of the company

Modul-System is one of the leading European companies that provides equipment for LCV:s used by craftsmen and service technicians. Their offers consists of racking- and shelving systems for service and delivery vehicles, and electrical systems such as work lights and converters. Their products are based on modules and are usually permanently installed in the vehicles and used throughout the vehicles' service life. As a company, Modul-System highly value quality and safety, and they put a lot of effort into creating innovative products. Their main customers are those who use service- and delivery vehicles and the company's products are sold in more than 50 countries. The head quarter is based in Mölndal, Sweden.(Modul-System, n.d.)

As a brand Modul-System see themselves as a premium brand providing high quality products. The products, which are manufactured in Mullsjö, Sweden, are carefully quality controlled along the the whole development process. (Modul-System, n.d.)

Modul-System has retailers in all continents and service centers in Europe, Asia, Africa and Australia. It is usually at their service centers or partners were the products get installed into the vehicles. Common for most of Modul-System's products are that they do not require destructive installation, such as drilling or welding, which in turn retains the vehicles' residual value. (Modul-System, n.d.)
Modul-System divides their product offers into four categories, namely; (1) Modul-System, (2) Modul-Express, (3) Modul-Floor and (4) Modul-Connect.

(1) Modul-System - Equipment for service vehicles
This segment mainly consist of modular racking systems, see Figure 1.1. The systems consist of extractable drawers and shelves fitted in metal frames, plastic boxes and removable tool boxes. In 2010 they released a new racking system platform, which is the one they use today. The frames in this platform is made from ultra high strength steel and all parts in the platform have dimensions which are multipliers of 27mm. Due to this Modul-System specific standard, all the different boxes, shelves, work tops etc. have to be designed and manufactured/outsourced by Modul-System. This also includes the mounting on to the base frames. They are spaced with multiples of 27mm and the frames geometries naturally also adhere to the same standard. From a design perspective these multiples of 27mm facilitate the making of different parts for the platform, creating a simple design space, reducing the need for coordination between the design functions. Installation is done by attaching the main frames to the floor and walls of the vehicle by the use of rails , see category (3) Modul-Floor below. (Modul-System, n.d.)

Figure 1.1: Modul-System's racking system (Modul-System, n.d.)

(2) Modul-Express - Equipment for delivery vehicles.
This segment includes shelving systems for delivery vehicles made from ultrahigh strength steel. In order to make room for both large and small packages the shelves are foldable which means the that the floor space can be used more efficiently when needed. Within this segment Modul-System also offer internal walls with a sliding door between the drivers compartment and the loading compartment. This means that the driver does not have to exit the vehicle while retrieving a package, which increases safety. This also means that the driver does not have to step out on the street. Thus, also lowering the delivery time since the driver only need to exit the vehicle once during a delivery (Modul-System, n.d.)

(3) Modul-Floor - Internal floors and walls for vans.
As most of Modul-Systems products, the floors consist of modular panels that can easily be fitted and adapted into the customers' vehicles. They can also be fitted with rails so that other products such as racking systems easily can be mounted and adjusted into the vehicles with non-destructive methods. The floor and wall elements are made from light-weight material (Aluminum and polymer sandwich construction) usually attached with glue. (Modul-System, n.d.)

(4) Modul-Connect - Electrical systems for vans.
This segment consist of various systems such as lights, switches, inverters etc. Modul-System has also developed a mobile app from which the different electrical systems can be controlled. (Modul-System, n.d.) Modul-System also plan to incorporate their fleet management system Modul-Fleet to Modul-Connect.

1.2 Purpose and Objectives

The purpose of this project is to develop a new service concept for racking systems, used in light commercial vehicles, that meets the future needs for electrification of power trains and to lead the way into a more sustainable future.

The objectives of the project are:

- To provide a comprehensive description of what is required to satisfy all stakeholders for a service solution with electrical vehicles.
- To deliver a racking system concept which is adapted to electrical vehicles, that is commercially viable and sustainable (environmentally, economically and socially).

1.3 Scope and Delimitations

- The project is a master thesis work and will span over approximately one term (20-01-2020 to 07-06-2020). It will be conducted by two students dedicating 30 study credits each, adding up to 60 credits.
- The project will focus on Modul-System's first product segment; (1) Modul-System, which mainly consist of racking systems for service vehicles. The inclusion of (4) Modul-Connect in the concept is also considered within the scope.

- A finished product will not be released at the end of the project, only a concept will be presented. This will be the equivalent of a 5 or 6 on the TRL scale (EuropeanCommision, n.d.).
- Sweden and Norway will be the main markets analysed with an extended focus to the European market as well.
- The users will be limited to service personnel and craftsmen. Use for delivery services will not the included in this project.

1.4 Clarifications of Research Questions

The following research questions will be answered in the project report:

- RQ1, How do the Swedish and Norwegian markets for racking systems for service- and transport vehicles look like?
- RQ2, What are the current trends in society and how will they impact the market in the near future?
- RQ3, What are the customer needs?
- RQ4, What are the requirements that must be met in order to increase sustainability?
- RQ5, How has Modul-System fulfilled the customer needs in their current offering and how will the use of electric vehicles affect this fulfillment?
- RQ6, How can a new product-service system be formed to fulfill the customer and sustainability needs/requirements?

1.5 Key Activities

The following points are the the key activities of the project:

- Identify constraints and opportunities for electric vehicles
- Identify customer needs
- Develop a service system that is both adapted for the new electrified power trains and increases sustainability
  - Identify current products that can be used in the service system
  - Develop new products/systems, for the requirements that can not be met by the current product offers
- Verify that customer needs and commercial conditions are met

Chapter 2

Methodology

The project will be conducted by following a classical product development methodology, heavily inspired by "Product design and development" by Ulrich and Eppinger, with an additional focus on service innovation (Ullrich & Eppinger, 2016). This will include a pre-study, market and customer analysis, a concept generation phase and a detailed design phase.

The goal is to first get an understanding of the problem at hand, its relevance to the current market and who the customers and stakeholders are. Then get an in depth understanding of the customer and their needs, to be able to relate them to a target specification. After that an iterative phase of functional analysis, concept generation and concept elimination will commence. Here the aim is to increase the detail and understanding of the solution space for each iteration. There will be approximately 3 iterations, each time increasing the product specificity. The last step is detailed design were both the service and product sides of the concept get refined and detailed. Figure 2.1 gives a graphical representation of the methodology with additional methods that are going to be used. The rest of Chapter 2 will further detail and give context to the methods and methodology being used.

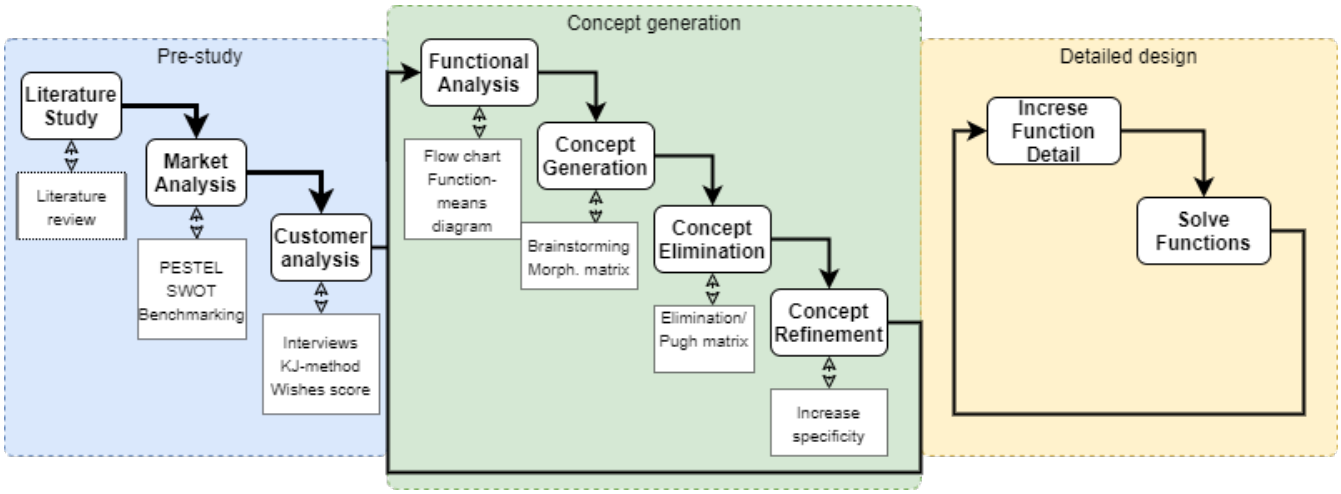

Figure 2.1: Methodology

2.1 Methodology of Pre-study

This is the starting point for every project, the exploration phase. The pre-study's main goal is to gather background information, paving the way for the concept generation phase. Included in this stage is a literature study, market analysis and customer analysis.

2.1.1 Literature study

To first get a general and complementary understanding of the surrounding technology, societal requirements and sustainability aspects (like circular economy and product service systems), a literature study will be conducted (Ullrich & Eppinger, 2016). The main source of information will be through the Chalmers library and Google Scholar. These are used as search engines to find relevant research papers and articles in the previous described subjects. The main focus in technology is to find EV-van/vehicle related reports. In societal it will mainly be focused on laws and regulations, including taxes regarding vans. Service innovation will be a more general search since this topic is a less experienced field for the authors. Focus here will be on finding methods and information on combining physical products with a service to enhance competitiveness and sustainability.

2.1.2 Market analysis

Having created a knowledge platform from the literature study, the in depth analysis of the market can commence. Here the company and its competitors will be analysed based on their current offerings and reaction to future trends.

Current state and its future trends:
To get an understanding of the factors that currently affect the market/company, and how they might impact the future, a PESTEL analysis will be conducted (OCM, n.d.-b). Here the six external factors Political, Economical, Social, Technological, Environmental and Legal will be analysed in relation to Modul-System and their product offerings for rack mounting in vans.

Competitor analysis:
To gauge the competition and how they perform in relation to Modul-System benchmarking will be conducted (Ullrich & Eppinger, 2016), comparing their racking systems and business models against Modul-System's.

Company analysis:
Looking internally, the company's role and impact in the market will be assessed. This will be conducted through unstructured and semi structured interviews with the employees of Modul-System, their partners and customers. This information, in combination with complementary articles found online, will be the foundation on which the SWOT analysis will be conducted. This analysis aims to, in a structured way, portray the position Modul-System has in the market by identifying its Strengths (s), Weaknesses (W), Opportunities (O) and Threats (T) (OCM, n.d.-a).

2.1.3 Customer analysis

Concluding the pre-study is the investigation of the customer, who they are and what needs they have. The main sources for this information will be gathered through interviews (Ullrich & Eppinger, 2016), both internally with Modul-System employees and with their customers. This will be done in the following steps:

Identify customer segments:
Interviews with Modul-System employees and their partners, semi structured.

Identify customer needs:
Interviews with Modul-System employees, their partners and their customers, semi structured. The interviews will then be analysed and sorted through the KJ method, sorting the statements into common categories and combining them into customer needs (Scupin, 1997). To complement the interviews, study visits to Modul-Systems racking installation work shop and their factory will be conducted. Here the aim is to give context to the statements from the interview. If possible a study visit will also be done at a racking system user, to see how they use it.

Convert needs to demands/wishes in a requirement specification:
When the customer needs have been identified they will be converted into demands or wishes for the service (Ullrich & Eppinger, 2016).

2.2 Methodology of Concept development

Setting the target specification then enables the Concept development to commence (Ullrich & Eppinger, 2016). This will be an iterative process were the team works from a general level in early iterations, then going into more and more detail per iteration. The iteration steps are as follows: Functional analysis, concept generation, concept elimination and further development of concept(s).

2.2.1 Functional analysis

The system analysis is conducted by making a function diagram or function-means diagram. This aids in breaking down the problem into smaller functions and sub-functions (Ullrich & Eppinger, 2016). The first iteration will have more general functions, with the subsequent iterations having more detailed sub-functions.

2.2.2 Concept generation

The functions have now been defined and will be the cornerstone in generating concepts. First, a concept generation (brainstorming) session to solve each sub function will be conducted (Ullrich & Eppinger, 2016). Here no restrictions on the ideas will be implemented, I.E the requirement specification will not be considered in this stage. To increase the creativity, first each member of the team will try and come up with solutions on their own, then they will discuss and compare solutions and develop new ones together. The next step is to combine concepts from each sub-function to a complete concept. This will

be done by using a morphological matrix, combining different sub-solutions into themes relevant for that iteration.

2.2.3 Concept elimination

Here a systematic elimination of concepts will occur, removing non-conforming concepts and comparing them against each other with regards to the requirements. The methods used will be elimination matrices (Pahl, Beitz, Feldhusen, & Grote, 2007), Pugh matrices, that look at how well each concept fulfills the wishes in the requirement specification (Ullrich & Eppinger, 2016). Worth noting is that due to some concepts and iterations having more abstract development and concept generation other, less rigid, methods will be used. These will be described and motivated when they are implemented.

2.3 Methodology of Detailed design

Once the final concept(s) has been chosen it is time for the detailed design phase. Here the chosen concept will be further refined to better fullfil the customer needs. The methods that will be used in this phase will be determined later in the project depending on to what degree the selected concept is a physical product (tangible solution) and service (intangible solution). The end result will be represented by a prototype that shows the physical product.

Chapter 3

Pre-study

Having detailed the purpose and the methodology for how to achieve it, the research stage will commence. This chapter will explore and gather the needed information for starting the concept development. It includes a literature review, market analysis, company analysis and finally a customer analysis. The culmination will be the requirement specification which will be the backbone for the concept development phase.

3.1 Result of Literature study

This section is dedicated to the results from the conducted literature study, described in Chapter 2. It will include sustainability aspects in terms of servitisation and circular economy, an outsourcing analysis strategy, information regarding electrical vehicles and their current regulations.

3.1.1 Service innovation and product service systems

There is a servitisation trend within manufacturing companies (Rexfelt et al., 2011). This is due to a need for differentiation and increased focus on sustainability, with the aim to increase customer loyalty and competitiveness (Wallin, Parida, & Isaksson, 2015). A service is commonly described as processes or a series of activities provided by a company in interaction/collaboration with a customer, and eventual mediating resources, that solves the customers described problems/needs. It is something intangible with complex interactions between humans to humans and humans to machines. (Rexfelt et al., 2011)

The following section will detail how the literature defines what product service system (PSS) is, how it relates to increased environmental sustainability, the difficulties of transitioning into developing PSS and requirements to innovate within this field.

Product service systems

Tukker, van den Berg, and Tischner (2006) have compiled definitions for product service systems from a sustainability perspective and concludes that all definitions acknowledge a link between services and products. That services are made up of tangible and intangible elements and seeing something as a pure service or a pure product is flawed. They further state that a service is on a spectrum between mainly product (tangible) oriented and

service (intangible) oriented. Tukker (2004) illustrates this in his article *"Eight types of product–service system: eight ways to sustainability?"* as can be seen in Figure 3.1.

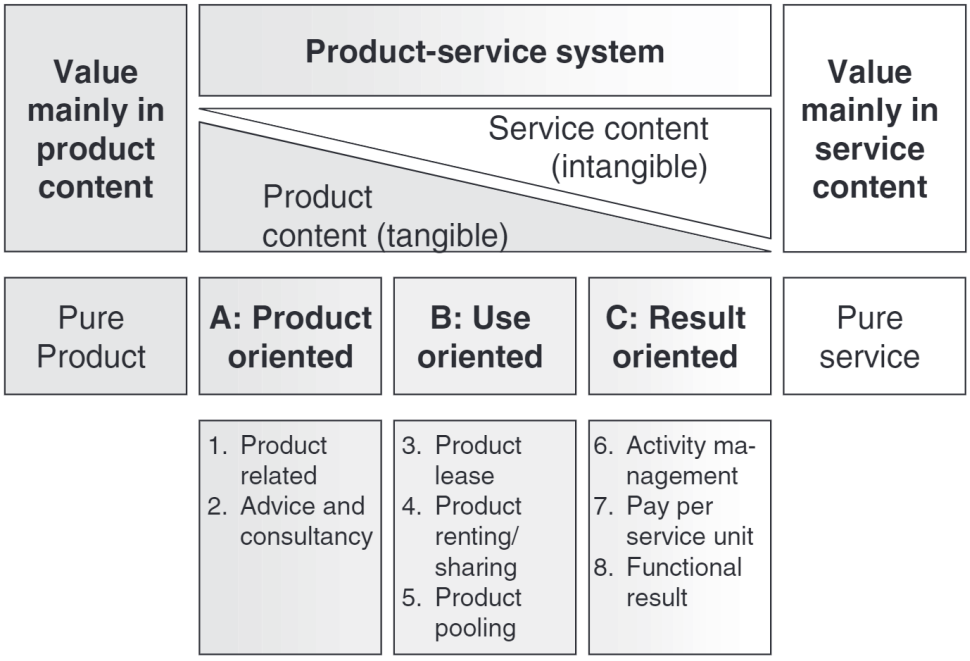

Figure 3.1: Main and sub categories of PSS (Tukker, 2004)

Here this spectrum is divided into three main categories: Product oriented, Use oriented and result oriented. They further also categorise 8 different PSS types. In Figure 3.2 these are tentatively scored on the environmental sustainability impact of implementing each type of PSS types compared to a regular product. The list below describes the 8 types and their potential for reduction in environmental impact.

1. Product related service (Product oriented)
    - Description: This service is based on selling a product in tandem with providing a maintenance contract or the supply of consumables.
    - Environmental impact: Does not encourage internalising life cycle costs into design process. Only incremental improvements, by optimising maintenance or consumable usage.
2. Advice and consultancy (Product oriented)
    - Description: The provider of the product gives advice on how to efficiently use the product and how to structure the organisation around it.
    - Environmental impact: Same as in product related service, the provider might suggest some optimisation advice for the use of product. This only leads to incremental reduction in environmental impact
3. Product lease (Use oriented)
    - Description: The provider still owns the product and usually stands for repair, control and maintenance. The customer pays a fee for the use of the product and usually has unlimited access to it.

- Environmental impact: It is unclear if this gives a reduction or not. There could be some incentive in the efficiency of repair and maintenance. If the leasing company designs and produces the leased product then they could also be encouraged to increase the life span of the product. Most leasing companies though only buy the products they lease. The leaseé also has a tendency to not be as careful with the product and usually uses it more harshly, reducing its lifespan and then increasing environmental impact.

4. Product renting and sharing (Use oriented)

    - Description: The provider still owns the product and usually stands for repair, control and maintenance. The customer, as in leasing pays, for the use of the product but does not have unlimited/individual access to it, I.E the product is used by several users.
    - Environmental impact: Sharing/renting means that it is more intensely used and if the main life-cycle impact is in manufacturing the environmental impact will be reduced. Furthermore, this PSS has a barrier for use in terms of difficulty of renting, thus possibly pushing the user towards more environmentally friendly options such as public transport etc.

5. Product pooling (Use oriented)

    - Description: Very similar to renting or sharing with the exception that there is a simultaneous use of the product.
    - Environmental impact: Same type of environmental impact as renting/sharing with the difference that pooling implies simultaneous usage, further decreasing environmental impact

6. Activity management (Result oriented)

    - Description: Usually used for outsourcing, where the results are controlled through contracts. The service is performing the same activity that the customer company before did internally. This could for example be cleaning, providing food etc.
    - Environmental impact: There will not usually be a large change in technology compared to how it was used before but the new providing company has a bigger incentive to do the job more efficient to increase margins. If the efficiency gains are in material usage then there will be a reduced environmental impact. Worth noting is that many of the efficiency gains are through personnel costs, with a very small reduction gain for environmental impact.

7. Pay per service unit (Result oriented)

    - Description: This PSS has a physical product tied to it but the customer only pays per unit. An example of this is the pay per print service that many printing companies provide. The service provider ensures that the printer and all consumable materials are there and the customer only pays per printed paper.

- Environmental impact: There are two major reduction possibilities here. Firstly, the provider is responsible for all life-cycle costs, incentivising them to design products that are efficient throughout the life-cycle. It also makes it more viable to re-use components after a product life. The provider will simply try and develop and improve products with a life cycle performance perspective. Secondly, there are cases where the customer will try to be more efficient of the use of a certain product like in the case of pay per wash. Due to the tangible cost per use the customer will be more conscious of how often they wash and will try and optimise it.

8. Functional result (Result oriented)

    - Description: The service is an agreement between provider and customer of a delivered result. In contrast to activity management, which specifies the way of providing the result, functional result services only promise the end result (functional result). The means of providing this result is then completely up to the provider. An example of this could be that a pesticide company guarantees <x% of the harvest lost instead of selling pesticide per volume unit.
    - Environmental impact: This has the highest potential of reduction. Providers only deliver a result and can therefore be very creative in how they deliver that result. They will be encouraged to come up with innovative ideas that are as cost efficient as possible, which could result in radically new, environmentally and economically efficient solutions.

(Tukker, 2004)

Table 3. Tentative (environmental) sustainability characteristics of different PSS types

PSS type	Impacts compared to reference situation (product)				
	Worse	Equal	Incremental reduction (<20%)	Considerable reduction (<50%)	Radical reduction (<90%)
1. Product-related service		←----------→			
2. Advice and consultancy		←----------→			
3. Product lease	←----------→				
4. Product renting and sharing		←----------→			
5. Product pooling		←----------→			
6. Activity management		←----------→			
7. Pay per unit use		←----------→			
8. Functional result		←----------→			

Notes:
- Renting, sharing: radically better if impact related to product production.
- Pooling: additional reductions compared with sharing/renting if impacts related to the use phase.
- Renting, sharing, pooling: even higher if the system leads to no-use behaviour.

Figure 3.2: Service type environmental impact (Tukker, 2004)

Delving into what the literature says about the transition manufacturing companies have to make to implement PSS and its development, there are several challenges described. To develop a PSS there is a tangible side in terms of the physical product and an intangible side, relating to the services (Karlsson, Larsson, & Öhrwall Rönnbäck, 2018). It is also important that these two aspects are developed together and not independently, which is

called functional product development (Isaksson, Larsson, & Öhrwall Rönnbäck, 2009). Further, since value in a service is extensively co-created with the customer there needs to be more customer focus in PSS (Isaksson et al., 2009). Rexfelt et al. (2011) and Almefelt et al. (2009) also state that involving the customer in the idea generating process is beneficial. Further emphasising this is that customer ideas have in many cases been found to be more innovative than the professionals developers (Rexfelt et al., 2011).

Since manufacturing companies are used to dealing with tangible products, they need to develop new capabilities within the organisation to cope with the intangible aspect of a PSS. This is especially important in the earlier stages of development called the fuzzy front end (FFE). In the beginning when an idea is being formed within an organisation the development is very informal, chaotic and abstract. This is what characterises the FFE, which ends when a project gets funded within the company. Thus, the ideas have to compete against each other to see which are chosen to be moved forward with. If an organisation does not have experience with handling intangible things (services), then they will have a great disadvantage against the traditional, tangible ideas. Therefore an organisation needs to have the capability to see the value in the intangible parts, or the service ideas will not even make it to the funding stage. (Karlsson et al., 2018)

3.1.2 Circular economy

Circular economy is a business model that is becoming more considered by companies, since it can have both economic and environmental benefits. The main idea is to close resource loops and therefore use the resources in a more efficient way. Usually this has not been done at all in traditional business models (Guldmann, 2016). Instead a linear economy has been the standard and it generally includes the following phases:

1. Excavation/production of raw materials
2. Product design and manufacturing
3. Product use/consumption
4. Disposal or waste in landfills

(Naturskyddsföreningen, n.d.) (Guldmann, 2016)
In this way the resources has been lost at the end of products life cycles, both the raw material itself and the value gained from the 2nd phase (product design and manufacturing).
Circular economy aims to close the resource loops and keep the resources in the system as long as possible. According to a study by Guldmann (2016) companies can do this in various ways. Some companies focus on single loops while others focus on several. The loops can be closed at different levels, for instance on a small level in collaboration with the customers or at a larger level with external suppliers. Figure 3.3 shows examples of how the resource loops can be closed to create a circular economy. Closing of the resource loops and therefore elongate the products life cycles can be done through maintenance, reuse/redistribution, refurbish/remanufacturing and recycling (Guldmann, 2016).

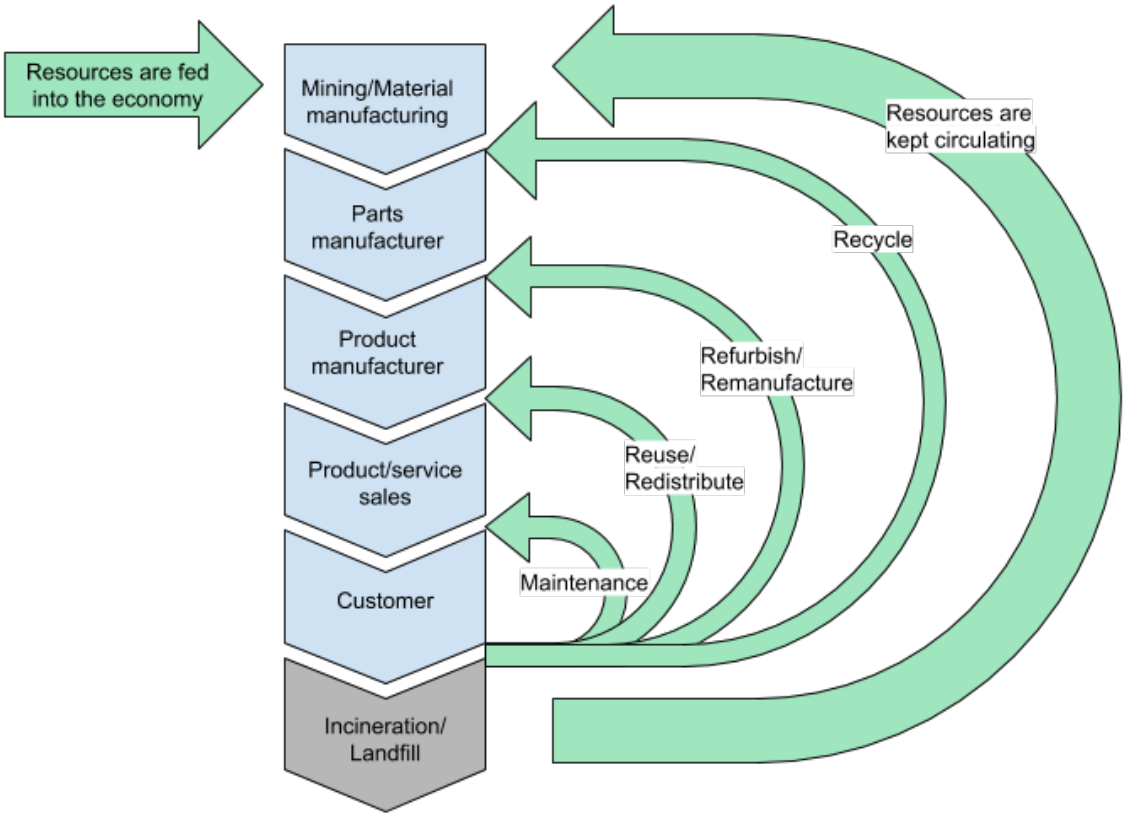

Figure 3.3: Circular economy with resource loops at different levels (Guldmann, 2016)

A case study made by Accenture (2014) identified five different business models among 120 companies that has introduced circular economy into their businesses. These identified business models were:

1. Circular supplies:
   This business model focuses on avoiding scarce resources and instead use materials that are renewable, recycleble and biodegradible. The model also emphasises the removing of inefficiencies and waste.

2. Resource recovery:
   This business model focuses on recovering the value of products in the end of their life cycles, and to possible take advantage of this value by inserting it into other product life cycles. This can for instance be done by smart recycling and upcycling services (turning waste into value).

3. Product life extension:
   This business model focuses on extending product life cycles by through repairing, upgrading, remanufacturing and remarketing. In this way the embedded value in products can be kept for longer in the system instead of being turned into waste.

4. Sharing platforms:
   This business model focuses on users sharing the products and therefore enable

efficient resource utilization. This can decrease the need for newly manufactured products since many users can share the same product.

5. Product as a service: This business model focuses on providing product as services (for instance as leasing or "pay-for-use") instead of providing them as "buy and own". The advantage of this is that the providing companies has to focus on product quality and durability, rather than product quantity, since they are in the ownership of the products.
   (Accenture, 2014)

More information about the business models 4 and 5 can be found in section the service innovation section (3.1.1).

3.1.3 Outsourcing

The term outsource is an abbreviation of outside resource using and is defined as the act of utilising external resources to perform operational tasks. It most commonly known as a means to outsource manufacturing but can also be applied to other parts of the business, like accounting, cleaning or HR. Choosing to outsource is often for long term cost reduction and/or focus on the companies core competencies and strategic advantage. (Weimer & Seuring, 2009)

Capability sourcing

Gottfredson, Puryear, and Phillips (2005), describe in their article, a strategy called capability outsourcing. This entails moving from a vertically oriented organisation, owning the most of the supply chain, to only focusing on the companies core strategic advantage and outsource the rest to competent partners.

Figure 3.4 illustrates a method on how to identify which parts of ones business are candidates for outsourcing and which should remain in house. The vertical axis how proprietary the process or function is, with the four categories, listed from the bottom up: *"Profit model is proprietary", "Business process is proprietary", "Data are proprietary"* and *"Not proprietary"*. The horisontal axis is the uniqueness of the business process or function, with *"Unique to self"* being on the far left and *"Common across industries"* being on the far right. If the process/function is in the top right corner of Figure 3.4 it is a prime candidate for outsourcing. If is is in the lower left part then it not suitable to outsource and could even be a potential service that the company offers to other ones.(Gottfredson et al., 2005)

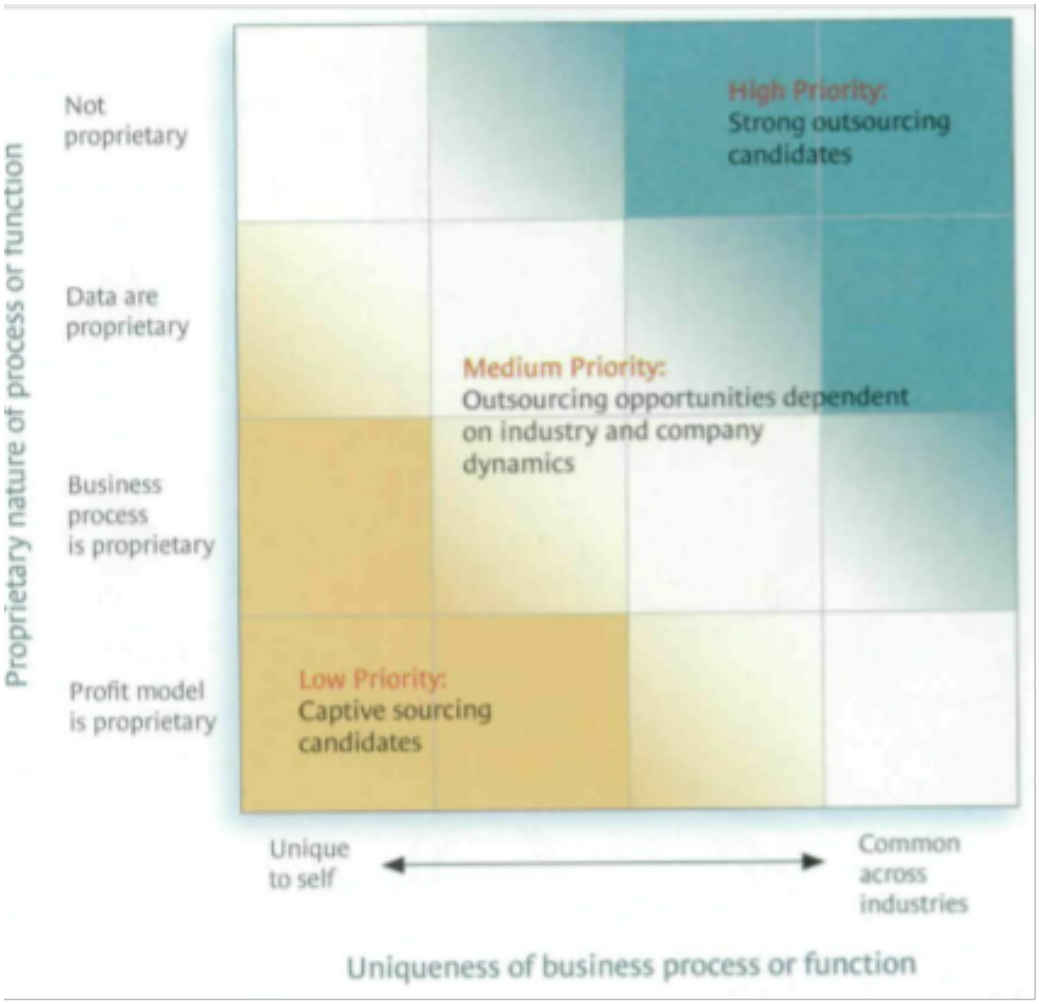

Figure 3.4: What should you outsource? (Gottfredson et al., 2005)

In Figure 3.5 one takes the identified outsourcing candidates and analyse them based on the companies ability to perform the function, on the vertical axis, and the cost per transaction on the horisontal. The ability to perform function, from the bottom up is categorised in *"Not good enough"*, *"Sufficient"* and *"Better than it needs to be"*. Cost per transaction is based on industry median, with above median on the left and below on the right. If the capability is in the top and middle right section one should consider creating a new business instead of outsourcing it. In the case of top middle and left, sourcing for cost reduction and sacrifice of capability to do so is recommended. Middle and middle left one should source to reduce costs. Bottom left, one sources to both increase capability and to reduce cost. If the capability is in the bottom middle and right, then one should consider to source for increase in capability even if it is at a higher cost. (Gottfredson et al., 2005)

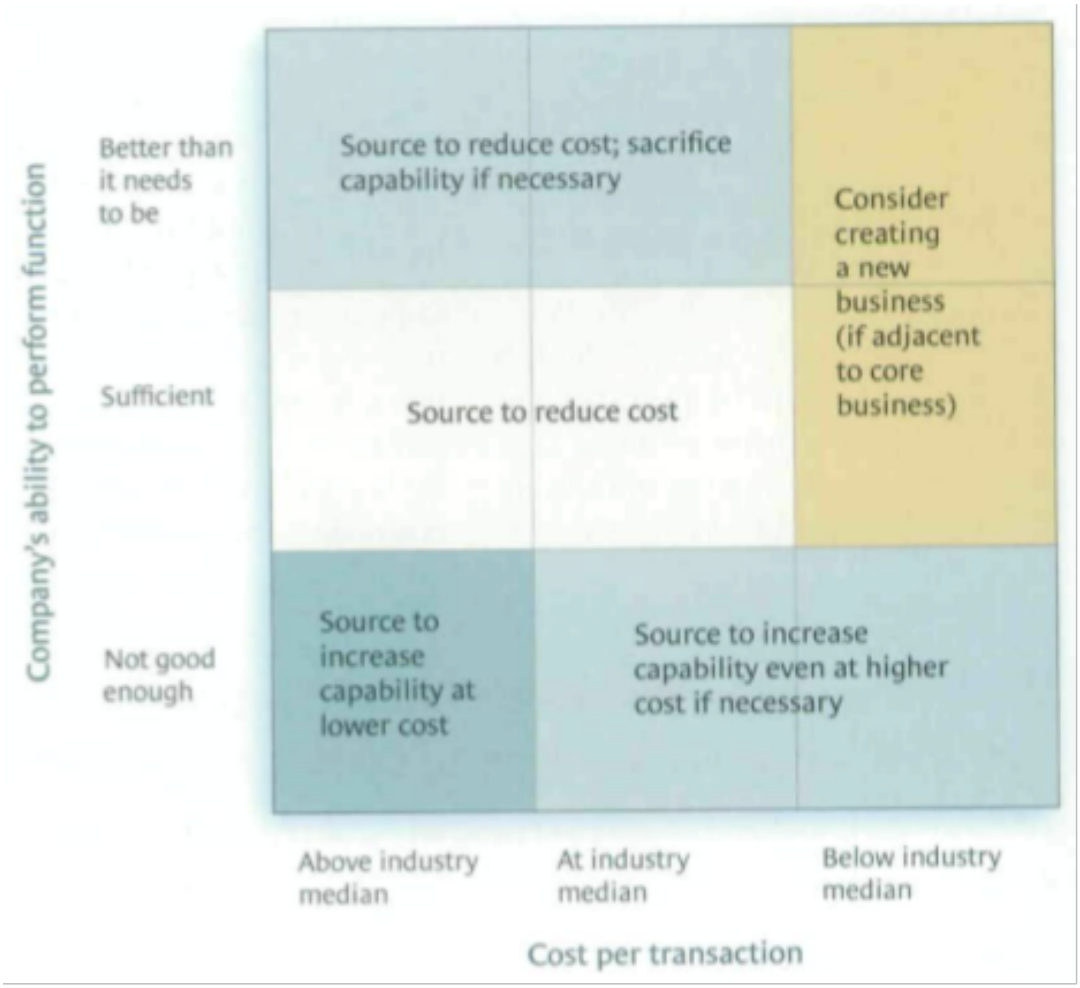

Figure 3.5: How strong are your capabilities? (Gottfredson et al., 2005)

3.1.4 Electric vehicles

In this section literature regarding electrical vehicles will be presented. It will include current trends, advantages and possible barriers with electrical vehicles, both generally and from the perspective of craftsmen and service companies. The final section will present possible solutions to the barriers.

Current trends and market

There has been a growing interest for electric vehicles during the last years. EU transport policy stipulates that the number of internal combustion (IC) engine vehicles should be reduced by 50% by year 2030 and gone by year 2060 and electrical vehicles are regarded as a feasible substitutes. The fastest growing markets for electrical vehicles are Europe and China, and there has been a large increase in the number of electric vehicles (EVs) in Europe during the last years; In 2009 700 EVs were registered and in 2017 more than 100000 EVs were registered in Europe (Wątróbski et al., 2017). One of the major reasons for this increase is that taxes and oil price increased together with the rising air quality concerns have lead to stricter regulations of diesel vehicles in European cities (Morganti & Browne, 2018). Therefore, emission policies such as European Parliament initiatives (Directive, 2014/94/EU) are encouraging companies to use vehicles with alternative fuels

in cities, such as electric vehicles that produce less pollution than IC vehicles (Wątróbski et al., 2017). In terms of substitutes for diesel driven light commercial vehicles (LCV:s) several car manufacturers have begun to offer electrical counterparts; some examples are the Nissan e-NV200, Renault e-Kangoo, StreetScooter Work and Peugeot Partner Electric (Morganti & Browne, 2018).

The advantages of electric vehicles

One of the advantages with EVs are that they can reduce costs. This according to Wątróbski et al. (2017) is because electrical transport vehicles can reduce transportation costs by 40% compared to conventional vehicles due to larger restrictions on conventional vehicles (taxes, fees etc). The authors also claim that other costs such as insurance costs and maintenance costs are lower compared conventional vehicles. The lower maintenance costs is a result of an EVs simpler drive train which is not as prone to failures as IC engines. Because of this Wątróbski et al. (2017) claims that companies with large vehicle fleets can substantially reduce maintenance costs by introducing electrical vehicles. Also, even though the retail prices for EVs usually are higher compared to conventional vehicles, making them expensive in short term, companies can make cost savings in the long run. Apart from the cost savings another advantage is that electrical vehicles operates more quietly than IC vehicles (Wątróbski et al., 2017).

Barriers that comes with electrical vehicles

An investigation made by (Morganti & Browne, 2018) shows that operators of LCV:s in the urban freight transport and service operations sectors are concerned about range, charging times, payload, charging grids and retail prices.

Limited range
A fundamental problem with electrical vehicles are related to the batteries; it is difficult to make them energy dense meaning that they are heavy compared to the amount of energy they can store. This results in electrical vehicles generally having lower range and/or are heavier compared to conventional vehicles (Wątróbski et al., 2017). Regarding the range a key issue for companies that plan to introduce EVs in their fleet is finding EVs that fulfill their logistic demands. Climate and geographic area has impact on EVs efficiency and range. For instance in cold climates/winter months more energy is needed for heating the interior, and in warm climates/summer months air conditions takes up energy (Wątróbski et al., 2017). Another issue addressed by Figenbaum (2018) is that the EU official type approval for vehicles generates too optimistic ranges for EVs. In Norway EV users achieves ranges during the summers that are about 25% less than the what the type approval states. During the winters the corresponding number is only 50% of the type approval value. This is mainly a result of the higher driving resistance of winter tyres, higher air drag and internal car heating (Figenbaum, 2018). Factors such as these must be taken into consideration when companies purchase EVs. Often they have to optimise and adapt their fleet to the new vehicles which can include optimization of driving routes etc (Wątróbski et al., 2017).

Long charging times
Another problem related to the batteries is the fact that it takes time to recharge them,

which can result in lost income for the companies since it limits the time they can use their vehicles (Figenbaum, 2018)(Wątróbski et al., 2017).

Payload limitations
Another operational barrier is the limited cargo space and weight (Wątróbski et al., 2017) of EVs. Increased vehicle weight results in payload limitations, especially for 3,5 tons electric LCV:s (Morganti & Browne, 2018).

High retail prices
Even though the range and payload limitations concerns companies to a large extent it seems that the largest barrier for implementing electrical vehicles is the retail prices, which usually is higher than for conventional vehicles (Wątróbski et al., 2017) (Morganti & Browne, 2018).

Possible ways to overcome the barriers

Some literature discusses how companies can overcome the barriers of obtaining EVs into their fleets.

Predictable driving routes
Companies that have predictable driving routes can more easily adapt to Electric vehicles (Figenbaum, 2018). These types of companies include:

- Service companies - Companies such as cleaning and facility service usually have very predictable driving routes which means that they know the distance they need to drive and also were they possibly can charge their vehicles. Usually these types of companies can easily adapt to EVs compared to craftsmen companies (Figenbaum, 2018).

- Craftsmen companies that work on larger projects - Craftsmen companies that work on large projects during long time periods can more easily plan their driving routes compared to companies that work on many project at different sites. Therefore they find it more easy to adapt to EVs (Figenbaum, 2018).

Working within a limited radius
There is a higher potential of replacing IC LCV:s with electric LCV:s if a company's fleet is reorganized so long trips are avoided or done only with a limited amount of vehicles, while the rest are used for shorter trips. This will of course limit the company's flexibility (Figenbaum, 2018).

Charging during work
A possible solution to range concerns among service and craftsmen companies could be to charge at customer sites. This could however be seen as unprofessional among the customers (Figenbaum, 2018).

3.1.5 Vehicle regulations, taxations- and bonus systems

This section will present different regulations regarding taxation - and bonus systems for vehicles in Sweden and Norway as well as a description of the new vehicle test procedure WLTP used in the EU.

Taxation and subsidies Sweden

The taxation and subsidy system in Sweden for incentivising the use of more environmentally friendly vehicles is called Bonus-Malus. It is a bonus and taxation system used in Sweden for cars and RV:s (class 1 and 2), light trucks (maximum total weight: 3500kg) and light busses (maximum total weight: 3500kg). The system applies to new vehicles with model year 2018 or newer and registered earliest 1st of July 2018. Bonus-Malus gives the vehicle owner either a bonus ("Bonus") or taxation ("Malus") depending on fuel type, retail price, the amount of CO_2 emission the vehicle releases, the year it was taken into traffic and depending on if the owner is a private person or company (Transportstyrelsen, n.d.-a).

For a privately owned vehicle the highest bonus is 60000 SEK, which will be obtained if the vehicle is a zero emission vehicle, such as EVs and fuel cell vehicles. For companies the bonus is maximum 35% of the price difference between the vehicle and the corresponding vehicle with conventional fuel (same model, model year and level on equipment level) (Miljöfordon, n.d.).
Cars that have emissions of 95 gram CO_2/km or more will get the Malus-taxation during a three years period. After this period the increased tax will be removed (Miljöfordon, n.d.).

Taxation and subsidies Norway

Norway is ahead when it comes to subsidies related to EVs. Here are some of the advantages of buying/owning an EV in Norway:

- During a purchase of EVs the customers does not have to pay the taxation (VAT), which is 25% for conventional vehicles.
- Drivers of EVs only has to pay a maximum of 50% of the cost of gasoline driven vehicles in existing toll gates throughout Norway.
- The price for parking with an EV is maximum 50% of the price for gasoline- and diesel driven vehicle. The price varies between different regions in Norway. In Oslo the corresponding cost is only 20%, but electical vans, busses and trucks will park for free.
- EV drivers only have to pay 50% of the price for ferries compared to conventional vehicles. (Elbil.no, n.d.)
- Companies can get a climate discount when purchasing electric vans. Vans which has less than 80hp will get 15000 NOK discount, vans with 80 to 120hp will get 25000 NOK discount and vans with more than 120hp will get a 50000 NOK discount. (ENOVA, n.d.)

A new vehicle test procedure - WLTP

WLTP (Worldwide Harmonized Light-Duty Vehicles Test Procedure) is a new test procedure introduced in the EU 2017 for testing vehicles fuel consumption and CO_2- and pollutant emissions. It also includes procurement of ranges for electric cars and energy consumption for alternative drive trains. Unlike its predecessor NEDC (New European

Driving Cycle) which was based on theoretical driving values, WLTP is based on data from real driving which better corresponds to the real on-road performance for vehicles. However, the values produced by WLTP will still not completely correspond to the real driving data since different drivers drives differently and traffic and weather condition change over time (WLTPFacts, n.d.).

WLTP test conditions are:

- Driving behaviour that is more realistic
- Different driving situations (main road, highway, urban and suburban)
- Longer driving tests
- Accelerations and decelerations that better represents real driving (more dynamic)
- Tests conducted at higher speeds (both average and maximum speeds)
- Tests conducted in temperatures closer to average European values
- Shorter stops
- CO_2-values and fuel consumption measured individually for vehicles with optional equipment (including racking systems)
- Measurement conditions and car set-ups are stricter
- Gives best- and worst case values on customer information

(WLTPFacts, n.d.)

3.2 Result of Market Analysis

Delving into what the literature has had to say about PSS, EVs, regulations etc. has given a theoretical understanding when it comes to the subjects this report touches upon. The next step in the pre-study is then to get a grasp of the space in which the problem resides, the market. This section will define what and who is relevant in this market, its external drivers, the competitors within the market and of course Modul-System's role and position in it.

3.2.1 Definition of the market

The information in this section has been captured from the internal interviews and discussions held at Modul-System. As stated in Chapter 1.3 the area to be studied is the provision of racking systems for EV vans. Within this market there are several actors. The user/customer of the racking system, the manufacturers and providers of racking systems, car retailer, leasing companies and retailers of racking systems (car dealers and other companies). Figure 3.6 shows the actors and illustrates the interactions they have.

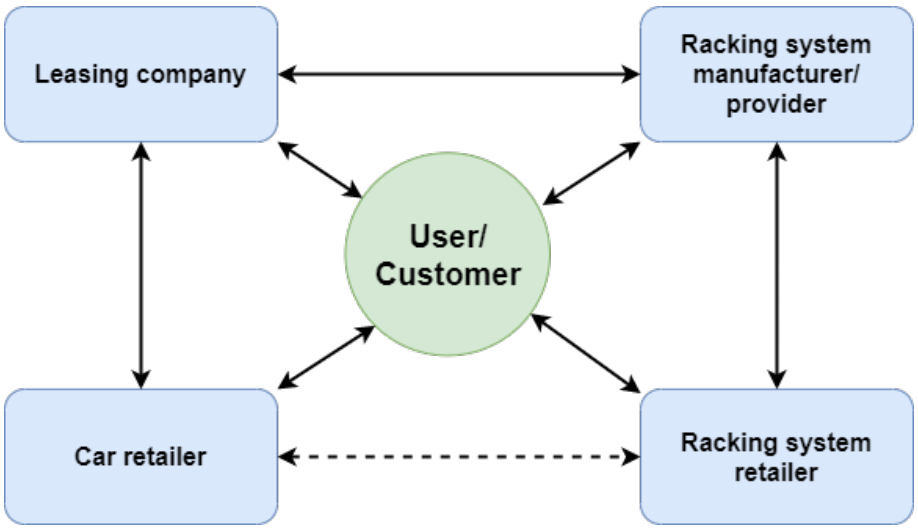

Figure 3.6: Actors within the market and their interactions

The user/customer can get a hold of the racking system for their vans in several different ways. This results in that they interact with all the other actors. They either go directly to the racking system provider for a van, either leased or bought, thus also interacting with leasing company or car retailer. Another way is for the customer to get the racking system from a retailer. Larger companies sometimes also go through a leasing company to get the racking system. Asking the leasing company to provide them with it, letting them approach a racking system manufacturer. The racking system manufacturer then provides and usually installs the racking system into the soon to be leased cars. The leasing company interacts with the car retailer, buying vehicles. In many cases the car retailer can also be the car manufacturer.

3.2.2 External market drivers

The market for providing van racking systems is, as all markets, tied to what is happening in society. To capture how these factors affect Modul-System and its market competitors now and in the future, a PESTEL analysis was conducted, see Figure 3.7. The main take away is that the Swedish government has ambitious environmental goals, striving for a zero sum emission rate by 2045. This is evident in the taxation policies for LCV:s. As mentioned in Chapter 3.1.5, the Bonus Malus system in combination with the new WLTP testing standard penalises diesel van users and subsidises electric powertrain vans. Furthermore, the WLTP standard also includes the racking system weight in the car. This pushes the service and craftsmen companies to go electric. The maturity of these EV-vans is increasing, further accelerating the transition to electric vehicles within the market.

Another trend is that companies with a sustainability focus are more attractive to both consumers and investors, increasing the likelihood of companies within this market to profile themselves as sustainability focused. According to resources inside Modul-System, companies like Amazon are already taking this step, by adopting a "green fleet" of EV-vans. It is therefore deemed likely that service companies and craftsman companies will do the same. Furthermore, a scenario were racking suppliers would benefit from a sustainability branding is not unlikely.

The economic factors are split in this matter. The Swedish krona has been decreasing in value against the euro for several years, making it more expensive to import products from outside the company. It becomes more expensive for Modul-system to do business abroad, but it could be more likely for Swedish companies to buy from a Swedish manufacturer for the same reasons. Companies from countries with the Euro currency might also be prone to buy products from Swedish companies, due to the beneficial exchange rates. The prime rate has been at sub zero since 2015, with it only going up to zero around the start of 2020. As a result loans have had low interest, boosting the consumption rate in society. This will also have positively affected this market as well. The increase in prime rate in 2020 is something to look at more carefully moving forward, since if the rate increases, so will interest rates on loans.

POLITICAL

1. Emission policies such as the European Parliament initiatives (Directive, 2014/94/EU) are encouraging use of alternative fuel vehicles (Wątróbski et al., 2017)
2. Bonus Malus system, economically penalises use of diesel powered LCV:s and subsidises E-LCV:s through taxation and subsidies in Sweden. (Transportstyrelsen, n.d.-a)

ECONOMIC

1. The Swedish krona has lost value to the EUR since 2017, see Appendix A.1.1. (EuropeanCentralBank, n.d.)
2. The Prime rate has declined since 2011, been sub zero from 2015-2019 and in 2020 went back to zero. Interest rates for banks has been low as a result, see Appendix A.1.1. (Carlgren, n.d.)

SOCIAL

1. It is becomming more attractive to investors and consumers for a company to have a sustainability profile. (Whelan & Kronthal-Sacco, n.d.) (Mcavoy, n.d.)
2. In a Swedish population opinion survey 86% believe that societal intervention is needed to decrease climate change. (Naturvårdsverket, n.d.)

TECHNOLOGICAL

1. There is a shift towards electrification of LCV:s due to increased maturity in this field. (Wątróbski et al., 2017)

ENVIRONMENTAL

1. Sweden wants to live up to the Paris agreement, no higher than 2°c global temperature increase, by acheiving Zero sum emission by 2045 (SwedishGovernment, n.d.-a)
2. Sweden wants a to supply a sustainable (Economical, Environmental and Social) transport service for its citisens and industry. (SwedishGovernment, n.d.-b)

LEGAL

1. New standard (WLTP) for measuring emissions on diesel vehicles (WLTPFacts, n.d.)
2. Maximum total weight for a LCV is 3.5t, for a B-class drivers licence. An extended B-class license allows driver to drive 4.25t but with the LCV still only weighing 3.5t. (Transportstyrelsen, n.d.-b)

Figure 3.7: PESTEL-Analysis

3.2.3 Market actors

With the analysis of the external actors influence of the market conducted, the next step is to see who the internal ones are and how they place in the market. Modul-System's main Swedish competitors are System Edström Bilinredningar AB and Work Systems Sweden AB. Two other competitors are the German companies Sortimo (which is seen as the main competitor to Modul-System) and Bott (Sales manager at Modul-System, personal communication, February). This section will present Modul-System and these competitors. A brief introduction to each company will be given and thereafter a

description of their product offers. In Chapter 3.2.4 the competitors will be benchmarked against Modul-System and analyzed in relation to each other.

Modul-System HH AB

According to allabolag Modul-System has a annual turnover of 303 million SEK (2018), making them the largest company in Sweden that provides racking systems. The company was founded 1970 (Modul-System, n.d.).

Products and services

As previously described in Chapter 1.1 Modul-System has four main segments:

1. Modul-System - racking system and other accessories for service vehicles
2. Modul-Express - shelving systems and other accessories for delivery vehicles
3. Modul-Floor - flooring and attachments (rails) for the two product segments above. The rails make it possible to attach the racking systems without having to drill or weld in the vehicles.
4. Modul-Connect - electrical equipment such as lights and converters. The equipment can then be controlled by a mobile application. A previous segment called Modul-Fleet which is a fleet management system is also planned to be integrated with Modul-Connect.

Modul-System offer modular racking systems in ultra high strength steel, meaning that the material thickness can be lower which result in a lower weight. Another reason for that material choice is that the racking systems become more robust, and since Modul-System has a large focus on customers within tele-com (were vehicles usually have to drive on rough roads) robustness is a high priority (Product owner Modul-System and Modul-Connect, personal communication, February 2020). The main frames of the racking systems are made in Mullsjö, Sweden but some smaller parts are outsourced to countries in Asia.

Order placing is done by consultancy with Modul-System's sales staff. They have an in-house CAD tool where the customer and the sale staff can design a solution together based on the customers specific needs. There also exist several "standard" solutions for different car models. Once the order has been placed the customer can choose to install the racking systems themselves or let Modul-System do it. Most commonly the systems are installed at Modul-System (at their service centers) or at a dealer. The customer will get a 5 year warranty on the system. As an additional service Modul-System also offers transportation of finished vehicles to their customer. (Modul-System, n.d.)

System Edström Bilinredningar AB

System Edström is the largest of Modul-System's Swedish competitors with an annual turnover of approximately 165 million SEK (2018) (Allabolag, n.d.). The company was founded in 1958 (System Edström, n.d.).

Products and services

Similar to Modul-System they provide racking systems, electric equipment, such as lights

and power supplies, and shelves for service vehicles. System Edström claim that they offer the most flexible van's racking systems on the market and apart from this their main focus areas are quality and safety. System Edström offer complete kits for the most common vans. These kits can however be modified in accordance to the customer's needs similarly to Modul-System. The customers can use an online drawing tool to make drawings and 3D visualisations of their vehicles equipped with System Edström's racking systems. These drawings can then be used as a basis for consultancy with System Edström's dealers who can help to further fine tune them. The tool is described in Appendix A.1.2. In terms of installation the customer can choose to get the racking systems installed by a dealer or by themselves. If the racking system is bought and installed at a dealer the customer will get a 5 year warranty, otherwise a 3 year warranty. (System Edström, n.d.).

Work System Sweden AB

Another Swedish competitor to Modul-System is Work System. With an annual turnover of approximately 99 million SEK (2018) (Allabolag, n.d.) the company is also a fairly big player on the Swedish market. The company was founded in 2009 (Work System, n.d.), making them a young company compared to the other competitors.

Products and services

Work system has a wide variety of products for vans. It includes racking systems, floors, roof equipment, lights, ramps, driver related products and more. Work Systems claim that they have the Swedish markets lowest prices and similar to Modul-System their racking systems are manufactured and crash tested in Sweden. They sell both standard and customized racking systems for different van models and their customers get a 3 year warranty. They offer complete kits on their website which can be bought online or with consultancy with Work System. Their online order system is further described in Appendix A.1.2. Installation can either by done by Work-System or the customer. (Work System, n.d.)

Sortimo

Sortimo is a German company but their business exists in several countries in Europe (including Sweden, Denmark and Norway), North America and Asia. (Sortimo, n.d.) According to Allabolag (n.d.) Sortimo AB, which is the Swedish subsidiary, have an annual turnover of approximately 39 million SEK (2018). It should be stated however that the main company has a racking system segment that has a similar size to Modul-System's (Sales manager at Modul-System, personal communication, February).

Products and services

Sortimo offers several product types related to vans such as modular van racking systems, roof racks, E-bikes for craftsmen, mobile workstations etc (Sortimo, n.d.). Their latest van racking platform (SR5) has side profiles made in aluminum and shelves in plastic, and it is manufactured in Germany. SR5 can be configured on Sortimo's website with an online tool similar to System Edström's, and customers can place order by either using this tool or consult with Sortimo's sales staff. The online tool is described in detail in Appendix A.1.2. Installation is done either at Sortimo's partner or by the customers. Sortimo offer

a 3 year warranty for their racking systems.

Bott

Bott is a German competitor with a similar size to Modul-System in terms of their racking system segment (Sales manager at Modul-System, personal communication, February). The turnover was not found on Allabolag (n.d.). The company was founded in 1930 making it the oldest among the other companies.

Products and services
Bott's business includes sales of racking systems for vehicles and work places, vehicle conversions and work stations. They offer 3 core racking system ranges for vans depending on size, storing space and budget. These platforms are:

- Modulo - A racking systems for small and medium sized vans, which is designed to take up a small space so that the van still have space for loading (apart from the racking systems).
- Uno - A racking system for medium and large vans which is a low cost alternative made out of steel.
- Vario - A more advanced racking system used for more demanding applications. It is made from a combination of aluminum and steel.

Bott's racking systems are modular and manufactured in United Kingdom. Bott has a service called SMARTVAN which is a self-fit solution which does not require any drilling in the customer's vehicles. With SMARTVAN the customer can use an online tool similar to System Edström's and Sortimo's were the they can get suggestions on racking systems configurations based on vehicle type and business area (plumbing, electrician etc) or customize their own. Once that is done the customer can place an order and get it delivered non assembled within 3 to 5 days. Further information regarding the online tool can be found in Appendix A.1.2. Customers can also chose to get the racking systems installed by Bott (Bott, n.d.).

3.2.4 Benchmarking and analysis

Table 3.1 shows a compilation of company attributes and product (racking system) attributes for Modul-System and the competitors.

COMPANY ATTRIBUTES	Modul-System	System Edström	Work System	Sortimo	Bott
Turnover (Sweden 2018)	303 million SEK	165 million SEK	99 million SEK	39 million SEK	N.A
Company origin	Sweden	Sweden	Sweden	Germany	Germany
Company founded	1970	1958	2009	1973	1930
Order planning	Consultation and drawing tool at Modul-System	Online drawing tool and consultation	Consultation and online ordering of standard kits	Online drawing tool and/or consutation	Online drawing tool and consultations
Installation conducted by	Company ("Service centers"), dealer or customer	Dealer or customer	Company or customer	Partner or customer	Company or customer (with "Bott SMARTVAN")
Complementary related products/services	Modul-Connect, Vehicle transportation to customer	N.A	N.A.	E-bikes with racking systems for craftsmen, mobile work stations (WorkMo)	Specialist vehicles conversions , On site solutions for work men
PRODUCT ATTRIBUTES					
Product class	Premium	Medium	Basic	Medium	Medium to Premium
Warranty	5 years	3 years (when customer installs) or 5 years (when company installs)	3 years	3 years (if installed by ceritfied partner)	N.A.
Manufacturing country	Sweden	Sweden	N.A.	Germany	United kingdom
Material	Ultra high strenght steel	N.A	N.A.	Side profiles in aluminum, shelves in plastic	Uno: Galvinized steel, Vario: aluminum and steel, Modulo: unknown
Modular design	Yes	Yes	N.A.	Yes	Yes
Weight	Low	Higher	N.A.	N.A.	N.A
Destructive installation	No	N.A.	N.A.	N.A.	No
Delivery time (for stanard systems)	Approx. 10 days	Lower	Lower	N.A.	3-5 days

Table 3.1: Benchmarking table comparing Modul-System and their competitors

Analysis

Here the companies and their products will be analysed and compared against each other. Figure 3.1 will be used as a reference for this analysis.

Turnover - Based on the numbers from Allabolag (n.d.) Modul-System has the largest turnover in Sweden compared to the competitors, indicating that they have a big influence on the Swedish market. It should be stated however that Sortimo, who has its main business located in Germany, has a larger turnover (for the main company) than stated Figure 3.1. This could indicate that they are a larger player on the European market than what the number tells. A corresponding turnover for Bott can not be found on Allabolag, making the company hard to compare to the Swedish market.

Order planning - The four companies have similar ways for customers to plan their purchases of racking systems. The customers mainly have to rely on consultation with the

companies, but System Edström, Sortimo and Bott also offer online tools which can be used to plan racking systems configurations. Work Systems offer online sales of standardised kits.

Based on a quick trial System Edströms drawing tool seems easy to use in the initial steps, i.e. to choose vehicle brand, model, door configurations and finished racking configurations. From this point it is easy to visualize how the interior of the vehicle would look like since you can easily rotate and zoom in on the model. It is however difficult from this stage to understand how to modify the racking configurations. From a customer point of view this could be frustrating since the initial steps are so straight forward. Additional explanations or short tutorials throughout the program steps could be an alternative to solve this problem.

Sortimo's online tool on the other hand was very straight forward to understand, even during the first try, mainly due to explanations on each step. Another feature that was especially good with this tool was the fact that the prices and the total weight were specified the whole time. This gave a good overview of the purchase.

Bott's online tool is also very straight forward and easy to use and does not differ much from Sortimos except that it is more limited in terms of customization.
Modul-System also has a drawing tool (not availble online) were the customer and Modul-System's sales staff can make custom racking system's setups (Sales manager at Modul-System, personal communication, February). The advantage with not having the tool available online could be that the customers are "forced" to consult with Modul-System before making a purchase, meaning that they will have a better understanding about their purchase. The disadvantage could be that it is cumbersome for the customer not to make a quick purchase online, which they can on do on Sortimo's, Bott's and Work System's websites. This can also make the sales cost higher for Modul-System.

Installation and warranty - All the companies provides installation of the racking systems as a service, usually through their partners. It is however possible for the customers of all five companies to mount the racking systems themselves. However, System Edström and Sortimo encourage their customers to use their certified partners/dealers for the installation. This will give them a better warranty on the racking systems. Modul-System and Bott is the only companies that state on their websites that their racking systems do not require destructive installation. (i.e. no drilling or welding)

Racking system designs - In terms of product class Modul-System and Bott offers the most high-end/"premium" racking systems. Sortimo's and System Edström's racking system would be classified as medium class, while Work-System's racking systems are more basic (Product owner racking system and module connect, personal communication, February 2020). In terms of the design there are great similarities between Modul-System's, System Edström's and Bott's racking systems. Their racking systems have box-shaped frames where different modules can be inserted. The three companies claim that their racking systems are highly modularized and can therefore be customized to the customer needs. It seems however that Modul-System is the only company that uses ultra high strength steel for their racking systems meaning that they can lower the weight since the material thickness can be made thinner. Although Work Systems products look similar to Modul-

System, System Edstöm and Bott it is difficult to get a sense of the level of modularity and compatibleness. The design of Sortimo stands out. Instead of having box-shaped frames their racking systems consists of vertical aluminum profiles were horizontal shelves of plastic shelves and modules of various kind can be placed. Sortimo also claims that their racking system is modular and compatible with other systems. Modul-System's racking system can be seen in Figure 1.1 and the competitors' racking systems can be seen in Figures 3.8a, 3.8b, 3.8c and 3.8d

Complementary services - The different companies have a similar approach when it comes to serviceability. On the PSS scale, seen in Figure 3.9, all companies seems to fall in the main category "A: Product orientated". It seems however that based on Chapter 3.1.1 Modul-System, Sortimo and Bott would fall under the sub category "2. Advice and consultancy" since they provide additional products/services related to the racking systems, which can be used by the customer to optimise their business. It should be stated however that all companies provide consultancy during purchasing but to a varying degree. Therefore the serviceability assessment in Figure 3.9 is somewhat subjective. It is clear however, that all companies is on the far left on the scale and therefore are "product orientated".

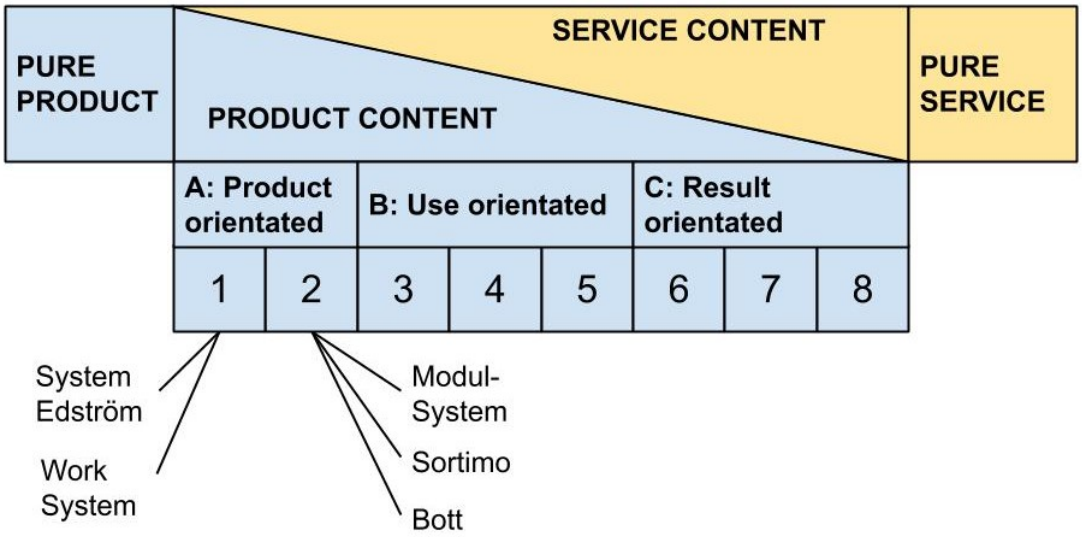

Figure 3.9: Level of serviceability among competitors

(a) System Edström (System Edström, n.d.)

(b) Work System (Uppsala Bilgalleri, n.d.)

(c) Sortimo (Sortimo, n.d.)

(d) Bott (Bott, n.d.)

Figure 3.8: Competitive racking systems

3.3 Result of Company Analysis

Above sections have mapped the general market, its trends and actors. A comparison and analysis of Modul-Systems competitors has also been made. Now a more detailed analysis of Modul-System's capabilities and offerings is going to be described. This will be conveyed by showing and analysing the results from a SWOT-analysis, see Figure 3.10. The base of this analysis is from interviews with key actors within the company, which can be seen in the list below.
Interviews:

[1] Sales manager, personal communication, February 2020

[2] Product manager racking system and module connect, personal communication, February 2020

[3] Product manager floor and express, personal communication, February 2020

[4] Vice president Modul-System, personal communication, February 2020

STRENGTHS

1. High development capacity compared to competitors. [1] [2] [3]
2. Strong owner that gives economic support and autonomy. [4]
3. Highly flexible and fast in specifying a custom solution for a customer. [2]
4. High communication speed within organisation (flat organisation). [3] [4]
5. On the forefront for in software and fleet management integration for the racking system industry. [3] [4]
6. Highly customisable solution with wide range of products. [3] [4]
7. Low weight solution, reducing environmental impact during use. [4]
8. Image of a premium product brand. [1] [3] [4]
9. Providing a "Turnkey solution"/ "One stop shop", covering all the customers needs, with a finished and functional racking system when done. [1] [2] [4]

WEAKNESSES

1. Long and varying lead-time from order to delivery on standardised solutions, compared to competitors. [1] [3]
2. Not as good at relationship building with customers as some competitors. [2] [3] [4]
3. Factory is not next to the product development building (1.5h away with car) [3]
4. Many different part numbers, becomes complicated for sales and customer during spec and ordering process. [3]
5. Some products produced in China, resulting in longer delivery times. [4]
6. High sales cost (from proposal to closure) that is not billed, covered in product price. [4]

OPPORTUNITIES

1. Utilise development capacity to go into new market
2. Continue developing the turnkey solution approach into a product service system. [3]
3. WLTP pushes light truck users to go to vans due to drag reduction, increasing possible customers. [2]
4. Modul-system is a global company, can more easily attract global partners.
5. Can sell second hand products to prolong life cycle, possibly with help of a partner. [4]
6. Develop a PSS to increase sustainability

THREATS

1. Loose marketshare due to long lead-time from order to delivery.
2. Outside factors such as regulation changes/taxation change. [2]
3. Radical change in transport industry (ex. shift towards drones etc). [2] [3] [4]
4. Loose potential customers due to complicated ordering system and no intuitive online tool. [3]

Figure 3.10: SWOT-Analysis

The interview objects all stated that the main strength of Modul-System is their development capacity and engineering skills. Compared to the Swedish competitors they see themselves as the clear product leaders and are as good or better as their international counterparts such as Sortimo and Bott. This gives them the development muscle to design integrated solutions, with racking systems, electronics and software. Furthermore, it enables them to more quickly react to market change and get an edge on their competitors. The fact that they in addition to this already work with bringing a turnkey solution for the customer upon purchase, makes them well suited for developing a PSS. They have already started this journey with integrating solutions and increasing the level of service for the customer, as was mentioned in Chapter 3.2.4. It is therefore deemed that this is the companies greatest strength and opportunity, in context of this report. Another strength is that the high development capacity in combination with their large product range and modularity means that they can quickly customise a solution for a customer. This lends itself particularly well to customers who want big order quantities with custom solutions, such as tele-com and service companies.

The large product range comes with some drawbacks though. Having so many different parts, makes it hard to stock resulting in that the lead-time for standard packages can take longer compared to its competitors that have a more basic product range. This has the risk of loosing potential customers who only want a basic solution. Another issue with a large product range is how the solution is packaged to the customer. There are many different article numbers and it has been described as confusing and complicated both from the customer and sales team. Worth noting is that Modul-System are not the only ones having trouble with this, many companies with large product ranges and highly customisable solutions have the same issues. Another weakness is that Modul-System do not see them selves as good as some of their competitors in relationship building with the customers. They feel like other companies are better at taking care of their customers in a more personal way. This was described as particularly important within this business, since the product quality is not enough to gain a lot of market share. The sales team are the main source of marketing for the company and the success of a business heavily relies on their performance. With this said, the interviewees feel like their sales team do a very good job and that the company culture and values sometimes come in the way. Apart for the above mentioned weaknesses and threats, the main risk for the company and the industry was described to be outside factors. These would be, legislation forcing companies to stop using as many vans or the workflow shifting from LCV's. Drones were cited as a potential threat, for tool delivery. This would affect the whole industry and since Modul-System have such a good development capacity they are one of the companies with the best chance to survive and maybe even thrive in such a change.

3.4 Result of Customer Analysis

The market, its trends and the racking system providers, including Modul-System, have been detailed and analysed. What remains in the pre-study is performing the customer analysis, which will be described below.

3.4.1 Customer segments

As described in Chapter 3.2.1, the customer is in the center of interactions within the market. The customer though is not one entity, but is split into several segment from different companies and industries, mainly service/maintenance personnel and craftsmen. There are also different levels of customers. There are the users, described in previous sentences, but also fleet managers who are responsible for the purchase and management of the racking systems. So that they can get the correct personnel and the correct equipment to the sites so they can perform the work orders.
To better understand the different customers needs they are here divided into segments. Based on the interviews described in Chapter 3.4.2 three main customer segments could be found, which does not necessarily depend on the customer's trade. These segments are (1) the long distance segment, (2) the urban fleet segment and (3) the small/start-up segment.

The long distance segment - Companies within this segment can for instance include energy- and telecommunication companies. Modul-System state that they have targeted these types of companies with their relatively robust racking systems. These types of companies/customers are characterized by the following points:

- Long drive distances
- Work in rural areas
- Drives on rough terrain (gravel roads, forest roads etc)
- Driver depends on vehicle as office/housing
- Use vehicle as power source for tools etc
- Bring everything they need for the work task(s) which may take several days

The urban fleet segment - This segment could include service or craftmen companies that are characterized by the following points:

- Medium/short driving distances
- Work in urban/suburban areas
- Has proximity to office, material suppliers etc
- Bring what they need but might stop at suppliers if needed
- Is dependent on efficient fleet management to optimise business

The small/start-up segment - These are small or recently started companies who use a small amount of LCV:s in their business. The companies could be characterized by the following points:

- Has a limited budget
- Drive medium/short distances
- Potential that company grows and therefore want to upgrade solution
- Need basic functions but nothing too fancy
- No need for fleet-management (for a start)

3.4.2 Customer needs

In order to gather customer needs semi structured interviews were conducted, both internally with Modul-System (Sweden and Norway) and externally with Modul-System's current and potential customers. Below each interviewee is described shortly:

[1] Sales manager at Modul-System, personal communication, February 2020

[2] Product manager at Modul-System (segment Modul-System and Modul-Connect), personal communication, February 2020

[3] Product manager at Modul-System (segments: Modul-Floor and Modul-Express), personal communication, February 2020

[4] Site and sales Manager at Modul-System, personal communication, February 2020

[5] Product chief at Modul-System, personal communication, February 2020

[6] Vice President at Modul-System, personal communication, February 2020

[7] Service technician for large scale cooperation, personal communication, February 2020

[8] Vehicle manager for a large Swedish energy company that will introduce EVs in their work fleet, skype interview, February 2020

[9] Brand director at Modul-System Norway, skype inteview, February 2020

[10] Purchase manager at a real estate company that have begun to introduce electrical vans, telephone call, February 2020

Each interview was reviewed in order to find statements that described the customer needs, both expressed by Modul-System employees and the actual customers. The KJ-method was then used to sort the statements meaning that each statement was written down on a post-it note and then sorted into different categories. Each category represented a customer need. The statements "The users want to personalise their racking systems" and "Craftsmen are picky and usually want an individual solution" was for instance categorized as the need: "Solution should be possible to individualize/customize". Table 3.2 shows the identified customer needs stated by the corresponding interviewee. The needs are sorted by their occurrence.

	NEED	INTERVIEWEE
1	Low weight solution	[1], [2], [3], [6], [7], [8], [9], [10]
2	The solution shoud be robust (both rugged and long life span)	[2], [3], [7], [8]
3	Non destructive installation (no drilling etc)	[2], [3], [4], [9]
4	Complete/"Turn-key" solution	[1], [2], [3]
5	Solution should be possible to individualize/customize	[1], [2], [3]
6	Give space for misc material, large tools etc	[4],[7],[8]
7	Easy to order (in terms of planning and packaging)	[2], [3], [4]
8	Want to be able to transport equipment in the vehicles	[2],[10]
9	Easy installation	[3], [6]
10	Should be able to use powertools, heat food etc in the vehicle	[5],[8]
11	Driver should be safe from everything in loading compartment during a crash	[8], [9]
12	Large storage capacity	[7],[10]
13	Solution should fit different sized vehicles	[2], [3]
14	Easy to order (in terms of order size)	[1]
15	Should provide overview of vehicle fleet for fleet managers (position, speed, battery, inventory of vehicles)	[2]
16	Different products should work together (modularization)	[3]
17	Low drag solution (VLTP)	[3]
18	Solution should be possible to move between vehicles	[2]
19	Should be able to steer related equipment such as light with the solution	[2]
20	Easy to upgrade solution	[4]
21	Enable good customer experience	[4]
22	Give a professional appearence	[4]
23	Easy accessible locking mechanisms for withdrawebles (work benches etc)	[7]
24	Should organize in volume (rather than area)	[4]
25	User friendly solution	[6]
26	Easy to locate parts/tools	[7]
27	Should have dedicated space and fastening for large equipment (tool boxes, welding tools etc)	[7]
28	Life span of 7 years	[8]
29	Minimum range of vehicles: 400-500km	[8]
30	Payload capacity after racking system is installed (excluding tools): 500kg minimum	[8]
31	All worktools should fit in vehicle for week works	[8]
32	One car per driver	[8]
33	Inverters and electrical equipment should interface with main battery system	[8]
34	Driving characteristics should not be adversly affected by loaded equipment (center of mass)	[8]
35	Need fleet management system and driving journal	[10]
36	Want to be able to resell racking system to M-S	[4]
37	Want to buy second hand racking system from M-S	[4]

Table 3.2: Customer needs table

3.4.3 Requirement specification

Based on the needs gathered from the interviews, and the main objectives of the project, a requirement specification was formed, see Table 3.3. The requirements were divided into four categories; (1) product specific, (2) service specific, (3) environmental specific and (4) business and cost specific. Depending on their importance the requirements are either stated as demands (D) or wishes (W) were the demands has to be fulfilled while the wishes are non-compulsory but can increase customer satisfaction and project fulfillment if they are fulfilled. The demanders are stated in the table. Each number correspond to the interviewee presented in Chapter 3.4.2 and "M-S" stands for Modul-System (requirement from the company in general). The right-most column indicates which requirements that are regarded in which concept generation iteration, Chapter 4, or in the detailed design phase, Chapter 5 (marked "D.D"). Requirements marked with "e.s." (existing solution) in the same column are considered fulfilled by Modul-System's existing product platform. Due to the nature of the development phase, the requirements get more and more specific for each iteration. Some of the requirements have been included in a later stage of the project, than during the pre-study. These requirements included all business and cost specific requirements (Req 4.1-4.10) as well as the requirement related to refurbishment (1.18).

Chalmers	Master Thesis Project: Modul-System	Requirement specification			
Created: 2020-03-04, Latest update 2020-05-06					
Criterias	Function/Requirement	Goal	D/W	Demandée	Mainly regarded in iteration:
1. Product specific					
1.1	Vehicle payload capacity after racking installment	>500kg	D	M-S, [1], [2], [3], [6], [7], [8], [9], [10]	3b
1.2	Enable use of electrical equipment such as powertools in vehicle		D	M-S ,[5], [8]	2b
1.3	Scalable solution	Fit all common EV-vans	D	M-S, [2], [3]	1 (e.s.)
1.4	Rugged solution	Withstand vibrations during driving on rough roads	D	M-S, [2], [3], [7], [8]	1 (e.s.)
1.5	Non destructive installation	No drilling or velding in vehicle during installation	D	M-S, [2], [3], [4], [9]	1 (e.s.)
1.6	Overview of fleet, position, battery, inventory etc.		W	[2], [10]	2b, 3b
1.7	Area efficient solution	Organize in volume rather than area	W	[4]	1 (e.s.)
1.8	Large storage capacity		W	[7], [10]	1 (e.s.)
1.9	Allow space for different sized tools/equipment		D	M-S, [4], [7], [8]	1 (e.s.)
1.10	Have dedicated space and fasteners for large equipment		W	[4], [7], [8]	1 (e.s.)
1.11	Not increase vehicle drag		W	[3]	1 (e.s.)
1.12	Easy accessible locking mechanisms for withdrawebles		W	[7]	1 (e.s.)
1.13	Easy to locate tools/material		W	[7]	2b, 3b
1.14	Driver should be safe from loaded material during a crash	Approved after crash test	D	M-S, [8], [9]	1 (e.s.)
1.15	Minimise change in vehicle dynamics	Approved after vehicle inspection	D	M-S, [8]	1 (e.s.)
1.16	Inverters and electrical systems interface with main battery system		W	[8]	D.D.
1.17	Low drag solution	Should not affect vehicle aerodynamincs	W	[3]	2b
1.18	Functionality of refurbished product should be the same as the new version	>1 year	D	M-S	3a
2. Service specific					
2.1	Solution should be adapted for EV:s	Increase resource utilization efficiency of EV:s	D	M-S	1
2.2	Upgradable solution	Both hardware and software	D	M-S, [4]	3a, D.D.
2.2	Easy to order solution		W	M-S, [1], [2], [3], [4]	D.D.
2.3	Provide all material and equipment management needed to operate		W	[8]	3b
2.4	Provide fleet management system	Service by M-S	W	M-S, [2], [10]	2b
2.5	Install solution	Service by M-S	W	M-S	2a
2.6	Move solution between vehicles	Service by M-S	W	M-S, [2]	2a
2.7	Maintain solution	Service by M-S	W	[4]	2a
2.8	Dismantel solution after end of use	Service by M-S	W	[4]	2a
2.9	Continually uppdate software		W	M-S	3b
2.10	Payment as monthly fee		W	[4]	3b
3. Environmental specific					
3.1	Environmental friendly solution	Should increase resource utilization	D	M-S	1
3.2	Re-sell complete products as second hand		W	[4]	2a
3.3	Re-use components together with first hand solution		W	[4]	2a
3.4	Re-cyclable materials		W	M-S	1 (e.s.)
3.5	Low weight solution		W	M-S, [1], [2], [3], [6], [7], [8], [9], [10]	2b, 3b
3.6	Aid low wear impact and energy usage in vehicle		W	M-S	2b, 3b
3.7	Aid lower wear impact and energy usage in vehicles in fleet		W	M-S	2b, 3b
3.8	Life span	>7 years (one car lifecycle)	D	[8]	2a
3.9	Life span	>14 years (two car lifecycles)	W	[8]	D.D.
4. Business and cost specific					
4.1	Profitable short- and long term		D	M-S	1
4.2	Short implemetation time		W	M-S	1
4.3	The solution should not require a large change for Modul-System	It should be based on current product platform	W	M-S	1
4.4	The solution should be accepted among customers in present time		W	M-S	1
4.5	Low bound capital	As low as possible	W	M-S	1
4.6	Cost efficient solution	Same value for money as current solution	D	M-S	2b, 3a
4.7	Cost efficient solution	More value for money as current solution	W	M-S	2b. 3a
4.8	Second hand system affordable for customer	20% cheaper than new system	D	M-S	3a
4.9	Standard price (cost for M-S) lower for second hand system than for new system	30% lower in Sweden and 40% lower offshored than new system	D	M-S	3a
4.10	Standard price (cost for M-S) as low as possible		W	M-S	3a

Table 3.3: Requirement specification

3.5 Summary of Pre-study

The literature review has found relevant literature and articles detailing innovation within product service systems, also showing how different service types can affect environmental impact. Articles regarding how circular economy can increase resource utilisation by closing key resource loops were also detailed. Outsourcing through capability sourcing was described and methods for how to identify outsourcing candidates and what outsourcing strategy they should have was found. The current state of EVs and where they are heading was also described, highlighting some key issues regarding range and payload restrictions for Evs. Further information regarding the current regulations and taxation for vans was explored. Highlighting how the use of diesel driven vans will be costly due to the new WLTP regulations and taxation for vehicles. It also showed the current taxation benefits an EV owner can get in Sweden and Norway.

The market analysis analysed the current and future state of the market based on internal and external forces, through a PESTEL analysis and market actor analysis. External factors consisted of a fossil fuel neutral vision for 2045, backed up with emission policies in terms of both subsidies for EVs and taxation for ICEs with the bonus-malus system. The main drivers for change within the market are the companies who innovate, mainly being Modul-System and Sortimo.

Looking at Modul-System, the SWOT-analysis concluded that they have a strong development capacity making it possible for them to quickly develop new technologies and solutions if the market changes. They do however have a worse relationship/contact with the customer, making it harder for them get and keep customers, compared to their competitors.

Finally the customer analysis was performed. There were several segments found, mainly being the Long distance, Urban fleet and Small/Start-up segments. Interviews with customers and other stakeholders yielded a customer needs list that was translated into a requirement specification. Some key requirements were that the solution needs to be light weight, up-gradable and a "turnkey-solution".

Chapter 4

Concept Generation

Chapter 3, Pre-study, has detailed the market, its actors, including Modul-System and its competitors. With the conclusion being the customer analysis, culminating in the requirement specification. This information will now be utilised to come up with and develop concepts.

As stated in Chapter 2, Methodology, the concept generation will include three iterations. The first iteration takes a broad perspective, looking at different business oriented concepts. The subsequent iterations will be more detailed and develop two different concepts in tandem, with concept Re-use being developed in iterations 2a and 3a and concept Optimise use in iterations 2b and 3b.

The general progression for each iteration will be the following: *1.Regarded requirements*, *2.Functional analysis*, *3.Idea and/or concept generation*, *4.Concept screening* and *5.Fulfilled requirements for said iteration.* Iteration 2a will deviate from this model, evaluating the different outsourcing possibilities.

4.1 Iteration 1

This section will present the first concept iteration loop. It will include the regarded requirements at this level, a functional analysis, idea generation with generated concepts and finally a concept screening where the chosen concepts are shown.

4.1.1 Regarded requirements for iteration 1

The regarded requirements in this iteration loop are mainly linked to the main purpose of this project as well as Modul-System's business/cost specific requirements. This is to ensure that the generated concepts are within the project scope and are realistic for Modul-System to even implement. At this stage the regarded requirements are relatively broad since the detail level in this iteration is kept at a low level. The regarded requirements can be seen in in the requirement specification (Table 3.3). See the requirements that are marked with "1" in the rightmost column. The requirements fulfillment will be evaluated at the end of iteration 1.

4.1.2 Functional analysis

To achieve a common understanding of the system, in which the service will be developed, a function flow chart was created, see Figure 4.1. It gives an overview of what the customer (fleet manager) wants to achieve, namely, perform the work orders with the right personnel and the correct equipment. This first functional analysis is more generic in nature, describing the overall work flow. The identified inputs for this function is divided into two categories, physical resources (red) and information (green). The physical resources consist of the vehicle fleet, in this context existing of EV-vans, equipment, being both tools and materials, and personnel, the workers performing the work. In terms of information flow the input is the work orders received. The output is the work orders being fulfilled.

The process in which the inputs are converted to outputs is the following: The work orders come in and there is an allocate function were the personnel and equipment are allocated based on the requirements of the different work orders. Based on the allocation, the necessary equipment is gathered and, together with the personnel, is transported to the work site through the vehicle fleet. Worth noting is that each worker commonly have their individual vehicle and equipment that they have in their racking system. It is still divided into separate functions to investigate other solutions as well. After being transported to the work site and the job is completed, a status update will be sent to the fleet management. If there are remaining work orders the personnel, equipment and vehicle will begin the loop anew. This is conducted until all the work orders are completed. In reality there will come in new work orders, meaning that the loop will seldom be broken.

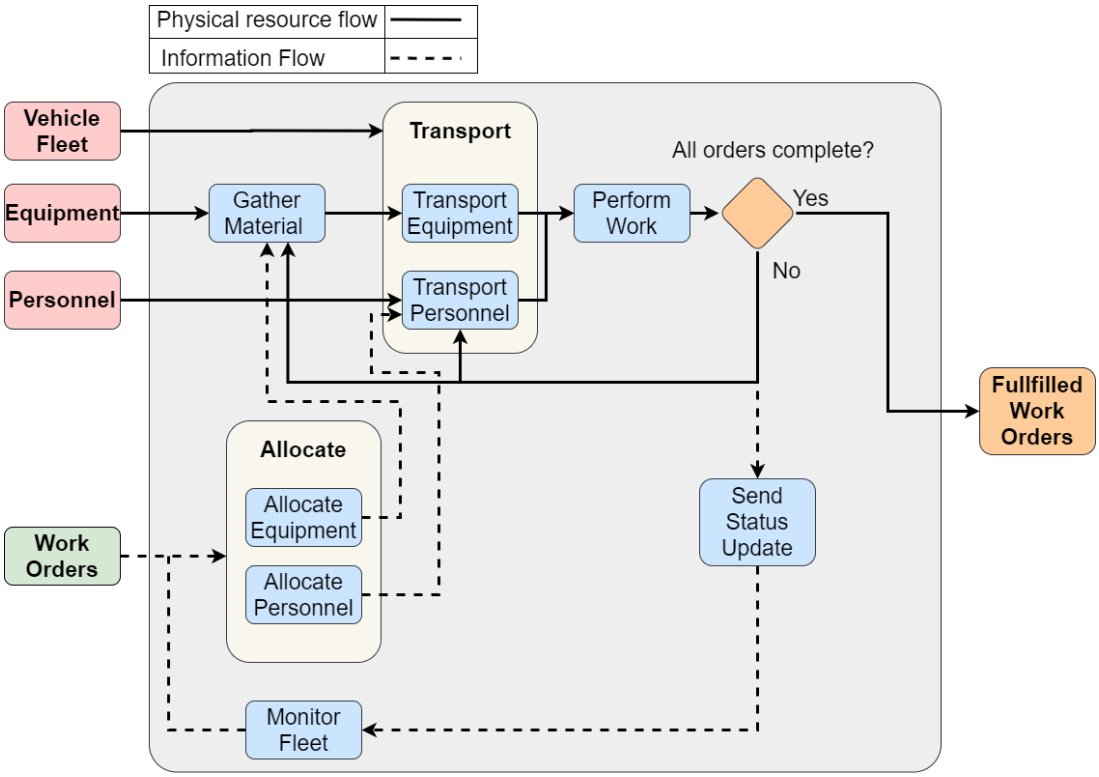

Figure 4.1: Function flow chart

Function categories

To cover all relevant aspects of the solution the functions are divided into three categories or perspectives. These functions will then be used in the morphological matrix in each iteration loop. The function categories are:

1. Sustainability specific functions
2. Service specific functions
3. Product specific functions

The sustainability specific functions are functions that are supposed to decrease the solution's environmental impact. They will mainly be used to solve/answer the research questions RQ4; "What are the requirements that must be met in order to increase sustainability?" and RQ6; "How can a new product-service system be formed to fulfill the customer and sustainability needs/requirements?". The service specific functions describes the non-tangible aspects that are linked to the product, such as ownership, service type etc. The product specific functions are related to the hardware of the solution. These functions are based on the function flow chart in Figure 4.1. Together with the service specific functions they will form the PSS.

4.1.3 Idea generation

As mentioned in Chapter 4.1.2 the morphological matrix will be based on the three different categories sustainability specific, service specific and product specific functions. The sub-functions will now be described and then the morphological matrix, with included solution alternatives to the sub-functions will be shown in Table 4.1. The red boxes indicate sub-solutions used by Modul-System's current offers.

Sustainability specific

- *Increase resource utilisation* - To increase the products use-ability throughout its life cycle. The sub-solutions was based on the findings in Chapter 3.1.1 and 3.1.2

Service specific

- *Ownership* - Who owns the solution and the products in it.
- *Service type* - Defining what type of service it is, based on the findings in Chapter 3.1.1.

Product specific

- *Transport equipment* - To transport the equipment to the work site.
- *Transport personnel* - To transport the personnel to the work site.

C1. Reuse	C2 . Lease	C3. Optimize use	C4. Collective	C5. Result based

Sub functions	Sub solutions				
Sustainability					
Increase resource utilisation	Re-cycle product	Reuse product	Maintain product	Optimize customer use	Share product/solution
Service-specific					
Ownership	Customer	Modul-System	Partner/Dealer		
Service type	Product orientated	Use orientated	Result orientated		
Product-specific					
Transport equipment	Racking system in electric car	Mobile workstation			
Transport transport personnel	Electric car	Bicycle, mini-EV or public transport			

Table 4.1: Morphological matrix and generated concepts for iteration 1

4.1.4 Generated concepts

This section describes the main ideas of the five generated concepts that was visualised in the morphologiclal matrix (Table 4.1). As can be seen in the figure, there were five generated concepts. C1 "Re-use", C2 "Lease", C3 "Optimise use", C4 "Collective" and C5 "Result based". These were generated based on combining one or several solutions from each sub-function with a certain theme in mind. One of the themes were different types of PSS, resulting in that Re-use, "Lease" and "Result based" were generated. Another theme was based on utilisation efficiency, creating two additional concepts. One was "Optimise use" and the other "The collective". All concepts uses "racking systems in electric car" for transporting equipment and "electric car" for transporting personnel, but C4 "Collective" also uses mobile work stations and combines other means of transportation. Below a more detailed description of each concept will follow.

Concept 1 - "Re-use"

In short, it is a concept that focuses on the prolonged life of the product through a circular economy business model that increases the value for the customer and increases the revenue potential for Modul-System. . It is based on a traditional owner style with customers owning physical products, but Modul-System owning the software and maintenance responsibility. Modul-System takes more responsibility of the product life cycle by offering packages and plans that span over several car life-cycles, helping the customer to re-use their purchased product. Inspired by the "Product life extension", described in Chapter 3.1.2 it aims to close the three resource loops *Maintenance, Re-use and Refurbish*. To maintain the functionality of the product they will be swapped out if something breaks and software upgrades will be installed to increase the customer value. After the product life cycle Modul-System offers the dismantlement of the product and will give a discount on the next purchase for the customer, further integrating them into the ecosystem. The racking system products and electronics, if in condition, will be refurbished and resold, continuing the monetisation of the product and increasing the life span of it. Furthermore this will be sold to a market were Modul-System, with its high end products, has a hard

time selling to: The start-up businesses and smaller craftsmen companies. The customer gets more out of their purchased products, by getting a solution that can be used over several car life cycles, increasing the customer value. Modul-System will get more loyal customers and a new customer segment who will purchase used products that already have, in part, been paid for by the first user. Figure 4.2 illustrates this concept.

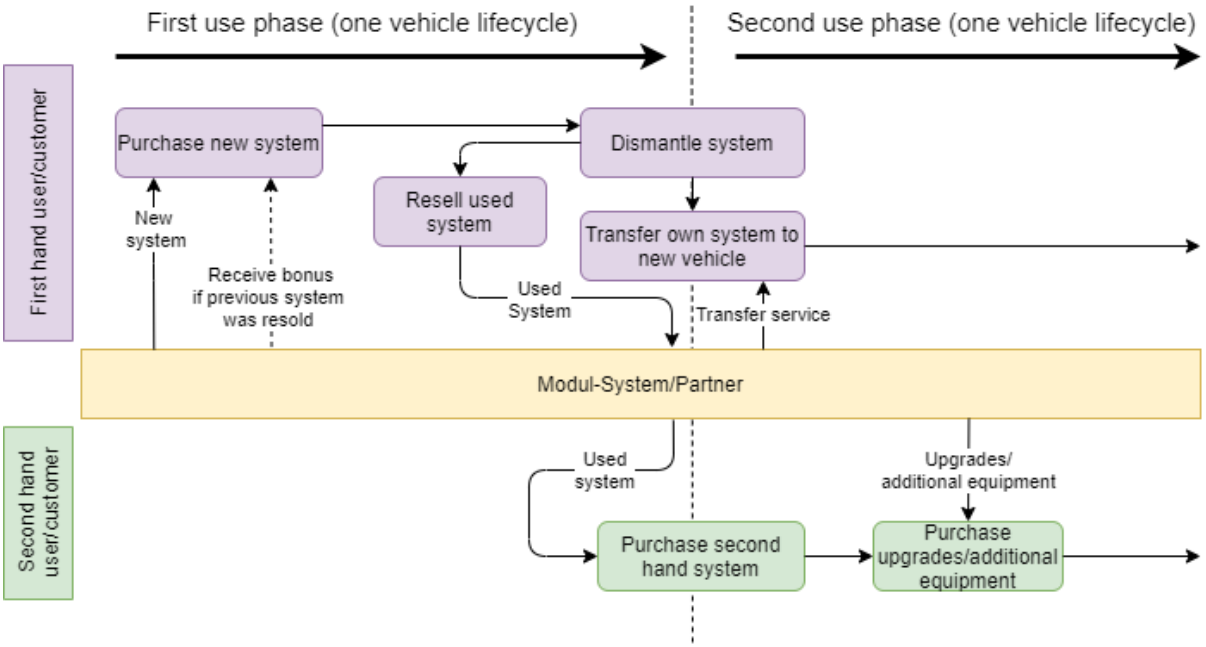

Figure 4.2: Illustration of Concept 1 - Re-use

Concept 2 - "Lease"

The leasing concept is about implementing a use oriented PSS, with Modul-System owning the product and letting the customer lease the product for a certain time period. This could be for one, two or three vehicle life-cycles for example. Modul-System could further take responsibility for the maintenance of the solution to guarantee that it works during the expected service life. Furthermore, software support and upgrades could be included in the leasing fee. This type of system can enable Modul-System to prolong the life span of the product by leasing it over several car life-cycles and then dismantle and re-cycle the product. Figure 4.3 illustrates the concept.

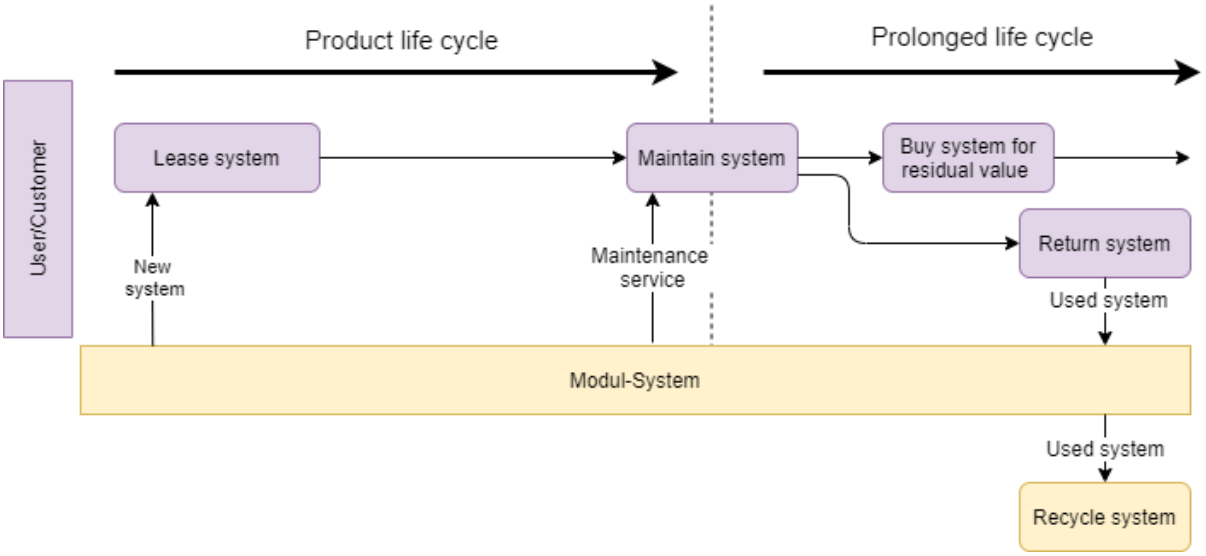

Figure 4.3: Illustration of Concept 2 - "Lease"

Concept 3 - "Optimise use"

This concept focuses on optimising the way the customer uses the product and its EV fleet. An equipment- and fleet management system will be included in the concept. The equipment management system helps the customer to bring only what is needed for the upcoming work task. Here, Modul-System can also provide a service were they help their customers to sort their equipment in the best possible way. The two systems will together minimise the wear on the products and vehicles by optimising driving routes and reducing payload in the vehicle. This type of implementation would save the customer money by being more time and resource efficient and increasing range for each vehicle. Such a solution would be heavily software based and thus owned by Modul-System, possibly a further development of their Modul-Connect/Fleet application. Customers will own the hardware which will be based on Modul-System's current product platform with some possible hardware additions. A rough illustration of this concept is shown Figure 4.4. By implementing this concept the customers can optimise their businesses and driving behaviours. This will increase the life cycle of the physical parts of the system, such as the racking systems and the vehicles themselves.

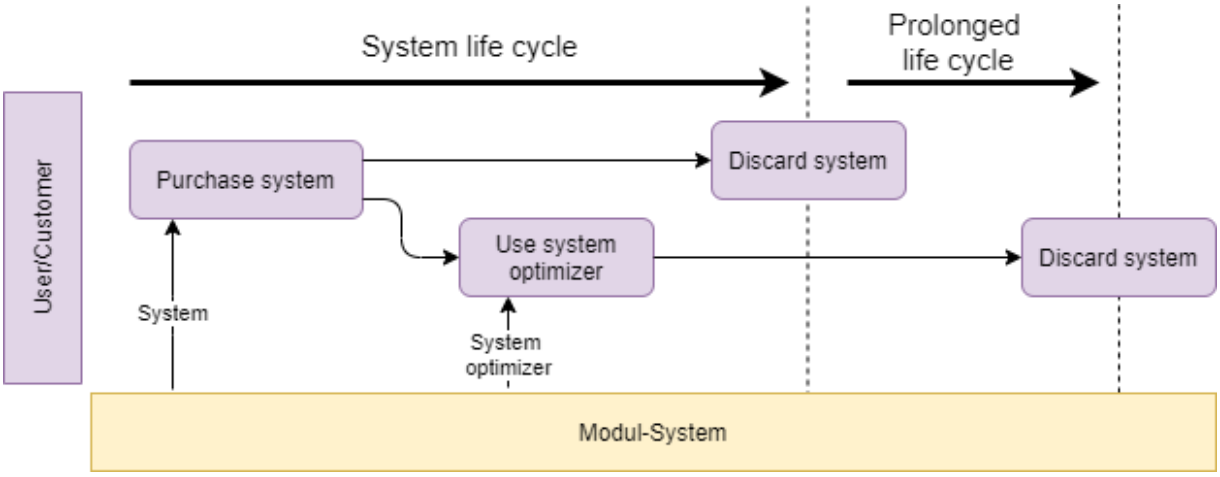

Figure 4.4: Illustration of Concept 3 - "Optimise use"

Concept 4 - "The collective"

Inspired by collectives and how they share resources, this concept is based on how the customer can share some key resources to make it more cost and environmentally efficient. It aims at maximising the utilisation of the vehicle and other key resources during its life span. The idea is that the use of electric vehicles is shared by two or more operators who, have their own or share, a set of portable tool management systems. They then have a designated driving route, dropping off the operators with their accompanying tools at the work place. Another alternative is to have some last mile transportation solutions in the car, like bicycles with smaller racking systems to transport some of the operators the final distance to the work place, similarly to what Sortimo is providing (see Chapter 3.2.3).

This solution is mainly aimed at the farther future in urban areas were car traffic could be problematic and expensive, sometimes even not allowed in the city centers. It will become an environmentally less taxing and economically efficient solution if the urban areas start restricting vehicle transportation. Figure 4.5 illustrates the concept.

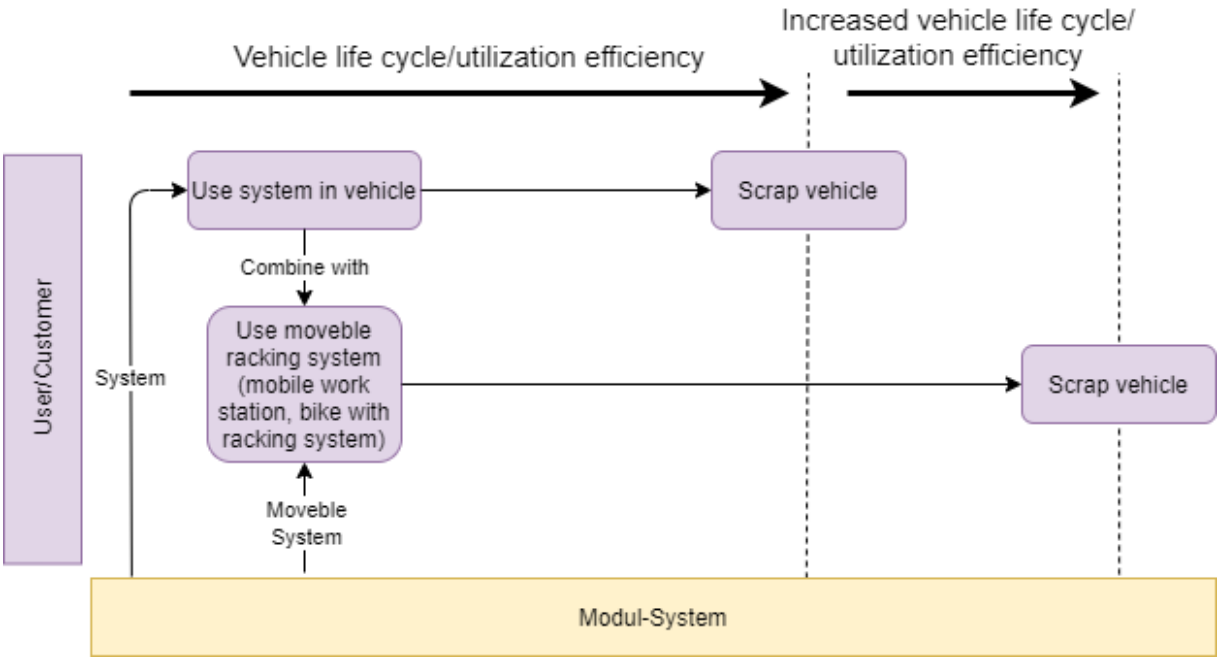

Figure 4.5: Illustration of Concept 4 - "The collective"

Concept 5 - "The result based service"

This radical, result based concept focuses on the functional result that the customer wants to achieve, get personnel and equipment to the work sites so that they can fulfil the work orders. The model is that the customer specifies the amount of personnel and equipment needed and were it needs to go. Modul-System then charges for this result and provides it in the way they see fit. This would mean that Modul-System and a potential partner, own the vehicles and material management solutions required to fulfill this functional requirement. It would give full control over the ownership of the life-cycle and how to fulfill the goal, giving the possibility to come up with innovative solutions that are both economically and environmentally efficient. Figure 4.6 gives a rough illustration of this concept.

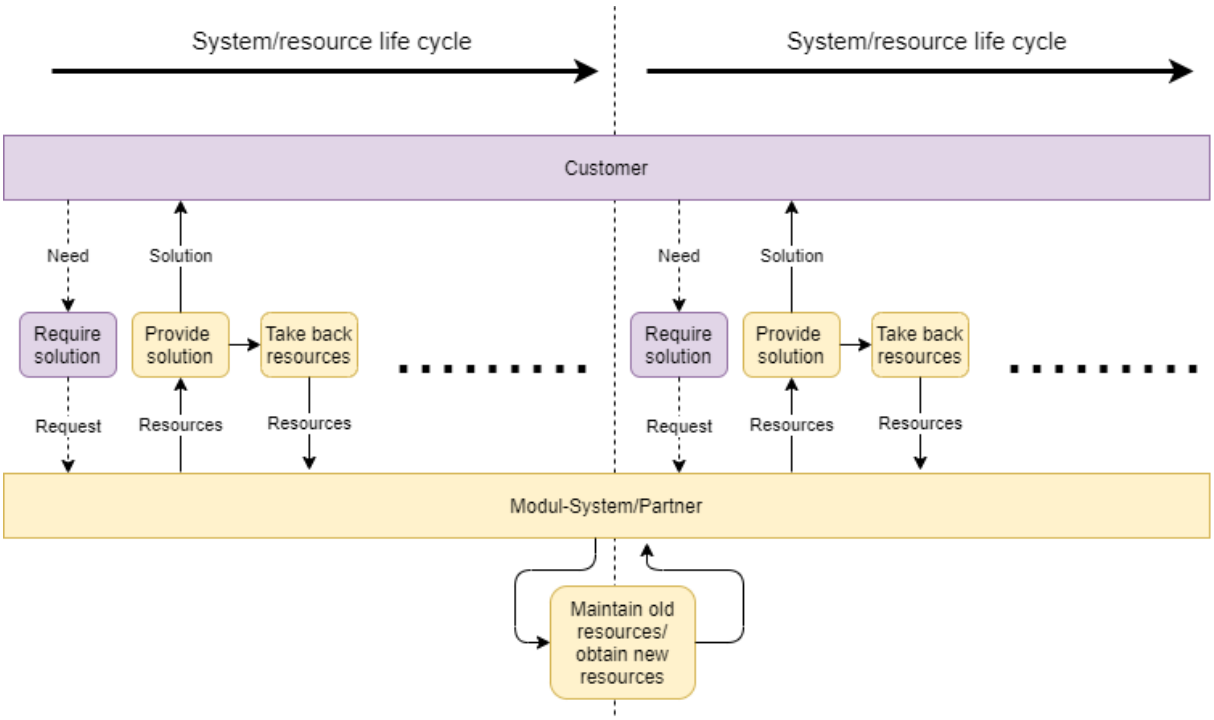

Figure 4.6: Illustration of Concept 5 - "The result based service"

4.1.5 Concept screening

Having come up with more general business oriented concepts, that will lay the path for the more detailed service and product solution, it is time to evaluate the concepts between each other, the scope of the project and the customer needs. Since the concepts were so general it was difficult to perform a detailed and number centered analysis of these concepts. Therefore, a more general, relative analysis was performed. First the concepts were compared against each other, inspired by the pugh matrix but visualised in a graph, in the following three figures:

- Figure 4.7 compares the short/long term versus implementation time for the concepts. Showing the potential development time and scope of the project. Short/Long term describes a concepts time scope, in terms of how long it will take before it will be profitable/give a lot of value to the company. Short term would be to implement an incremental update that immediately increases value, while long term would be to take a strategic path that does not immediately give large gains but will do so in the long run.

- Figure 4.8 maps out the relative degree of change that the customer and Modul-System will have to do/experience in the different concepts. The customer perspective focuses on how conventional the use and interaction will be for them, while for Modul-System it is about how different the business model will have to be compared to their current one.

- Figure 4.9 compares the potential environmental impact each concept can have against each other and the current, very product based business model.

Then the concepts were individually evaluated against the scope of the project and the general customer needs, see Table 3.2.

Short/Long term and Implementation time

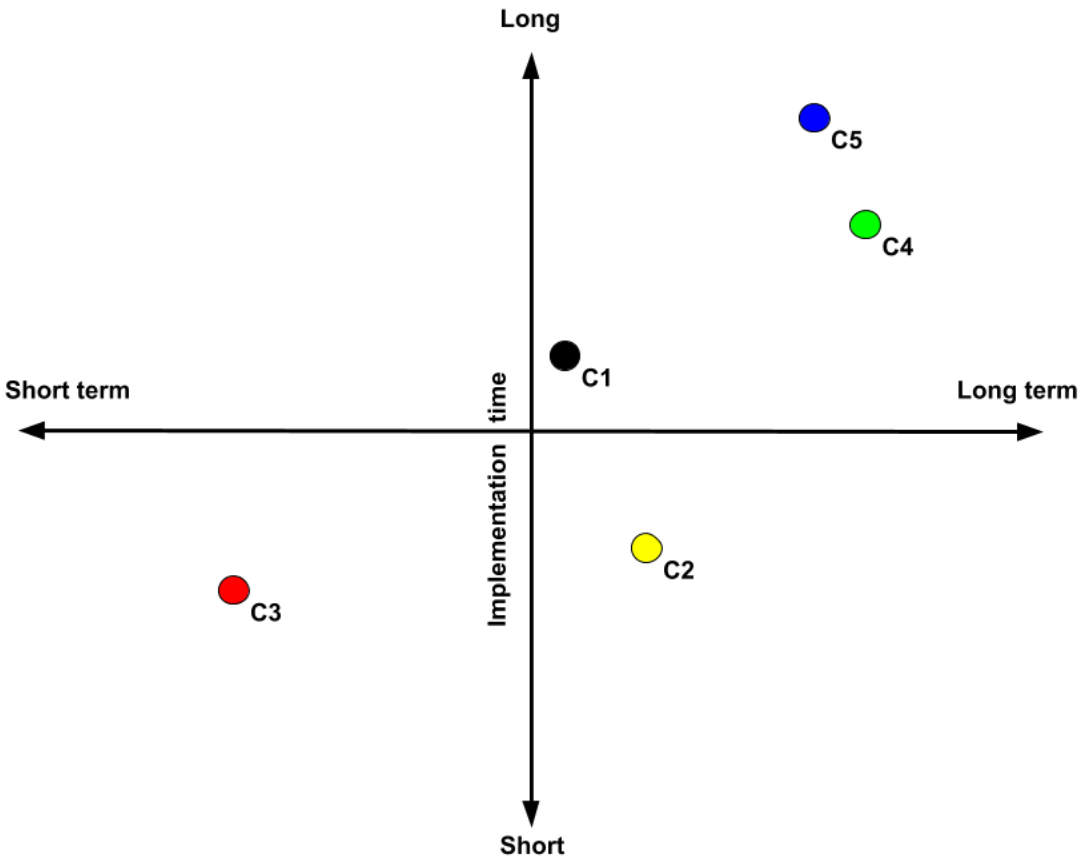

Figure 4.7: Short/Long term and implementation time

Starting with Figure 4.7, it is evident that C5 "Result based" and C4 "The collective" both have a long implementation time and are long term concepts. C5 was considered higher in implementation time due to the revamping of the offering a result based service would require, while C4 is slightly more long term due to its future outlook on the urban market. C3 "Optimise use" is on the other side of the spectrum, being both short term and short in implementation time. C2 "Lease" is from a technical perspective quick to implement but can take a longer time for the organisation to change and is more long term in its time to be beneficial compared to Optimise use. C1 "Re-use" was situated more in the middle, needing a medium amount of development and time was considered to be in the middle of long term vs short term since it can both have short term gains and long term. This is because it can attract new customers early on but also because it follows a strong sustainability trend and would become a first stepping stone for Modul-System to take in that direction if implemented.

Degree of change

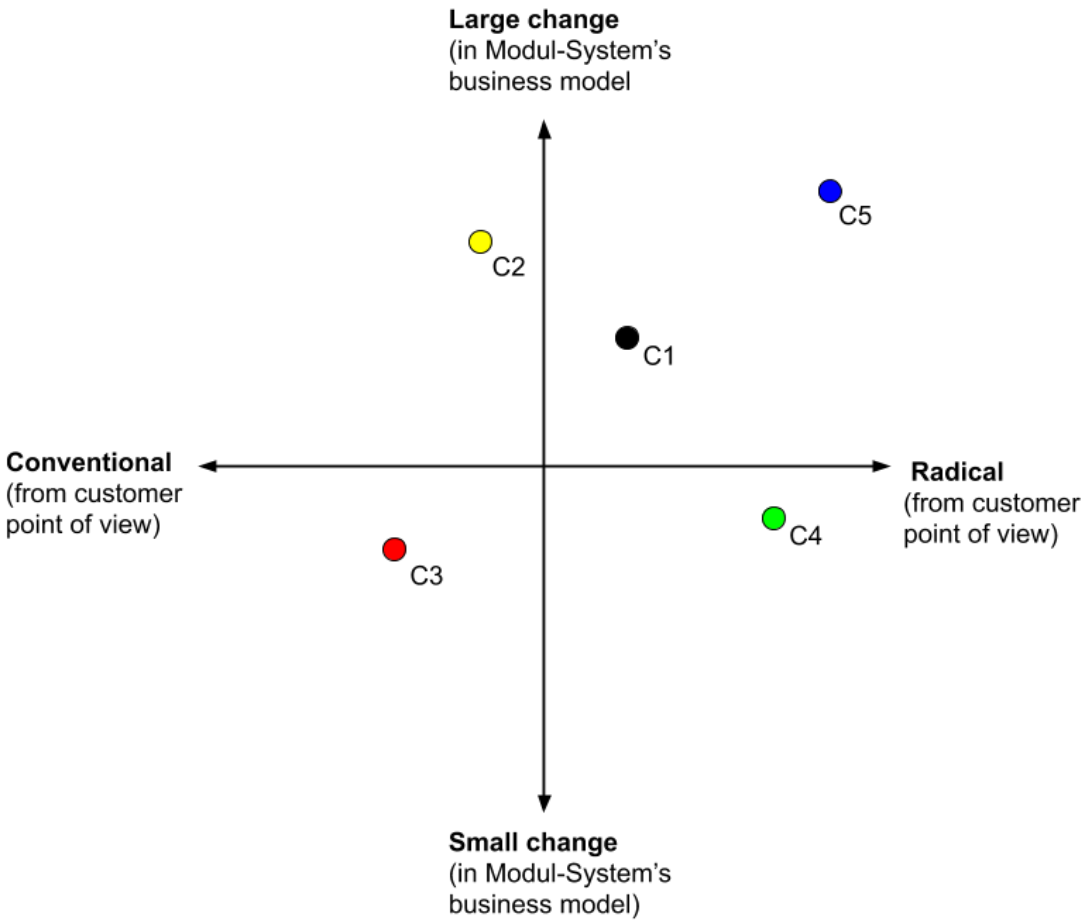

Figure 4.8: Degree of change for customer and Modul-System

In Figure 4.8 C5 is once again situated in the top right corner, requiring both radical change for the organisation and is very unconventional for the customer. It becomes a completely new way of thinking, were Modul-System has to rethink how to monetise and gain money from providing the result and the customer has to rethink what they own and what they use a service for. On the other side of the scale C3 is an iterative step towards a more service focused product offering, not requiring a big organisational change and is fairly conventional compared to the other concepts. C2 is not a radical change from the customers perspective since they are used to leasing deals with cars but for Modul-System's business model they have to completely rethink how they earn their money and also how they can handle the increase in bound capital from the physical products being leased. C4 is a radical change for the customer with the resource sharing but it does not have to be a radically different business model for Modul-System, who can still sell the physical part of the product to the customer and having them own it. Finally, C1 is in the middle of the concepts again. This time being slightly more towards the top right. Modul-System will have to change some of their business model to accommodate for the reselling of used products and the swapping of racking systems between cars, but can still largely have the same ownership type as before. The customer will have to get used to the idea of using the racking systems for a longer time, in several cars, but there are already some who do this. The customers who buy the used products will see this as quite radical

but there has already been customers who have asked for second hand products so the mentality for buying re-used products is forecasted to change in the future.

Effect on sustainability

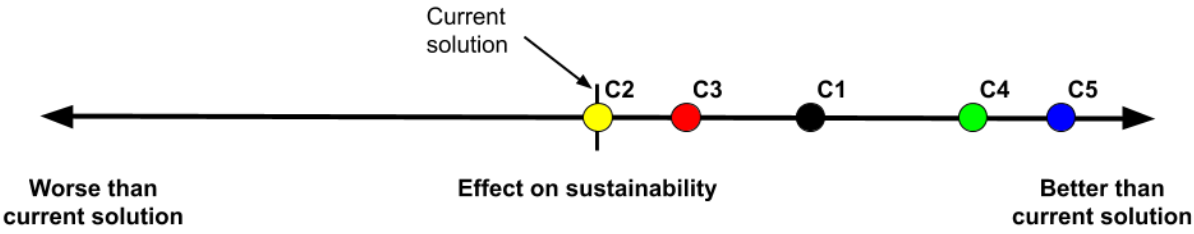

Figure 4.9: Estimated effect on sustainability

When looking at the comparison of sustainability effect, see Figure 4.9, C5 is once again the on the far right with the highest potential for a positive effect on the environmental impact. The literature study on PSS in Chapter 3.1.1, found that the result based approach has the highest possibility for a positive environmental impact due to its possibility to radically innovate within the field. C4 was considered to have the second best possibility to increase environmental sustainability, with its product pooling concept, also grounded in Chapter 3.1.1. The third best performer was C1, which takes increased responsibility for the life cycle of the product, prolonging its life and encouraging re-use. C3 was the second worst performer, since it is just an iterative optimisation of existing use of the vehicle which can reduce the environmental impact but not as much as the previously three mentioned concepts. Finally the worst performer, C2, this concept was rated the same as the current product offering since it does not bring anything new to the table that can reduce environmental impact. Furthermore, in the literature study it was found that the environmental impact could be worsened due to the more reckless behaviour of the user, increasing wear on the product.

Conclusion and additional constraints

The analysis of the five concepts performance against each other in five categories, Long/short term, Implementation time, Degree of change (Modul-system and customer) and environmental impact, has yielded some standout points. C4 "The collective" and C5 "Result based" have the greatest potential for increasing environmental impact but are radically different ideas for both the customer and Modul-System. These are also long term concepts that have a long implementation time and are predicted not to bring short term gains to the company. C1 "Re-use" is in the middle of the implementation time, also having both the possibility to short term and long term gains with an environmental impact that is lower than C4 and C5 but still has the possibility to give a sizable positive impact. C3 "Optimise use" is the most incremental solution, which also shows in the effect on sustainability were it is only assessed to give a slight increase compared to the current solution from Modul-System. C2 "Lease" is a bit all over the place, it requires a big change in business model for Modul-System, with a high amount of bound capital and is in the middle of the other parameters except for impact on environment. There it only has the same as the current solution, which makes it the worst performing concept in this field.

Modul-System is in the beginning stages of taking ownership of the product life-cycle. There is therefore a need to have a concept that can give both short and long term gain. This is a conservative industry thus having a high risk concept that can only be viable in the long term is not suitable. *Therefore concept C4 "The collective" and C5 "Result based" will be eliminated.* These are concepts that can be pursued once Modul-System and the market is more mature in this field. Another concern lifted in an interview is that acting as a bank for the customers, can become problematic, increasing bound capital. Some of Modul-Systems customers are very large cooperation's and could have the power to pressure Modul-System into lowering prices by not paying on time. Therefore it is currently not viable to have a leasing deal for the products, *thus eliminating C2 "Lease".*

4.1.6 Continued development of concepts "Re-use" and "Optimise use"

The two remaining concepts C1 "Re-use" and C3 "Optimise use" are not incompatible and seem to complement each other well. Re-use takes care of taking increased responsibility of the product life-cycle and its longevity, while Optimise use can be one of the tools to increase the life-cycle of the product and aid the use of EVs. It was therefore decided that both concepts will be developed moving forward.

4.1.7 Fulfilled requirements in iteration 1

Since the two chosen concepts will be based on Modul-System's existing product platform, with some possible hardware developments, the following requirements are now concidered fullfilled:

- Req 1.3 - Scalable solution
- Req 1.4 - Rugged solution
- Req 1.5 - Non-destuctive installation
- Req 1.7 - Area efficient solution
- Req 1.8 - Large storage capacity
- Req 1.9 - Allow space for different sized tools/equipment
- Req 1.10 - Have dedicated space and fasteners for large equipment
- Req 1.11 - Not increase vehicle drag
- Req 1.12 - Easy accessible locking mechanisms for withdrawebles
- Req 1.14 - Driver should be safe from loaded material during a crash
- Req 1.15 - Minimise change in vehicle dynamics
- Req 3.4 - Re-cyclable materials

Additionally the requirements that have been taken into consideration in this iteration are now considered fulfilled to varying degrees with the current detail level, see Chapter 4.1.5. These requirements are:

- Req 2.1 - Solution should be adapted for EVs
- Req 3.1 - Environmental friendly solution
- Req 4.1 - Profitable short- and long term
- Req 4.2 - Short implementation time
- Req 4.3 - Solution should not require a large change for Modul-System
- Req 4.4 - Solution should be accepted among customers in present times
- Req 4.5 - Low bound capital

4.2 Iteration 2(a): Further development of "Re-use"

Iteration 1 came up with the general concept for having a Re-use concept. This iteration will focus on performing a more detailed functional analysis of the concept and analysing which of the functions should be outsourced. The basis for this outsourcing analysis decision will be based on the capability sourcing literature study in Chapter 3.1.3.

4.2.1 Regarded requirements for "Re-use"

This iteration will be exploring how to fulfill the defined functions in Chapter 4.2.2, through different sourcing strategies. For this there are no defined requirement, thus no special requirements will be regarded in this step. The end of this section will instead verify which specific requirements that are fulfilled with this concept instead.

4.2.2 Functional analysis for "Re-use"

Before the different sourcing strategies can be made, the possible functions related to this concept need to be defined. To do this a function flow chart was created further detailing the functions necessary to enable the Re-use concept, see Figure 4.10. This chart has both the first hand customer, who buys a new system for a certain amount of car life cycles, and the second hand customer who buys the systems once again, in second hand.

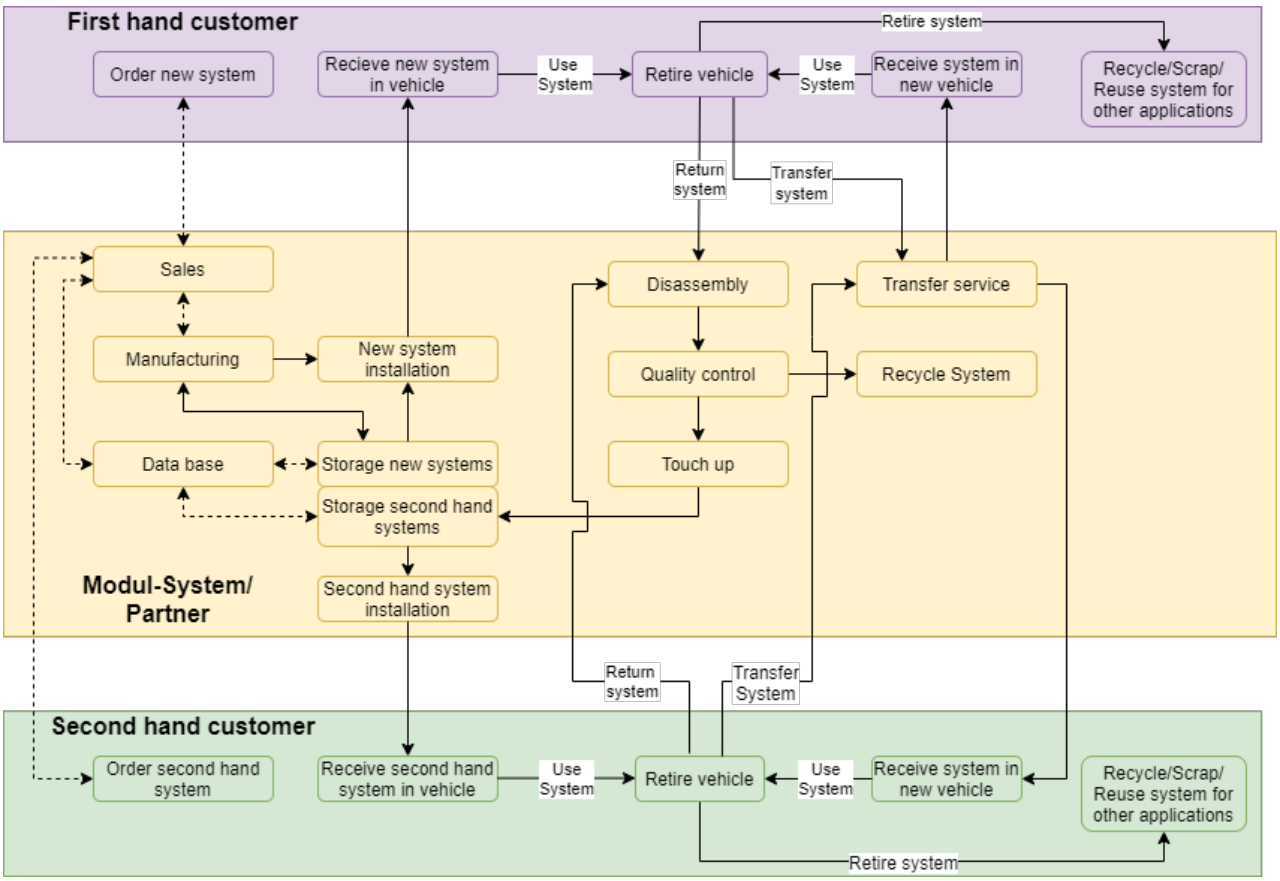

Figure 4.10: Function flow chart for Re-use

The middle section includes the functions that is of the greatest interest in this stage of the development. Some of the most important ones to look at are:

- Sales of the systems, new and used
- Storage of systems, new and used
- Installation of the systems, new and used
- Disassembly, quality control and touch up of used systems
- Transferring of systems between cars
- Recycling of systems

Sourcing analysis

These functions will need different types of resources and company competences. It is therefore imperative to evaluate what and how much of these resources will be required and if it is valuable for Modul-System to perform these tasks. If it is not, then those tasks should be outsourced. To aid this analysis the tools found from the literature study in Capability sourcing will be used, see Chapter 3.1.3. Each sub-function will be evaluated based on the criteria in Figure 3.4 and Figure 3.5. A complete list of the sub-functions that will be evaluated and what types of sourcing possibilities that have been generated can be found in Appendix A.1. The solutions marked in red are ones that are already

performed in an existing process and will not be evaluated for outsourcing potential. The list below will show the functions with their accompanying number:

- F1 - Sales second hand system
- F2 - Storage second hand system
- F3 - Installation second hand system
- F4 - Disassembly
- F5 - QC used product
- F6 - Touch up, used product
- F7 - Transfer between vehicles old product
- F8 - Recycle old product

The first matrix is for analysing which functions are eligible to be outsourced and which ones should be performed in house. To achieve this each axis, that is divided into four sections, got a score from 1-4, see Figure 4.12. The scoring was based on previous interviews and one additional one with a product manager at Modul-System (segment Modul-System and Modul-Connect), personal communication, March 2020.

			What to outsource?			
Proprietary nature of function	Not proprietary	1				F4, F8
	Data are proprietary	2		F3, F7	F5, F6	F2
	Business process is proprietary	3			F1	
	Profit model is proprietary	4				
			4	3	2	1
			Unigue to self			Common across industries
			Uniqueness of function			

Figure 4.11: Scoring of functions based on their uniqueness and proprietary nature

The general results were that the functions got medium to low scores. F4 (Disassembly) and F8 (Recycle) are the ones with the lowest scores of (1,1), making them prime candidates for outsourcing. F2 (Storage second hand product) had a score of (1,2) also making it suitable for outsourcing. F5 (QC second hand product) and F6 (Touch up used product) got a score of (2,2), which based on the literature review in Chapter 3.1.3, still

makes them strong candidates for outsourcing. The three remaining functions F1 (Sales second hand system), F3 (Installation second hand system) and F7 (Transfer) are in the zone were of it depends on the company and it's dynamics. F1 has an existing counterpart in the company which is the sales of new systems. This function is both performed in house and outsourced to partners who sell the product. Therefore this function will be further analysed for outsourcing possibilities. F3 and F7 are both installing a system into car, which today is, as with sales, performed both in house and with partners. These two functions will therefore also be further evaluated as outsourcing candidates. Thus, all functions will be further evaluated for their appropriateness for outsourcing.

The second matrix, scoring the functions based the cost per transaction and the company's ability to perform function, is used to determine an appropriate outsourcing strategy with a scoring of 1-3 for each category. As with the previous matrix, these results were based on previous interviews and an additional one with a product manager at Modul-System (segment Modul-System and Modul-Connect), personal communication, March 2020. The results can bee seen in Figure 4.12

			Outsourcing strategy		
Company's ability to perform function	Better than it needs to be	3			
	Sufficient	2	F2, F4	F5	
	Not sufficient	1	F1, F6, F8	F3, F7	
			1	2	3
			Above	Median	Below
			Cost per transaction in relation to industry median		

Figure 4.12: Scoring of functions based on their transaction costs and company's ability to perform functions

The results from this analysis show that functions scored medium to low points, placing in the middle and lower left parts of the matrix. F1, F6 and F8 are in the section "Source to increase capability at lower cost", indicating that the company should outsource these functions or greatly invest in increasing capability and decreasing costs. F2, F4 and F5 placed in the category "Source to reduce costs", while F3 and F7 placed the in the category "Source to increase capability, even if at a higher cost". F3 (Installation second hand system) and F7 (Transfer) will have to compete with the installation of new systems, therefore Modul-System were deemed to not have sufficient capability to perform these additional installations. Thus, it should be explored how these two functions can be achieved and if one or both should be using the same network as the new installation one.

4.2.3 Sourcing strategy for "Re-use"

The functions that have been analysed in Figure 4.11 and Figure 4.12 can be divided into two categories:

1. Re-use purchased racking systems for several car life-cycles (customer)

    - F7 - Transfer between vehicles old product. This is the only function in this segment of the concept, excluding the possible service of Re-cycling broken parts.

    To fulfill the transfer service only one of these functions (F7) needs to be achieved and since the installation network is already in place adding one extra function should be feasible without overtaxing this system. This is especially true since it is probable that many customers will choose to keep their racking systems for more than one car life-cycle, resulting in that the amount of installations/transfers having to be performed will stay largely the same. Thus, the transfer service will be a combination of performing it in house and outsourcing it.

2. Sell used racking system to new customer

    - F1 - Sales second hand system
    - F2 - Storage second hand system
    - F3 - Installation second hand system
    - F4 - Disassembly
    - F5 - QC used product
    - F6 - Touch up, used product

    This category will need more resources to be achieved and aims at a different type of customer than Modul-System currently cater towards: The budget/entry level customer. The in house sales team and strategy is towards high end customers so F1 will not fit well into there, which can also be seen in the outsourcing strategy Figure 4.12. The installation of the systems will be similar to the existing installation network but will increase the need for installation, taxing the current system. These two functions could therefore be suitable to outsource to a partner, who already has this customer base. However, there are some benefits to performing this in house, with increased profit margin and a higher customer interaction. Therefore this will be further explored in the detailed design Chapter 5.2.

    To reduce the costs for refurbishing (QC+touch up) and storing the systems, which are labour intensive tasks, it would be an option to perform this in a country were labour cost is lower than Sweden. An example of this is Poland, which is geographically close but has cheaper labour. These functions could then be outsourced to a company or a new business function for Modul-System. Based on the results from the sourcing analysis, outsourcing this to another business would be the best way to do so. With that said a further analysis regarding the costs and logistics for the

different sourcing strategies need to be performed. This will be further examined in Iteration 3(a) (Chapter 4.3), where costs of the different aspects of the Re-use concept will be evaluated.

The disassembly of the racking system is easy and quick, resulting in that it can be performed by either the existing installation network or new partners who can disassemble and then ship the products of shore to the refurbishment facility. This possibility will also be further evalutated in Iteration 3(a) (Chapter 4.3).

4.2.4 Fulfilled requirements for "Re-use" in iteration 2(a)

The following requirements are now considered fulfilled with the Re-use concept:

- 2.5 - Install solution - Re-use is supposed to include services were Modul-System and/or their partners install new systems for their customers.
- 2.6 - Move solution between vehicles - A large aspect of the Re-use concept is for Modul-System to highlight a transfer service for their customers where they can move their system from an old to a new vehicle.
- 2.7 - Maintain solution - The Re-use concept will include maintenance since this is one of the ways to close the resource loops in a circular economy (see Figure 3.3 in Chapter 3.1.2). The maintenance might include changing of movable parts such as ball bearing rails etc.
- 2.8 - Dismantle solution after end of use - The Re-use concept includes a service where Modul-System or their partners dismantle their customers' racking systems in the end of their life cycles. The dismantled systems might be reused depending on their condition (hence start a new life cycle).
- 3.2 - Resell complete products as second hand - This requirement is one of the core aspects of the Re-use concept. Both complete racking systems and parts of racking system will be resold to customers in second hand.
- 3.3 - Re-use components together with first hand solution - In the Re-use concept the racking systems within Modul-System's current product platform will be reused. It is therefore possible for a customer to first buy a second hand systems and later add new products within the same product platform to their system. An example could be to buy a second hand racking system and later add additional new racking system modules or electrical equipment.
- Req 3.8 - Life span: 7 years - Modul-System claim that some of their customers want to transfer systems that can be up to 20 years old. This indicates that even a reused system have the potential to have a life span of another 7 years, especially since Modul-System will conduct maintenance on their customers' systems.

4.3 Iteration 3(a): Further Development of "Re-use"

The previous iteration explored which functions are suitable outsourcing objects, with the takeaway being that most of them are but need to be analysed further. Thus, this section will analyse the dismantlement, quality control and "Touch-up" part, which has been summarised and "refurbishment". It will include, different methods to clean and recondition the systems along with their costs.

4.3.1 Regarded requirements for "Re-use"

This concept mainly focus on how to create a business model where Modul-System's racking systems are reused. In order to create such a concept it is important to investigate if it could be profitable for Modul-System to offer second hand systems, especially since they could compete with sales of new systems. The regarded requirements will therefore mainly focus on the cost aspects in the requirement specification (Table 3.3). Additionally, a requirement regarding the condition of a refurbished system is introduced to make sure that the system's are in a marketable condition. See the requirements that are marked with "3a" in the rightmost column in Table 3.3.

4.3.2 Functional analysis of the "Re-use" refurbishment process

In order to find different sub-solutions for a refurbishment process a functional analysis was made, see Figure 4.13.

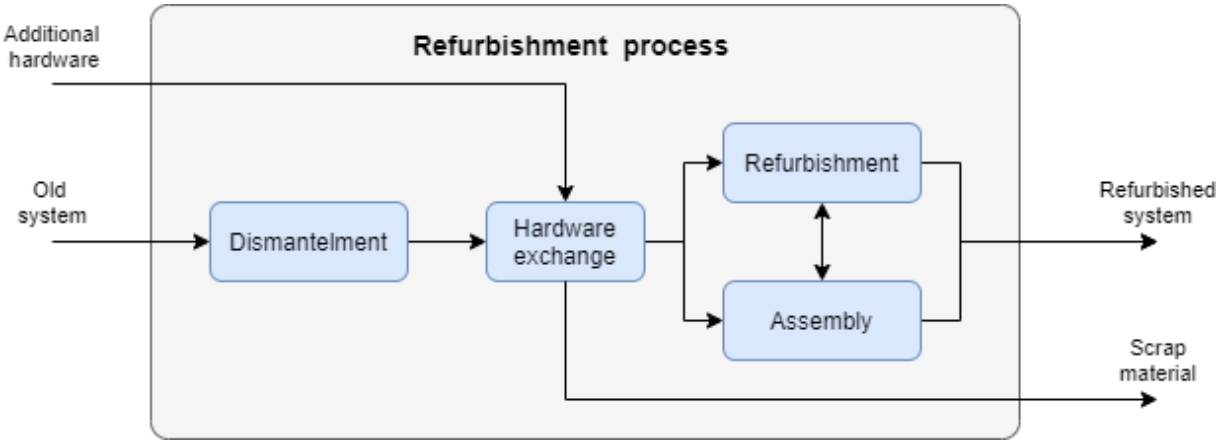

Figure 4.13: Flowchart showing the refurbishment process

Here, the input is old racking systems that has already been removed from the customer's vehicle and been through a first quality check to insure that it can be resold. Another input to the system is additional hardware (either new or old) that is meant to replace worn out or not aesthetically pleasing components of the old system. The system's output are refurbished racking systems that are ready for the market once again and some potential scrap material that can be recycled.
To quickly describe the process the whole racking system arrives to the site(s) were it (possibly) will be further dismantled. Once the dismantlement is finished a quality control will be conducted, ensuring that the different parts are in required condition and function properly. The faulty or non aesthetically pleasing components are then exchanged to fulfill the required quality level. The next steps are refurbishment, where the system gets

a touch up of some sort, and reassembly. The sequence of these two steps will depend on the chosen sub-solutions for these sub-functions.

4.3.3 Idea generation for "Re-use"

Based on the sub-functions identified from the Refurbishment process flowchart, in Figure 4.13, a morphological matrix was created. Here different solutions for how to solve each function were generated, but with some constraints. The highest amount of maintenance and refurbishment would be to swap some easily removable components and only apply new paint to the components. For example, cutting a bent side of the frame and welding in a new one was considered outside of this scope.

Table 4.2 shows the generated solutions together with the concepts combining said solutions. Below there will be a brief explanation of each solution, followed by a presentation of each concept.

Dismantlement

- *No dismantlement*: The systems are processed in the constellation they were originally mounted.
- *Dismantle into standard modules*: Systems are dismantled to the extent they match a complete or part of a standard kit. A standard module represents a base constellation of the system that a customer can choose straight away to fit into a car.
- *Dismantle into each sub-frame*: Each system is dismantled to a base frame. An example could be a cabinet with 3 boxes, that together with other similar modules would make a complete system (such as a standard kit).
- *Dismantle everything*: This entails dismantlement to each base product such as frame, box and each shelf floor.

Assembly:

- *No assembly*: No matter the components condition, no assembly will be performed.
- *Assemble into each sub-frame*: Similar to dismantlement, the system will be assembled into sub-frames.
- *Assemble into standard kits*: Similar to dismantlement the system will be assembled into standard kits.
- *Assemble into original constellation*: The system will be assembled into the constellation it was extracted from the vehicle.

Hardware exchange:

- *Do not swap anything*: All components will be kept in the system.
- *Swap drawer*: Drawers will be swapped, depending on their condition. Specific guidelines for which drawer to swap will be concept specific.

- *Swap ball bearing rail*: Swap the rail that enables the drawer to extrude. Specific guidelines for which rails to swap will be concept specific.
- *Add mats in drawer and shelves*: Add rubber matts to hide and reduce wear.
- *Swap plastic boxes*: Replacing the used plastic boxes with new ones to make the system look newer is the goal with this solution.

Re-furbishment:

- *Wash and degrease*: Clean the system by washing and removing oils and dirt.
- *Remove and paint over the rust stains*: Finding major scuff marks on the components that have produced or can produce rust stains and paint over them.
- *Polish/Re-paint scratches*: Cover scratches by polishing or applying paint to them. This mainly refers to the visible surfaces on the systems, not including the insides of drawers etc.
- *Re-paint whole frame*: The frames will be repainted/re-coated, giving them the appearance of almost being new.
- *Re-paint whole front of drawer*: Apply new coating of paint to the most visible part of the drawer, the front.

C1: Minimal work	C2: Function over looks	C3: Function and looks	C4: Almost as new	C5: Max preservation

Sub functions	Sub solutions				
Dismantlement	No dismantlement	Dismantle into standard modules	Dismantle into each sub-frame	Dismantle everything	
Assembly	No assembly	Assemble into each sub-frame	Assemble into standard kits	Assemble into original constallation	
Hardware exchange	Don't swap anything	Swap drawer	Swap ball bearing rail	Add mats in drawer and shelves	Swap plastic boxes
Re-furbishment	Wash and degrease	Remove and paint over rust stains	Polish/Re-paint scratches	Re-paint whole frame	Re-paint whole front of drawer

Table 4.2: Morphological matrix and generated concepts for Re-use

C1: Minimal Work

Minimal work is a concept were Modul-System do as little as possible to sell the system as second hand. Here, each system remains in its original configuration and is only washed and degreased before it is put up for sale. Faulty parts are not swapped out, meaning that each system is sold in existing condition and the price is adjusted accordingly. This concept corresponds to sales done by individuals through sale sites such as blocket.se or ebay.com.

C2: Function over looks
Function over looks is a concept were Modul-System makes sure that each second hand system works as it should while the appearance is not a priority. Here, each system is dismantled into standard modules or down to sub-frame modules. To make sure each drawer of the system will function faulty ball bearing rails will be replaced. Once this is done each module will be washed, degreased and possible rust strains will be painted. The last step will be to assemble the modules into standard kits (or kept as sub-frame modules).

C3: Function and looks
Function and looks contains similar steps as function over looks, but here the appearance of the system is also a priority. Each used system gets dismantled down to a sub-frame level. After this step faulty ball bearing rails and drawers will be replaced. This time the refurbishment will include washing, degreasing, polishing and adding of paint over rust strains and scratches. To further enhance the feeling that the systems are in good condition new rubber mats will be placed in the drawers and shelves. If the system contains plastic boxes these will also be swapped out if needed. Finally each sub-frame module are assembled into standard kits, ready for the market.

C4: Almost as new
Almost as new is similar to Function and looks but here the focus is to further guarantee high finish, quality and also allow customers to modify their second hand systems. The steps are the following. Each used system is dismantled so that boxes/drawer are separated from the main frames. The sub-frames are also dismantled from each other. The drawers are then changed (if in bad condition) and all ball bearing rails are exchanged (no matter condition). This is to guarantee that the system is "almost as new". Once this is done all parts that will be reused are washed and degreased and the frames are completely re-painted. All drawers and shelves get new rubber mats and all plastic boxes are replaced. Finally assembly is done into sub-frame modules. Based on these modules customers can customize their own second hand systems, similarly to what is done with the new systems.

C5: Max preservation
As the name states, the goal with this concept is to preserve as much as possible and minimize waste, through a step towards re-manufacturing. The first step of the process is to dismantle everything into a component level. Then, faulty ball bearings gets replaced while as many components as possible gets reused. The frame and drawer fronts gets repainted with their respective colors. Finally the system is put together to its original constellation, ready for the market.

4.3.4 Analysis of the refurbishment methods for "Re-use"

To find out the effects of the refurbishment methods "wash and degrease" and "polish" in the morphological matrix (Table 4.2) a physical test was carried out. The methods "remove and paint over rust strains" and "repaint scratches" are methods that are already conducted by Modul-System during racking transfer and maintenance, hence they will not be considered here. The final refurbishment methods "Re-paint whole frame" and "Re-paint whole front of drawer" are considered remanufacturing and these methods are conducted in Modul-System's factory (for new products).

In this test, three sets of used systems were sent to a reconditioning firm in Mullsjö. The choice of reconditioning firm was based on strategic values since this firm potentially could be a future partner to Modul-System, due to its close proximity to Modul-System's factory. According to the owner the price for reconditioning services varies, but generally speaking they invoice their customers around 500 SEK per hour. The three sets of systems used in this test were:

- **System 1 - "The worst case system"**
  A system in a very bad condition. This system was full of oil and grease stains and had plenty of scratches and dents, both externally and internally. This system was supposed to be scrapped due to its bad condition. Figure 4.14 shows the system and its imperfections.

Figure 4.14: System 1 - The worst case system

- **System 2 - "Used system in fairly good condition"**
  This system contained two standard modules with three drawers each. Although the system had some oil and grease strains it did not have any major defects. The system had some scratches, especially on the drawer fronts. This system was supposed to be transferred from one customer vehicle to another, meaning that its condition was good enough for at least another car life cycle. Figure 4.15 shows the system.

Figure 4.15: System 2 - A system in an fairly good condition

- **System 3 - "Another used system in a fairly good condition"**
  This system contained the same standard modules as System 2. It was used by the same customer/company and had a similar condition as the previous system. However, the bottom drawer had even more scratches then in System 2. A probable reason for this could be that the bottom drawer was located the vehicles floor level, meaning that material that has been dragged along the floor also has scratched the this drawer. Similar scratches can be seen on the bottom of System 1 (the worst case system) as well. Figure 4.16 shows this system.

Figure 4.16: System 3 - Another system in an fairly good condition

Results of the refurbishment methods

- **System 1 - Wash, degrease and drying**
  The worst case system was washed, degreased and dryed. The recond firm stated that it would take about two hours to wash a complete system (two sides) both externally and internally. Figure 4.17 shows the system before and after the cleaning process. Most of the dirt and oil strains have been removed with just the washing, degreasing and drying processes, both externally and internally. The scratches still

remains. The side/tool board seen in the bottom of Figure 4.17 appears to be in a new conditioning.

Figure 4.17: System 2 - Before and after refurbishment processes

- **System 2 - Wash, degrease and drying**
  System 2 went through the same process as System 1. Similarly to the previous System most of the dirt and oil strains have been removed while scratches remains. Here the inside of the drawers were also washed, giving them a clean appearance. Also, the discoloration on the handle in the bottom drawer remains after the process. Figure 4.18 shows the system before and after the cleaning processes .

Figure 4.18: System 2 - Before and after refurbishment processes

- **System 3 - Wash, degrease, drying and polishing (full reconditioning)**
  System 3 went through the same processes as the two other systems but additionally it was also polished with a polisher. This system stands out the most. Not only is it free from dirt and oil stains but most of the scratches has either disappeared or been faded (see the large scratches in the larger bottom drawer). Furthermore, the polishing removed some of the slight colour shifts on the surface, giving it a more homogeneous appearance, regaining some of the new product feel. Lastly, it was noted that the handles lost some of the color during polishing, in some cases giving it a more weathered appearance.

Figure 4.19: System 3 - Before and after refurbishment processes

Concluding discussion of refurbishment methods

Based on the results from System 1 and 2 it is clear that the cleaning, degreasing and drying processes, from a visual perspective, improves the appearance by removing strains of different kinds. For reused systems that do not have defects such as scratches and dents processes such as these could be enough to restore it into a sufficient condition. However, systems that do have larger scratches will have to be polished as well. Here, System 3 showed the potential of the polishing process. In summary, all processes (cleaning degreasing, drying and polishing) are considered to be reasonable options for refurbishment methods. The next section will further evaluate these processes in terms of their corresponding costs.

4.3.5 Cost analysis for the "Re-use" sub-concepts

In order to evaluate the cost of performing the different concepts a cost analysis was made. This will, together with the findings of the refurbishment methods effectiveness, be the basis for the evaluation of which concept to chose.

Here the five concepts costs in relation to the standard price of a new reference racking system was determined. Due to confidentiality no absolute numbers for costs or profit

margins will be presented.

Reference racking system

The system that was used as a reference during the cost analysis is the average of two systems; a high end and a low end system. Both systems are in this case adapted for a Volkswagen transporter T6 15, which is a mid-sized van that represents an average customer vehicle (Product manager racking system and module connect, personal communication, March 2020). Both systems contains two separate racks, one for the left and right side of the vehicle respectively. They also include some electrical components but these have not been taken into account during the cost analysis since these components will not be reused in the concepts.

The high end system contains a total of 12 drawers and four shelves for the right side, while the left side has four drawers and four shelves. The weight of this system is 164 kilograms. The high end system can be seen in Figure 4.20.

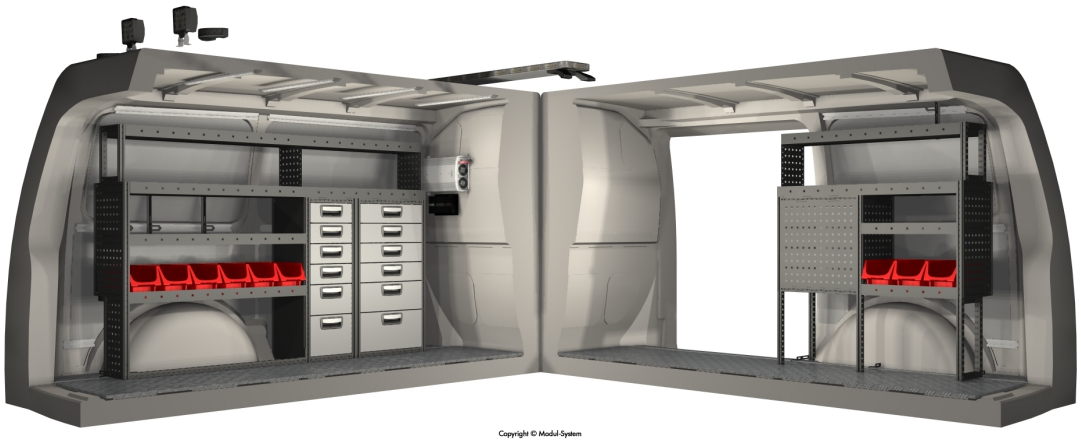

Figure 4.20: The high end racking system

The low end system is much simpler then the high end system. The left side only contains three drawers and three shelves. The right side contains a racking system of only three shelves. The weight of this system is 99 kilograms. Figure 4.21 shows the low end system.

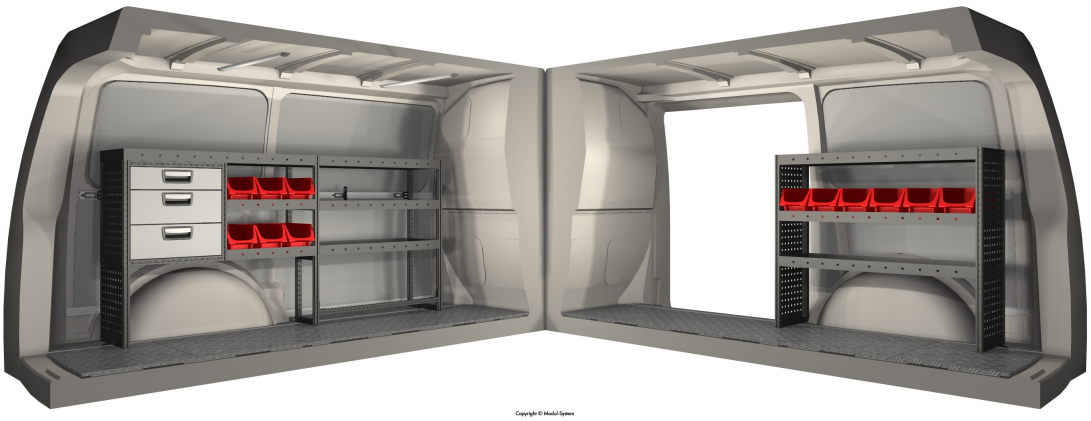

Figure 4.21: The low end racking system

Furthermore, the reference system will have an average amount of the components of the two systems. It will consist of 8 drawers and have a weight of 131,5 kilograms.

Assumptions for refurbishment process costs of the racking systems

To get a comparative cost between the average new system and a refurbished average system, a certain amount of assumptions have to be made. In a best case scenario there would be a minimal amount of assumptions, with most of the analysis being based on quantitative data collection on the condition of the systems and what needs to be swapped. Due to the limited time of the project, the procurement of data will not be possible. The recommendation will however be to test the assumptions validity by gathering more data in the relevant subjects.

Assumptions:

- The average of incoming racking systems will be similar in value and design as the reference system.
- 1 drawer will be badly damaged , either functionally or aesthetically
- 2 drawers will have visible scratch marks and
- 2 drawers will have ball bearing rails that are not operating smoothly
- The lower parts of the frames will have larger scratches and the rest only minor ones. Some lower parts will have to be treated to reduce risk of rust forming.
- The possibility to swap components, such as drawer fronts between each other and move drawers between frames is possible, thus reducing the need for new ones to be incorporated into the eco-system.
- The manual labour efficiency in Poland is 30% lower than in Sweden
- The time it will take to clean and degrease a system is, with an optimised process and less weathered systems, deemed to take 45 minutes instead of the quoted two hours. Some of the large gains to be made is through a more efficient drying process.

Calculations of second hand refurbishment cost for racking systems

The above assumptions for the refurbished racking system together with the defined standard system gives the basis for the calculation of the refurbishment cost for the racking systems. Due to sensitive company information, the specific costs will not be presented, only the formulas, methods to calculate the costs and some general numbers, mainly in percentage or in time.

Firstly general costs, that span over all different concepts were specified for performing the work in Sweden or Poland:

- Shared: *Workshop cost/h and time to remove racking system*
- Sweden: *Factory cost/h, Storage cost per system, Transport to factory cost*
- Poland: *Factory cost/h, Storage cost per system, Transport to factory cost*

Then all of the costs for the actual refurbishments of the systems were calculated, by taking "Factory cost/h"*"time to perform task"+"Material cost". Furthermore, as seen in assumptions, the efficiency for manual labour in Poland is considered to be lower than in Sweden which will be compensated by multiplying the result by 1,3. Each step in the refurbishment process was analysed with the aforementioned attributes. The processes/tasks were derived from the solutions in the morphological matrix and the times were estimated based on discussions internally and with the reconditioning firm:

DISMANTLE	ASSEMBLE
• Everything - 1h • Into sub-frames - 0,5h • Into Standard modules - 0,25h	• From component level to original constellation - 1,75h • From component level to standard modules - 1,5h • From component level to sub-frame - 0,5h • From sub-frame to standard kits - 0,5h
EXCHANGE	**REFURBISH**
• Drawer (front) - 5min • Ball bearing rail - 1min • Rubber mats - 0,1min • Module-boxes - 0,1min	• Clean and degrease - 0,75h • Paint over rust - 0,25h • Polish/Paint over scratches - 0,25h • Paint entire frame - 1h • Paint front of drawers (all 6 drawers) - 1h

Table 4.3: Cost drivers for refurbishment

Each of the generated concepts counts the relevant processes, in Table 4.3, to get a combined cost for the concept. Table 4.4 shows which and how many of each process will be used for each concept. The amount of ball bearing rails being swapped is based on the assumed median amount of drawers/ball bearing rails that have lost its smoothness. Concept C4, switches 12 rails to secure that the system feels as new and smooth as possible.

	C1. Minimal work	C2. Function over looks	C3. Function and looks	C4. Almost as new	C5. Max preservation
Dismantle					
To standard modules		1	1		
Into sub-frames					
Everything				1	1
Assembly					
Component level --> sub-frame				1	
Component level --> standard kits					
Sub-frame --> Standard kits		0,5	0,5		
Component level --> original					1
Hardware exchange					
Drawer (front)			1	4	1
Ball bearing rail		6	6	12	6
Rubber mats			6	6	
Module-boxes			12	12	
Refurbishment					
Clean and degrease	1	1	1	1	1
Paint over rust			1		
Paint/polish over scratches			1		
Coat frames				1	1
Coat front of drawer					1

Table 4.4: Amount of each process per concept

Concept C2 and C3 only have half of the "Sub-frame–>Standard kits" due to that part of the cost will be covered by the customer paying for the service of having it pre-assembled.

Cost results

Table 4.5 shows the result from the cost analysis. Two costs has been calculated per concept depending on where they would have been performed, either in Sweden or Poland. All costs are presented as a percentage of the reference system in a brand new condition.

Concept	Std cost compared to new system Sweden	Std cost compared to new system Poland
C1: Minimal work	27%	32%
C2: Function over looks	44%	42%
C3: Function and looks	62%	53%
C4: Almost as new	103%	74%
C5: Max preservation	126%	75%

Table 4.5: Cost results in percentage of new system

Comparing the two different locations, it is cheaper to do the re-refurbishment in Poland for all concepts except for *C1: Minimal work*, in which doing the work would be cheaper

in Sweden. This has mainly to do with the transport cost to the factory, which is a large cost that is the same no matter which concept is considered. The cost is also higher for shipment to Poland.

For concepts *C4: Almost as new* and *C5: Max preservation* the Swedish location would cost more than a new product, with the Polish location being 74% and 75% of the new product price. Concept *C2: Function over looks* had the Polish option being 2% cheaper at 42% of the new product price. Lastly, concept *C3: Function and looks* had the Swedish option being 9% more expensive at 62% of the new product price.

4.3.6 Concept screening for "Re-use"

Based on the requirements presented in Chapter 4.3.1, the five different Re-use concepts will now be screened. First a conformity check against the requirements will be conducted through an elimination matrix, see Table 4.6.

		Elimination matrix				Elimination criterias: (+) Does fullfill requirement (-) Does not fulfill requirement (?) More info is needed (!) Control against specification	
Concept	Req 1.18 - Functionality of refurbished product should be the same as the new version: *>1year*	Req 2.2 - Upgradable solution	Req 4.8 - Cost efficient solution: *Same value for money as current solution*	Req 4.8 - Second hand system affordable for customer: *20% cheaper than new system*	Req 4.9 - Standard price (cost for M-S) lower for second hand system then for new system: *30% SE, 40% PL*	**Decision:** (+) Yes (-) No (?) More info is needed (!) Control against specification	
						Comments	**Decision**
C1	-	+	+	+	+		-
C2	+	+	+	+	+		+
C3	+	+	+	+	+		+
C4	+	+	+	+	-		-
C5	+	+	+	+	-		-

Table 4.6: Elimination matrix for Re-use concepts in iteration 3a

The result from this matrix was that three out of five concepts were eliminated. Concept *C1: Minimal work* did not fulfill the requirement for the system to have the same functionality as a new product for over 1 year. This is due to the fact that no maintenance of the system will be performed, resulting in that some systems would be sold with faulty drawers or non smooth ball bearing rails. The Concepts *C4: Almost as new* and *C5: Max preservation* did not fulfill the requirement for the standard price reduction, both for Sweden and the offshoring version in Poland, see Table 4.5 for the standard cost estimation.

Comparing the two remaining concepts, *C2: Function over looks* and *C3: Function and looks*, they are similar in how they solve the functional requirements. The difference is in how they approach the aesthetic finish of the product. C2 takes a pragmatic approach, just performing the tasks that will ensure the functionality of the product. C3 takes this into account, but also tries to restore more of the surface finish through, polishing and re-coating of larger scratches. To evaluate which approach would be the most attractive to the customer, in relation to the price, the finding from an article by Almefelt, Rexfelt, et al. (2017) was used. This article found that the most important factor for the customer is perception of the functionality of the product. This included wear which would indicate that if the product looks less worn, it will (maybe unconsciously) be perceived as more trustworthy/reliable. Since these systems will be used for a long while and in a professional setting, it is imperative that the customer can trust that the racking system will function for the intended time. Thus it is deemed that concept *C3: Functions and looks* will be the most attractive in this market, motivating the extra investment in bettering the surface finish of the product.

4.3.7 Chosen concept for "Re-use"

As mentioned in the above section, Concept C3: Functions and looks is the concept that will be chosen to work further with. The concept includes:

- Dismantling the system into standard modules and sub-frames.
- Exchanging the most damaged front drawers and ball bearing rails
- Putting in new rubber mats in shelves and drawers and adding new module-boxes
- Washing, degreasing, polishing and scratch painting of system

4.3.8 Fulfilled requirements for "Re-use" in iteration 3(a)

Below a list of the regarded requirements will be presented and described how they were fulfilled.

- Req 1.18 (Demand) - Functionality of refurbished product should be the same as the new version: $>$ 1 year: Fulfilled through replacing worn ball bearing rails, which are the most common component to fail.
- Req 2.2 (Demand) - Upgradable solution: Fullfilled through utilising the same modular solution as the newly produced racking systems.
- Req 4.6 (Demand) - Cost efficient solution: Same value for money as current solution: Fullfilled with the same functionality at a lower cost but with reduction in theoretical lifespan
- Req 4.7 (Wish) - Cost efficient solution: More value for money as current solution: Fullfilled with the same functionality at a lower cost but with reduction in theoretical lifespan. Although the life span will be longer than most customers will use it.
- Req 4.8 (Demand) - Second hand system affordable for customer: 20% cheaper than new system: The standard cost from the chosen concept (Function and looks) was approximated to be 38% compared to a new system, thus making it realistic to be able to sell for at least 20% less of the price.

- Req 4.9 (Demand) - Standard price (cost for M-S) lower for second hand system than for new system: 30% lower in Sweden and 40% lower offshored than new system: Fulfilled with standard cost estimated to be 38% lower in Sweden and 53% lower in Poland.
- Req 4.10 (Wish) - Standard price (cost for M-S) as low as possible: Partly fulfilled, since it has been a compromise between low cost, retained functionality and aesthetics.

4.4 Iteration 2(b): Further development of "Optimise use"

Apart from the Re-use concept the Optimise use concept was chosen for further development in iteration 1. This section will further detail how to realise this concept. The main theme is the evaluation of hardware and software based solutions.

4.4.1 Regarded requirements for "Optimise use"

In this iteration the focus was to find concepts that can optimise the use of EVs, EV fleets and minimize weight/payload. Some of the regarded requirements were therefore:

- Req 2.4 - Provide fleet management system
- Req 3.5 - Low weight solution
- Req 3.6 - Aid low wear impact and energy usage in vehicle
- Req 3.7 - Aid lower wear impact and energy usage in vehicles in fleet

All the regarded requirements for this iteration can be seen in in the requirement specification (Table 3.3). See the requirements that are marked with "2b" in the rightmost column.

4.4.2 Functional analysis for "Optimise use"

To further develop the concept Optimise use a function-mean diagram was created, see Figure 4.22. Here the main focus was to develop functions that was specifically related to EVs and therefore help the customer to optimise their EV usage with Modul-System's possibly future products. Based on the findings in the literature study (Chapter 3.1) two main functions were identified to Optimise use, these were: (1) Increase EV range, concidered as one of the main barriers with EVs, and (2) Increse EV utilisation efficiency. Related to these functions several means and sub-functions were produced. The sub functions for "Increase EV range" were:

- Minimize weight
- Minimize energy usage of the main battery
- Provide additional energy

The sub functions for "Increase EV utilization efficieny" were:

- Increase resource utilization during driving of single vehicles
- Increase resource utilization during driving of fleet
- Increase resource utilization during charging
- Increase resource utilization during work

These sub functions were all concidered relevant for solving the barriers related to EVs mentioned in Chapter 3.1.4. These lower level of functions are the ones that will be used in the morphological matrix in the next section (see Table 4.7).

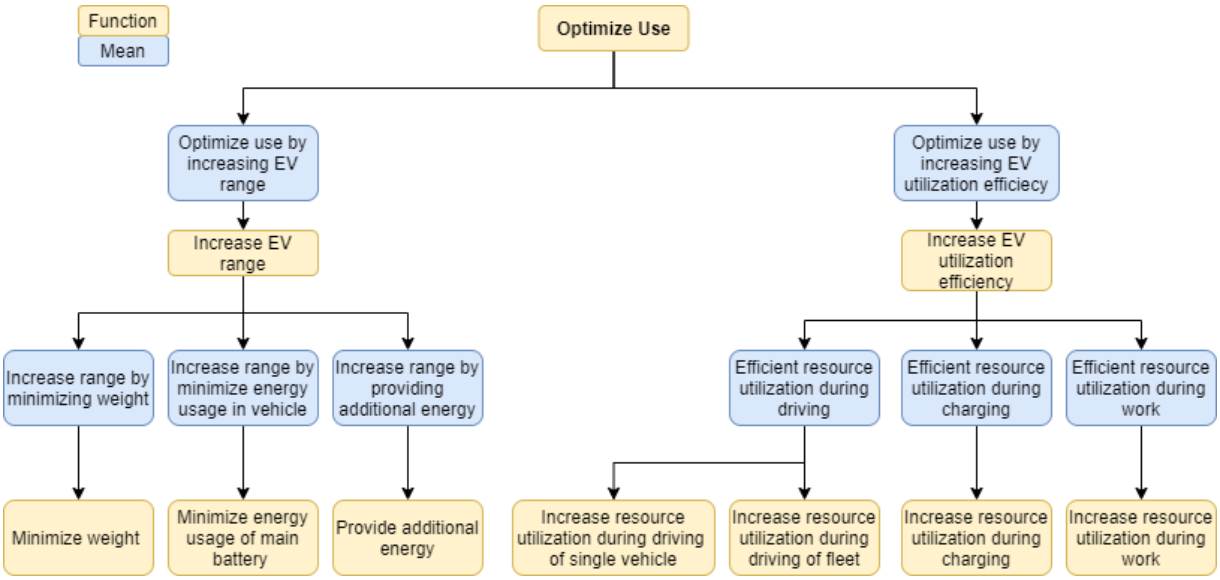

Figure 4.22: Function mean diagram for the Optimise use concept

4.4.3 Idea generation for "Optimise use"

A new morphological was created for the further development of the concept Optimise use. At this stage the morphological matrix only consisted of functions that were derived from the function Optimise use in Figure 4.22. Other functions that might be important for a business perspective for Modul-System (such as payment system, ownership etc) will be left out at the moment and only focus on EV-related functions. The cells that are marked in red are already fulfilled/used with Modul-Systems current products.

C3.1: Software based	C3.2: Hardware based

Sub functions	Sub solutions			
Increase EV range				
Minimize weight	Light racking systems	Weight sensors & warning system	Equipment management system (bring only whats needed)	Removeable racking systems (bring only whats needed)
Minimize energy usage of main battery	Vehicle insulation	Timed heating system		
Provide additonal energy	Solar panels on vehicle	Additional battery packs for tools etc	Generator	
Increase EV utilization				
During driving of a single EV	GPS system (for drive route optimization)	Range prediction system based on: outside temperature, driving behaviour, weight, current energy draw (both for driving and charging of peripherals), proximity to charging stations		
During driving of an EV fleet	Allocate work based on availible charge	Allocate work based on proximity to work site	Allocate work based on competences and availible equipment	Monotoring drivers status: km/charge, average payload, driving behaviours, running costs
During charging	Extractible racking systems	Charge during work: System that tells location to closest charge point (from work site)	Energy sharing between vehicles	Recieve reports on EV:s status: charging to driving ratio
During work tasks			Smart cabin heating system	

Table 4.7: Morphological matrix and generated concepts for Optimise use

Two concepts (for Optimise use) were generated based on the morphological matrix, these are:

- C1 - Optimise use: Software based - A concept that is based on solutions which are mostly software related, including a fleet management system that is adapted for an EV fleet. This concept is marked with green points in the morphological matrix.
- C2 - Optimise use: Hardware based - A concept that is based on solutions which are mostly hardware related. Focus here is to maximize range by minimizing vehicle

payload, providing extra energy and to efficiently use the equipment in the vehicle while it is charging. This concept is marked with yellow points in the morphological matrix.

The two concepts will now be explained in more detail.

4.4.4 Generated sub-concepts for "Optimise use"

C1 - Optimise use: Software based

This concept can be incorporated in Modul-System's current software/mobile application Modul-Connect but it will include functions that makes work easier for businesses that uses EVs in their fleets. For Modul-System it will therefore not be a concept that radically changes their business, but more of an addon to their current Modul-Connect segment.
Firstly the system will include weight sensors which will warn both the EV driver and the fleet manager if the vehicle is overloaded. To further encourage the driver to lower the payload of their vehicles a equipment management system will be integrated in the application. This system will be similar to a check-list and tell the driver what tools and materials that is needed for a specific job, which means that the rest of the equipment can be left behind. Some of Modul-System's customers, especially within the long distance concept, let their vehicles idle for long time periods in order to keep them warm during cold weathers (Product Manager at Modul-System, personal communication, February 2020). To ensure that minimal battery energy is used for heating in the EVs the application will come with an addition to preheat the vehicle at certain times.

Further the system will also give an estimation of the vehicles reduction in range based on current payload, outside temperature, driving behaviour and current energy usage (from cabin heating/cooling). Additionally the system will warn the driver when he/she needs to head of to the closest charging point in order to not be stranded during work. The system will also tell the personnel where the nearest charging point, so that he/she can charge the vehicle during work tasks. This of course requires the charging station to be within a reasonable walking distance from the work site.
Work allocation will be based on the EVs available charge, proximity to work sites, competences of the personnel and available equipment in the vehicles. Fleet managers will also get the status on the vehicles/drivers live or over a certain time span. This information can include:

- Driving behaviour characteristics (km/charge and number of hard accelerations/decelerations)
- Average payload
- Running costs (cost/km)
- Charge-to-drive ratio

With a system such as this fleet managers could easily identify personnel that uses their EVs in a non efficient way and give them advice on how to improve.

C2 - Optimise use: Hardware based

This concept mainly focuses on hardware based optimisation solutions. From Modul-System's perspective this would mean developing new physical products to their existing product segment or adapting their current products so they can perform new functions. In order to minimize the weight of EVs payload, an alternative could be to have racking systems that are removable. This could be accomplished by either having large parts of the system removable or only the trays. Modul-System's already existing product "Multi-box" could be an example of this, see Figure 4.23. This would have two advantages. Firstly, the personnel could easily remove tools and equipment not needed for their work tasks during the day. They could for instance have a system where they sort their tool/equipment based on work tasks. A craftsman could for instance sort tools related to woodwork and metalwork in different parts/modules of the racking system. This would mean that they could minimize the payload of their EVs during each workday by removing unnecessary equipment. The second advantage with having removable racking systems/modules would be the fact that the work personnel could place their equipment at the work sites and park their EV at the nearest parking lot with a charging system. This would mean that the personnel would not be as dependent on their vehicle during their work tasks.

Figure 4.23: Modul-System's Multi box (Modul-System, n.d.)

Additional physical products that could be included in Modul-System's product range would be heat insulation. This would minimize the drivers use of their EVs cabin heating, minimizing the usage of the main battery. For Modul-System this would be a natural development for their segment Modul-Floor which includes flooring and lining. Other products that would decrease the usage of the EVs main battery (resulting in increased range) could be additional battery packs, solar cells or generators for powering tools and other equipment necessary for the work tasks. An additional feature that would facilitate charging in rural areas could be energy sharing between two to EVs, meaning that one vehicle could get energy from the other vehicle's battery.

4.4.5 Concept screening for "Optimise use"

Feasibility study

Here the different sub-solutions within the two concepts that have uncertain feasibility are discussed and analyzed. The requirements in with the requirement specification (Table 3.3) is used as a basis for the judgement.

Vehicle insulation
A theoretical investigation by Wirth, Eimler, and Niebling (2014) shows that heat insulation in EVs (in that case a Smart Fortwo) can minimize the need for cabin heating during winter temperatures (-7°C) by 20% in speeds of 50km/h. This would result in an increased range of 12km. The most feasible insulation concept was found to be polyurethane (PU) foams with thicknesses from 5 to 10mm for the the interior (roof, floor, firewall etc) and a low e-coating material for the doors. Insulation is therefore considered to fulfill the following requirements:

- Req 3.6 - Aid low wear impact and energy usage in vehicle, and
- Req 3.5 - Low weight solution - due to insulation materials generally low density.

Due to these reasons insulation will be further be a part of the "Hardware based" concept.

Timed heating system
A timed heating system could be difficult to implement in some vehicles which may limited access to their software, making it difficult control their heating system by an external product. This is something that has to be further explored. If an external heating system (such as a regular cabin heater) was to be installed however, a timed heating system would be possible to install. Therefore this sub-solution is considered viable and will continue to be a part of the "Software based" system.

Solar cells
Solar panels will be mounted horizontally on the car, resulting in that the autumn, winter and spring seasons will have very low efficiency. The angle of the sun in relation to the solar panels will be high in these months, greatly reducing its efficiency. (Professor in solar energy and sustainable energy at Högskolan Dalarna, Personnal communication, March 2020) Angling the solar panels on the cars, increases drag, which is not desirable. Furthermore, if the car is parked indoors or in the shade it will not be charging from solar power. These factors in combination of the added weight, complexity and cost makes it a non-viable option for this use case. (Professor in solar energy and sustainable energy at Högskolan Dalarna, Personnal communication, March 2020). To conclude, the following requirements may not be fulfilled with the implementation of solar cells:

- Req 3.6 - Aid low wear impact and energy usage in vehice - This requirement would only be fulfilled marginally within Sweden and Norway.
- Req 1.17 - Low drag solution - Not fulfilled if the solar panels would be angled towards the sun in Sweden and Norway.

Due to these reasons of solar cells on cars in Sweden and Norway was considered not to be viable in the "Hardware based" concept.

Range prediction system
A range prediction system (based on external conditions, weight and driving behaviour) would help drivers be more aware of what distances they can expect to drive with their current payload. It would also help fleet managers to plan allocate work tasks for different vehicles/drivers, hence it would fulfill the requirements:

- Req 3.6 - Aid low wear impact and energy usage in vehicle
- 3.7 - Aid lower wear impact and energy usage in vehicles in fleet

However, a possible obstacle with the development of such a system is that it might be difficult to get access to different vehicle's internal software and range prediction system. This is something that has to be further explored by Modul-System to see if it would be possible. A completely external system (non-dependent on the vehicle's software) based on driving history could be a possible alternative, but it would require a lot of testing for each vehicle model used by customers, meaning that the requirements:

- Req 4.2 - Short implementation time, and
- Req 4.6/7 - Cost efficient solution,

could be hard to fulfill. Since there are large possible benefits for customers, a range prediction system is considered viable for a continued development in the "Software based" concept.

Energy sharing
Energy sharing between vehicles are not commercially used and seem to be a novel technology. There are technologies that let vehicles share their energy to charging networks but not directly between each other. For Modul-System a development of such a system would most likely require a lot of resources which would be costly and time consuming. Requirements such as:

- Req 4.2 - Short implementation time, and
- Req 4.6/7 - Cost efficient solution,

could be hard to fulfill. Therefore, energy sharing is not considered feasible for further development in the "Software based" concept.

Further screening and combination of the concepts

From now on the two sub solutions "solar panels" and "energy sharing" have been eliminated from the "Hardware based" concept, otherwise the concept remains unchanged. In order to compare the and possibly further eliminate sub solutions in the two concepts ("Software based" and "Hardware based") an activity scheme was made, see Table 4.8. Here the two concepts were compared to each other. The activity scheme compares the desirable, non-desirable activities, drawbacks and benefits of choosing one concept over the other. Here the "Hardware based" concept was chosen as the reference and the "software based" concept as the one to be implemented instead.

Being unable to: - Use most tools at worksite without having vehicle nearby - Remove equipment from vehicle quickly by using removelable racking systems or system modules - Have more availible energy in vehicle for usage of power tools etc	**Being able to:** - Find charging station that is nearest to work site - Bring the only tools needed for the job by using material management system - Heat vehicle only when needed - Recieve system upgrades with ease - Get a good overview of their vehicles, for instance range prediction and current payload (drivers) - Get a good overview of fleets and reports of single vehicles/drivers (fleet managers)	DESIRABLE ACTIVITY
Having to: - Use more energy to heat vehicle because of non insulated vehicle - Pay for installation of electronics, senors etc	**Not having to:** - Pay for cabin insulation installations - Have additional equipment in/on the car resulting in higher payload: battery packs, generators and solar panels - Swap out current racking system with new removeable racking systems (Current customers)	NON-DESIRABLE ACTIVITY
DRAWBACKS	**BENEFITS**	

Table 4.8: Activity scheme that is making a comparison if the software concept would be implemented instead of the hardware concept

As seen in the activity scheme there are some aspects which would mean trade-offs for the customer/user and some aspects from the two sub-concepts that could complement each other. The main trade-offs derived from the activity scheme are:

- **More available energy vs increased payload:** Having more available energy in the vehicle (battery packs and generators) which would result in a higher vehicle payload and limited cargo space.
  - *External battery pack*: Using an external battery can increase the range by using it to power the tools and their batteries. It can also be connected to the power train to give some additional range. The issue with this solution is that it adds additional weight to the car, reducing the amount of tools and material that the user can carry. Therefore the customer has to weigh the pros and cons of utilising such a solution to increase range. It is considered a viable solution to use and will be kept in the continued development.
  - *Diesel generator*: The utilisation of a generator in traditional IC vans is common and well implemented. Diesel has a high energy density and the generator can be used for air compressors, charging etc. When integrating this into an EV-van there are some drawbacks. Utilising diesel to increase the range of an electric vehicle is from an environmental standpoint not optimal. This solution is one that will work and can provide charging of the battery and other components if needed for long remote trip were charging from a grid is not possible.

The customers will have to weigh the benefits of having a lighter, less environmentally friendly fossil fuel solution to a heavier but more environmentally friendly external battery pack. It is not an optimal solution for a company that wants to have a green branding but is still considered a viable enough solution to be kept for the next development stage.

- **Less cabin heating vs (potentially costly) cabin insulation installations:** Cabin installation would mean that Modul-System installs insulation in the customer vehicles as a service. This could be a fairly time consuming and costly operation for the customer but on the other hand it could increase vehicle efficiency and lower operation costs in the long run, as stated in the feasbility study (Chapter 4.4.5).

Apart from these trade-offs some sub-solutions from the two concepts could complement each other by combining them are:

- **(1) Removable racking systems, (2) material management system and (3) weight warning system**: To maximize the the efficiency of the function "minimize weight" the three above stated sub solutions could be implemented in the concept. By having removable modules users could easily gather the material/equipment needed for their expected work and use the material management system as a guideline of what to bring. The weight warning system could then tell the user how much payload the vehicle have to ensure that it is within a reasonable range. From the interviews it is clear that not all operators know what to bring before each work task since it may include trial and error, but for now all three sub-solution will remain as options for the Optimise use concept.

- **(1) Finding charging station nearest to work site and (2) being able to use most tools at work site without having vehicle nearby (by having removable racking systems):** The ability to find charging stations easily near work sites and the possibility of bringing material/equipment from the vehicle, hence not being dependant on it as a storage, could be a viable alternative. As stated earlier Modul-System has already developed a toolbox or removable racking system that could be used for this matter, see Figure 4.23. Therefore it seems viable to include these two sub-solutions for further development.

- **(1) Heat vehicle only when needed with timed heating system and (2) using less energy for heating with thermal insulation:** A vehicle manager for a large Swedish energy company (interviewee [8] in Chapter 3.4.2) gave some important insights to the importance of vehicle heating. He stated that some of their operators who work in Northern Sweden let their IC vans idle for long time periods in order for them to heat up their vehicles, even when they are out doing work. This makes a timed heating system interesting for further development, especially if those IC vans would have been replaced with EVs. In that way less energy would be used for cabin heating increasing vehicle range. The same goes for vehicle insulation as stated earlier.

Chosen concept

Based on the analysis in Chapter 4.4.5 the chosen concept for this iteration will be a combination of the two concepts "Software based" and "Hardware based", taking the

main advantages from each. Table 4.9 shows the chosen and eliminated sub solutions of the concept. From now on this new concept will remain under the name Optimise use.

	Sub-solution	Status
Parts of optimize use	Weight sensors & weight warning system	Remains
	Equipment management system	Remains
	Removeble racking systems	Remains
	Vehicle insulation	Remains
	Timed heating system	Remains
	Range prediction system	Remains
	Fleet management system (work allocation & driver monotoring)	Remains
	Warning system (closest charge point)	Remains
	Energy sharing	Eliminated
	Solar cells	Eliminated

Table 4.9: The chosen and eliminated sub solutions of the Optimise use concept

4.4.6 Fulfilled requirements for "Optimise use" in iteration 2(b)

With the chosen concept in this iteration for Optimise use the following requirements are considered fulfilled:

- Req 1.2 - Enable use of electrical equipment such as power tools in vehicle
  Portable batteries or generators will make it possible to use electrical equipment in the vehicles.

- Req 2.4 - Provide fleet management system
  The Optimise use concept will include a fleet management system were work can be allocated based on various aspects and drivers can be monitored.

- Req 3.5 - Low weight solution
  Based on the "Feasability study" in the top of Chapter 4.4.5 the weight aspect was discussed. The additional weight from additional hardware (insulation, portable battery/generator) will not increase the weight significantly. The racking systems used will be based on the existing solution and therefore have some of the lowest weight on the market.

- Req 3.6 - Aid low wear impact and energy usage in vehicle
  Solutions such as insulation, timed heating system, weight warning system and removable racking systems will decrease energy usage and wear on the vehicles.

- Req 3.7 - Aid low wear impact and energy usage in vehicles in fleet
  A more efficient fleet management system will enable better planning, work allocation and driver monitoring. This together with a range prediction system will ensure that the vehicles does not have to drive longer distances or be loaded with more equipment then they have to. Those aspects will minimize the energy usage and wear of the whole vehicle fleet.

4.5 Iteration 3(b): Further development of "Optimise use"

Iteration 2(b) resulted in a concept hardware- and software based concept. This iteration will continue on this path, analysing which functions to focus on, leaving some for future development in a different project.

4.5.1 Regarded requirements for "Optimise use"

The requirements that will be regraded in this iteration for Optimise use are on a more detailed level then previously. Previous requirements will however also be considered. Some of the regraded requirements are:

- Req 1-6 - Overview of fleet, position, battery, inventory etc
- Req 1.13 - Easy to locate tools/material
- Req 2.3 - Provide all material and equipment management needed to operate

All regarded requirements for this iteration can be seen in the right-most column in the requirement specification (Table 3.3) marked as "3b".

4.5.2 Functional analysis and delimitation for "Optimise use"

The concept "Optimise use is now in a stage where several sub-solutions have been chosen. These solutions were broken down into one or several functions that needed to be solved, which will be the basis for the further development of Optimise use in iteration 3 (see Figures 4.24 and 4.25).

Due to the limited time constrains of this project a decision was made to leave some of these sub solutions at their current detail level and continue to develop the rest. It should be stated however that the sub-solutions that will now be kept at their current detail level are still important aspects of the whole concept and will be left for Modul-System (or possibly other master's theses) to explore further. Figures 4.24 and 4.25 show the current state of Optimise use and the stop signs indicate which sub-solutions/functions that will be stopped developed in this project.

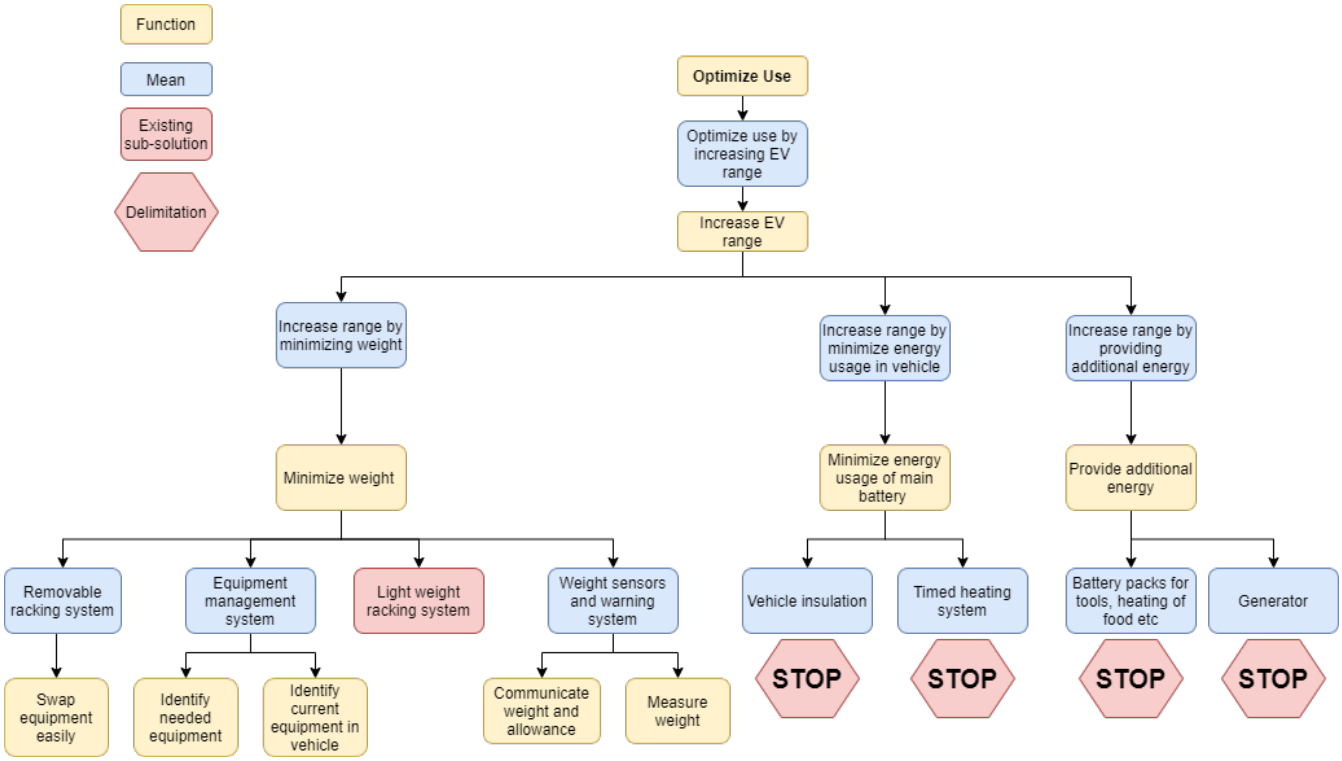

Figure 4.24: Function mean diagram for the Optimise use concept (part 1)

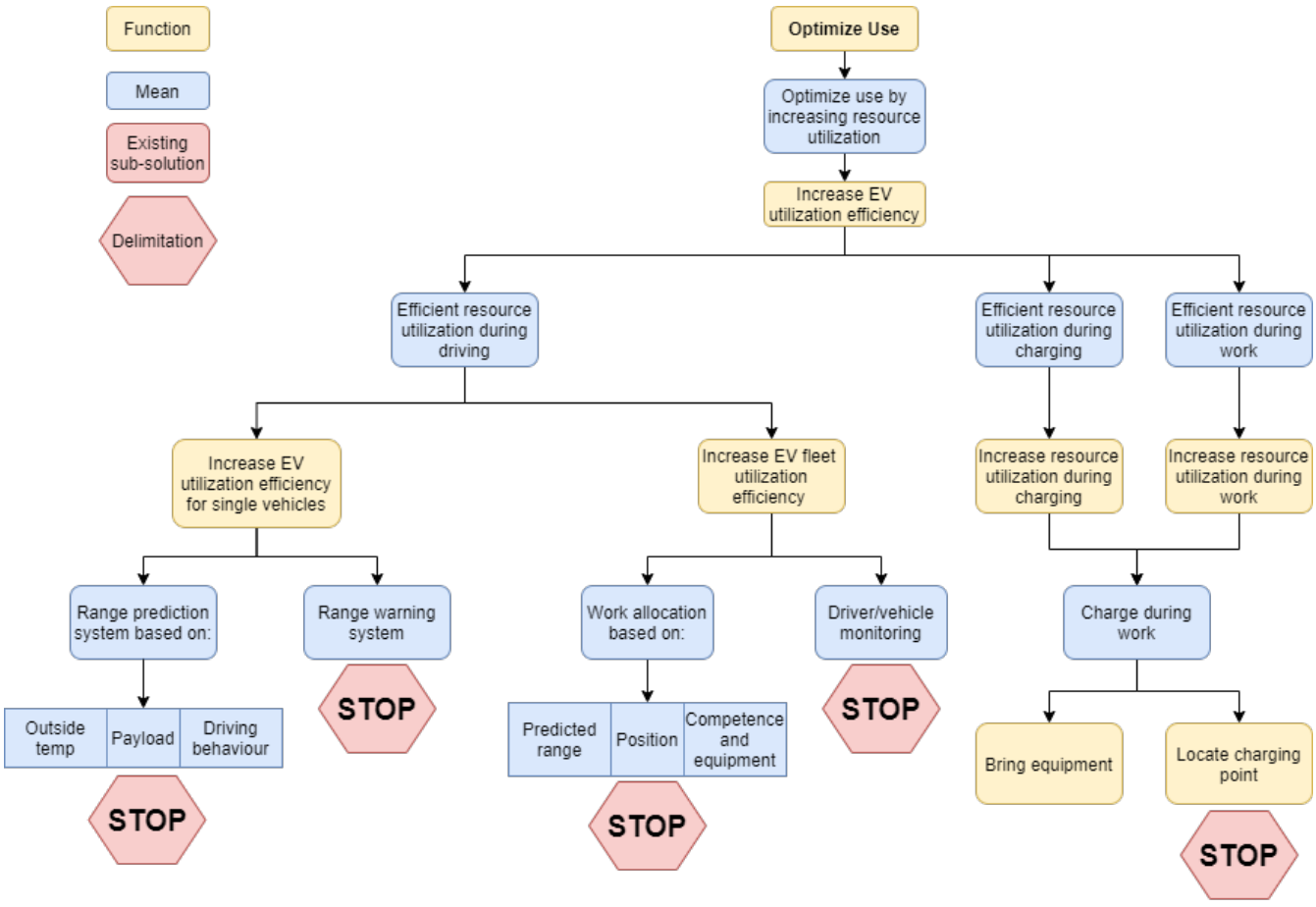

Figure 4.25: Function mean diagram for the Optimise use concept (part 2)

As seen in the two function means diagrams (figures 4.24 and 4.25) the focus from now on will be to continue to develop solutions for the functions:

- Identify equipment needed for work tasks
- Identify current equipment in vehicle
- Swap equipment in vehicle easily (to make it easy to bring only what is needed)
- Measure weight (payload)
- Communicate weight (payload) and allowance
- Bring equipment (from vehicle to work site)

The aim of this iteration is to further develop these functions.

4.5.3 Idea generation for "Optimise use"

Table 4.10 shows the morphological matrix based on the functions stated previously. The red cells are existing sub-solutions that is existing in Modul-System's products/services and used by their customers.

Simple and modular	Integrated and mobile	Minimise change

Sub functions	Sub solutions				
Charge during work					
Bring equipment	"Multi box" and trolley	Drop of at site	Racking modules with wheels		
Equipment management and Removable racking					
Identify needed equipment	Based on operator experience	Work orders with list of spec material for operatiors			
Identify current equipment in vehicle	Operator knowledge, no updated documentation	Manual typing in app	Check-list in app	Automatic sensing of mounted module (I.E RFID or similar sensors)	Include approximated weight for verification
Swap equipment easily	Single trays (such as the "multi box") in racking frame	Rack modules that can be swapped, with different eq. packages	Boxes/racking system on wheels		
Weight sensing and warning system					
Measure Weight	Sensors on wheel axles				
Communicate prediction	Through mobile application (notification)	Through display in vehicle	Fleet managers get informed	How many kgs to max and how many to complete needed distance	

Table 4.10: Morphological matrix for Optimise use (Iteration 3)

Based on the morphological matrix (4.10) three concepts were generated. These concepts are aimed to be integrated together with the software of the concept (i.e. the fleet management system). The generated concepts are C1: Simple and modular, C2: Integrated and mobile and C3: Minimize change. Now the concept will be described in more detail.

4.5.4 Generated sub-concepts for "Optimise use"

C1: Simple and modular

This concept aims at solving the different sub-functions by integrating already available options with new, simple hardware and software based solutions. To tie in the hardware and software part the weight management and material management system will complement each other, by giving feedback on the current payload and warn if it is exceeding the recommended or max payload. If it is over the specified range the user can easily remove some equipment modules that are not that frequently used and removed. A built in module sensing unit will then detect which one of the modules have been removed and update the inventory system.

The information of the current payload and its limitations will be communicated both to the user and fleet manager. The user can then adapt their payload to fit the planned routes and the fleet manager can also allocate new orders based on current payload (and equipment inventory). For the user to easily be able to swap out the less used equipment, a quick release rack module is proposed. The module(s) will be situated at the rear for easy installation and removal, with a mechanism for quickly dismantling it from the LVC. The goal is for it is to be a simple solution that is easy to manufacture and reliable, not integrating too many interdependent features.
To solve the "Bring equipment" function the use of the already existing trolley and its Multi box solution is proposed. Since what an operator usually needs to bring to a worksite are the most used tools, the Multi-boxes will be installed in the standard equipment module situated further back in the LCV. The boxes and trolley can then be deployed when necessary. This creates a system were the customer can choose what type of solution they want, without having to buy modules with unnecessary functions.

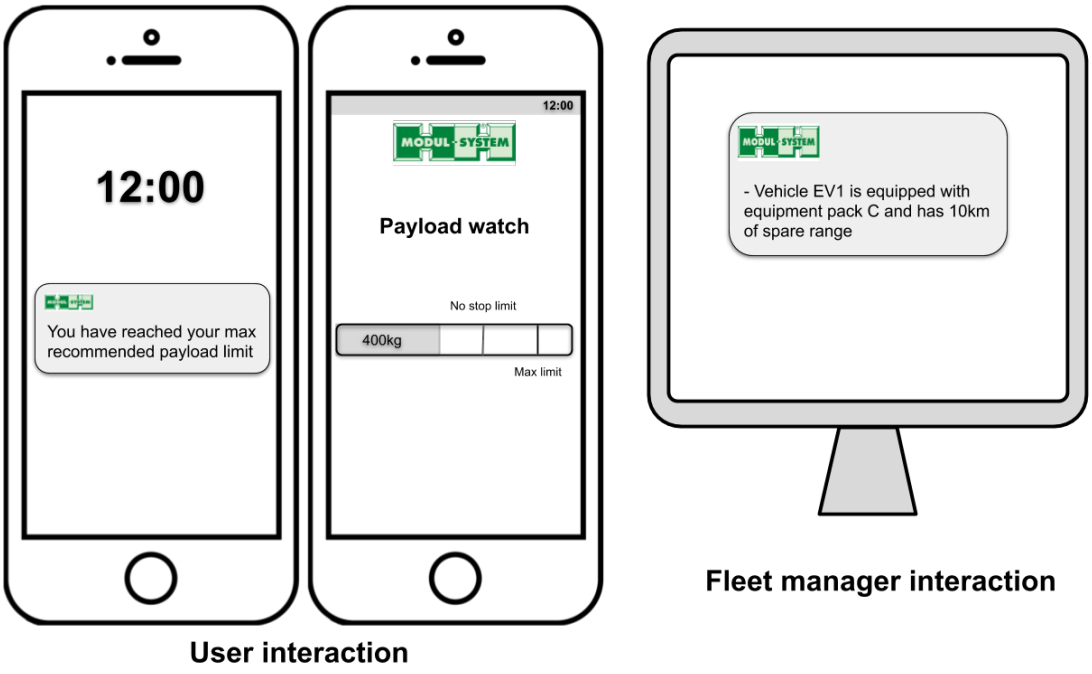

Figure 4.26: Illustration of concept 1 software: Simple and modular

C2: Integrated and mobile

This concept is based on having larger exchangeable modules (equipment kits) that can be swapped depending on what equipment the operator needs for their work. Sensors in the vehicle sense which modules each vehicle in the fleet have and a fleet manager can therefore easily allocate work tasks depending on available equipment. There will also be sensors that measure the vehicle's payload and warn the operator if it is overloaded. The exchangeable modules have integrated wheels making them mobile and eliminates the need for additional equipment such as trolleys. The mobility means that the modules can be easily dropped off at work sites. This would make it possible to charge the EVs at the closest charge point and still have the equipment easily accessible at the work site. It would also be possible to leave the equipment at the work sites for longer time periods, for instance during larger projects. This would minimize the payload and increase the EV range. Figure 4.27 shows the main idea of this concept.

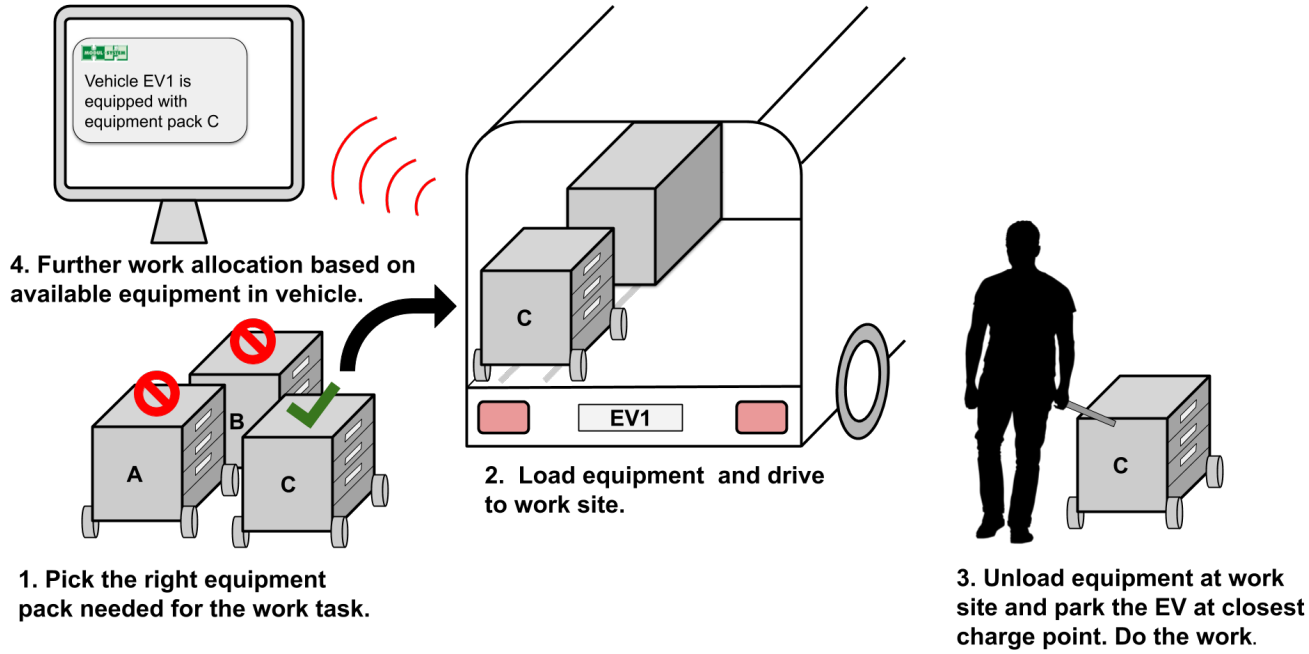

Figure 4.27: Illustration of concept 2: Integrated and mobile

C3: Minimize change

Minimise change is a concept were the goal is to fulfill the functions with as little change to the current solution as possible. This means that the concept will have little to no change at all to the current offering, then mainly focusing on packaging existing solutions to one concept. The existing hardware will be used and fleet managers will be informed regarding the vehicle's weight and estimated range.

4.5.5 Concept screening for "Optimise use"

To compare the concepts against each other Pugh matrices were used, see Table 4.11. The concepts were compared in relation to how well they fulfill the wishes specified in Chapter 4.5.1. Two runs of the matrix analysis was conducted using "Minimise change" and "Simple and modular" as references.

		REFERENCE		
Nr	Wish	Minimise change	Simple and modular	Integrated and mobile
1.6	Overview of fleet, position, battery, inventory etc.	-	1	1
1.13	Easy to locate tools/material	-	1	1
2.3	Provide all material and equipment management needed to operate	-	1	1
3.5	Low weight solution	-	1	1
3.6	Aid low wear impact and energy usage in vehicle	-	1	1
3.7	Aid lower wear impact and energy usage in vehicles in fleet	-	0	0
	Sum positive	-	5	5
	Sum negative	-	0	0
	Overall sum	**-**	**5**	**5**

			REFERENCE	
Nr	Wish	Minimise change	Simple and modular	Integrated and mobile
1.6	Overview of fleet, position, battery, inventory etc.	-1	-	0
1.13	Easy to locate tools/material	-1	-	0
2.3	Provide all material and equipment management needed to operate	-1	-	1
3.5	Low weight solution	-1	-	0
3.6	Aid low wear impact and energy usage in vehicle	-1	-	0
3.7	Aid lower wear impact and energy usage in vehicles in fleet	0	-	0
	Sum positive	0	-	1
	Sum negative	-5	-	0
	Overall sum	**-5**	**-**	**1**

Table 4.11: (Pugh matrices comparing the concepts against each other with respect to wishes)

The results were that "minimise change " was worse than the other concepts in five out of six wishes, resulting in that the concept will be eliminated. Comparing "Simple and modular" and "Integrated and mobile", the differences were small. "Integrated and mobile" was deemed better in one category: Provide all material and equipment management needed to operate. This was due to the fact that it has a more integrated solution for transporting material outside of the car. Although "Integrated and mobile" got one more point, it was not deemed conclusive enough to eliminate "Simple and modular". More detailed and nuanced comparison and analysis is needed to clearly choose which trade-offs of the two concepts are the most valuable. The most differing parts are how integrated the solutions to the different functions should be. If highly integrated the solution becomes compact and versatile, but with increased complexity and cost.

4.5.6 Fulfilled requirements for "Optimise use" in iteration 3(b)

As stated in "Iteration (2b)" (Chapter 4.4) some of the requirements such as Req 3.5, 3.6 and 3.7 was already considered fulfilled at that stage. In this iteration these same requirements has once again been taken into consideration to ensure that the chosen concept fulfills them even better. Apart from these already fulfilled requirements the following requirements are now considered fulfilled:

- Req 1.6 - Overview of fleet, position, battery, inventory etc
  The Optimise use concept will include a fleet management system which will include an overview of the above mentioned aspects.

- Req 1.13 - Easy to locate tools/materials
  The material management system will make it easy for the customer company to locate which vehicles that are equipped with respective equipment. The driver will also be informed which equipment to bring for each work task.

- Req 2.3 - Provide all material and equipment needed to operate
  Again, the material management system will tell which equipment to bring depending on work task.

Additionally, based on the weight of the reference racking system used presented in Chapter 4.3.5 the following requirement is considered fulfilled for average sized electric transport vehicles:

- Req 1.1 - Vehicle payload capacity after racking installment (larger than 500 kg)
  Assuming the removable racking systems has a similar weight of the reference system this requirement will be fulfilled for average sized electrical vans. The reference racking system's weight is 131.5 kg (average weight of high end and low end racking system) and a Volkswagen e-Transporter (average sized van) with a payload capacity of 695kg or 1186kg (depending on version) (VW-transportbilar, n.d.) will fulfill this requirement.

Furthermore the following requirements are considered fulfilled with the Optimise use concept:

- Req 2.9 - Continually update software
  The software solutions in Optimise use, such as the fleet management system, could easily be upgraded continually by Modul-System when new needs arise.

- Req 2.10 - Payment as monthly fee
  The hardware related solutions in Optimise use is supposed to be payed directly by the customer. This is to minimize the bound capital of Modul-System. The software related functions will however be payed on a monthly basis. This allows Modul-System to upgrade and add new functions to the software, which allows them to offer differnt packages depending on their customer's need. This can be compared to mobile operators that have different packages depending on the customer needs, such as number of free calls and amount of mobile data.

4.5.7 End of development for concept "Optimise use"

Due to time constraints the development of the Optimise use concept will end here in this report. The following development sections will focus on the development of the Re-use concept. This is due to the fact that Modul-System are good at detailed design and analysis of product platforms, meaning that the further development of concept Re-use will be more valuable to the company. A summary of Optimise use and how it ties into the project and its future development potential can be read in the Chapter 6, Final design, and Chapter 8.2, Future recommendations. Furthermore, a compilation of which requirements that are fulfilled by the concept can be seen in Chapter 5.3.

4.6 Summary of Concept Generation

Three iterations were conducted to generate concepts in this chapter. The first loop generated five broad business concepts with the goal to explore as much of the solution space as possible. These concepts were placed on different places on the axle describing the amount of product- or service orientation. Two of the concepts were chosen for the second iteration, these were Re-use and Optimise use.

The second iteration were divided into two parts; 2a and 2b, one for each concept respectively. Iteration 2a developed a holistic overview of which functions that should be included in Re-use. Examples of functions were "disassembly", "refurbishment" etc. A sourcing analysis was also conducted to determine which of the functions that could be outsourced. Here, it was concluded that all functions were outsource candidates but that further exploration would be needed for a final decision. During iteration 2b Optimise use was further developed. Here two sub concepts were generated, one which was software based and one that was hardware based. A feasibility study was conducted to see which of the sub solutions in the sub concepts that were feasible. The concept that came out of this iteration included a mix of integrated hardware- and software solutions.

In the third iteration Re-use and Optimise use were further developed separately (iteration 3a and 3b respectively). In iteration 3a the focus was to explore how the refurbishment process in Re-use could be developed. Here five sub concepts with different degrees of dismantlement-, maintenance. and refurbishment processes were generated. As a basis for the concept screening a physical test was carried out were three second hand systems were sent to a reconditioning firm to see the effect of different reconditioning processes. Additionally a cost analysis was conducted to estimate the costs for the five sub concepts. After the screening the chosen path for Re-use were to focus on a refurbishing methods that gave both functionality and aesthetics to the reused racking systems. Lastly, iteration 3b focused on some of the sub solutions for the Optimise use concept, namely a material management system, removable racking systems/modules and a weight sensing system. After this iteration it was decided that the continual development in this project will focus on the Re-use concept. This was based on time limitations and the fact that Modul-System have good capabilities to furhter develop the more technical Optimise use concept.

Chapter 5

Detailed Design

The concept generation, has in a systematic and iterative manor narrowed down and ended up with two concepts; Re-use and Optimise use. Due to time constraints Iteration 3 marked the end of development for Optimise use, leaving the concept Re-use to be further developed in this chapter, detailed design. The main focus will be on coming up with a solution for sales and detailing how the refurbishment factory will be laid out.

5.1 Refurbishment Process and Factory Layout

Figure 6.3 shows a flow chart of the refurbishment process. Here, the different steps of the process is shown and also were they or by whom they are conducted. All steps except the reconditioning is conducted in-house, with the exception of partners (retailers and leasing companies) that conduct the first steps "Remove system from car" and "Package and ship". The choice to outsource the reconditioning step is based on the outsourcing section in the literature study (Chapter 3.1.3). Reconditioning is not used within Modul-System, hence "not propriatary" as well as "Common across industries". This makes it a strong candidate to outsource according to the literature. Keeping the other processes, such as assembly and disassembly in house is because Modul-System have well functioning processes in these areas.

The process in 6.3 goes the following way. Firstly, customers return their used racking systems to Modul-System's service centers or partners where the systems get removed from the vehicles. The next step is to do a rough disassembly and package the systems and send them to the Mullsjö factory. At the factory the systems goes through a primary quality control were faulty components get removed. This can include movable parts such as drawers, drawer fronts and ball bearing/sliding rails. The faulty components get recycled while the rest of the system is dismantled into standard modules. These are then sent to the nearby reconditioning firm in Mullsjö (presented in Chapter 4.3.4) for cleaning, degreasing, polishing and application of paint on larger defects. Once the reconditioning is done the systems are sent back to the factory. Here, the systems go through a second quality control and new or reused components in good condition are added to the systems if needed. Which would be the case if drawers have been removed during QC1. The systems are then stored in the factory as standard modules. When an order arrives from the Modul-System's sales function the systems are assembled as much as possible into standard kits without compromising transportation efficiency/required space in lorries. The final assembly takes place in Modul-System's service centers or by the customers

themselves depending on their need.

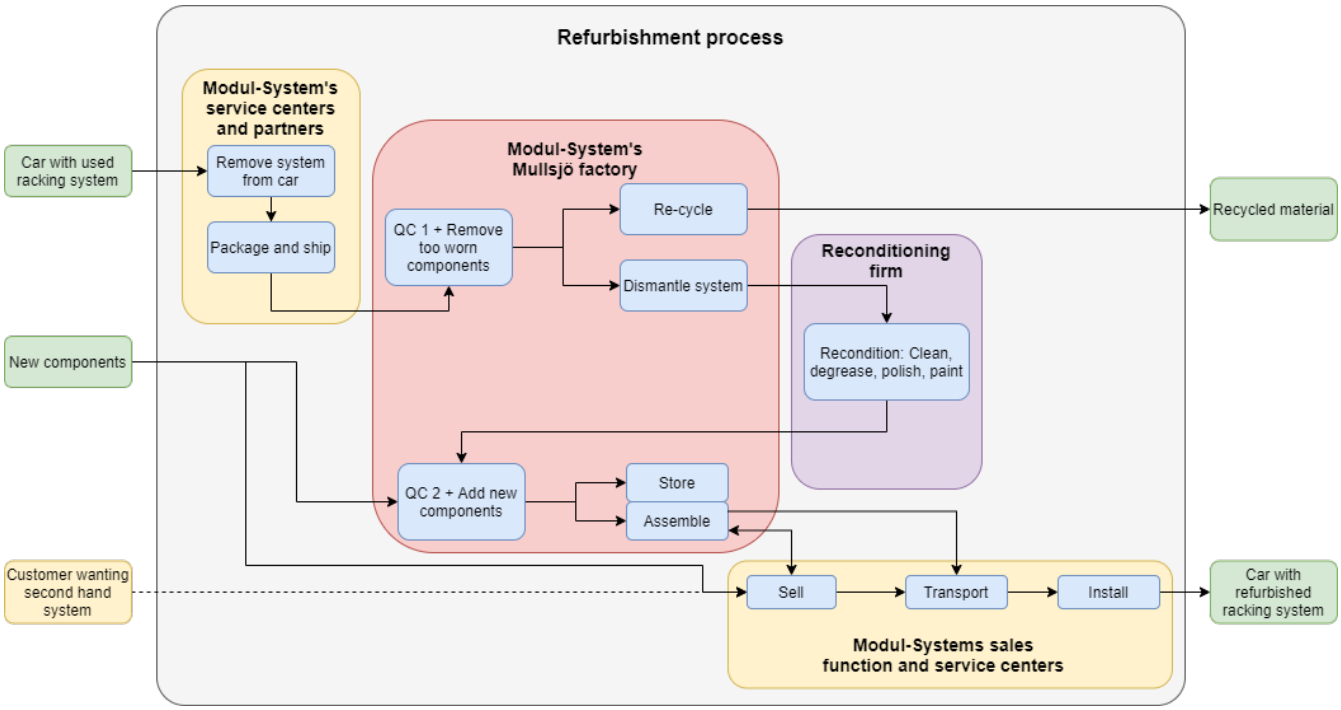

Figure 5.1: Flow chart of refurbishment process

5.1.1 Required factory space

According to a Sales manager at Modul-System about 1500 systems are sold each year in Sweden by Modul-System alone (excluding sales from partners). An optimistic but reasonable estimation of the number of potential returned systems would be around 500 per year (Sales Manager, personal communication, April 2020). This will be further elaborated on in Chapter 5.2.1 below. With an estimated stock turnover of 5 per year, the factory in Mullsjö must be able to handle/store 100 reused systems at any given point. Based on that the systems previously described steps in the factory the estimated factory space would be 40 square meters. 25 square meters would be needed for assembly/disassembly, quality control and hardware exchange. The remaining 15 square meters would be needed for storage in five shelving levels (Production manager and production technician at the Mullsjö factory, personal communication, April 2020)

5.2 Sale Strategies for the Reuse Concept

This section will describe possible sale strategies for reused system's for Modul-System. It will include strategies for both (1) acquiring used systems from first hand customers and (2) selling used systems to new customers.

5.2.1 Strategies for acquiring and transporting used systems

A strategy for Modul-System to both acquire used systems and sell more new systems could be to provide customers with a bonus. This bonus would give them a discount once they purchase a new system. In a discussion with Modul-System a reasonable discount

would be somewhere between 5% and 20%, but this is something that has to be further evaluated, see Chapter 8.2. In addition to this, Modul-System could also propose system dismantlement as a service, already included in the system purchasing deals. This could be relevant especially for larger customers or leasing companies, that have predetermined times for vehicle replacements and endings for leasing contracts. Currently, Modul-System states that they do not know what happens with their customer's old systems, but they suspect that their customers do not see the value in them. Therefore, the cost for acquiring old systems should not be especially high.

Modul-System could have collection points were a certain number of systems are collected before they are sent to the Mullsjö for the refurbishment process. This would minimize the transportation costs since a large amount of systems are transported each time. The exact acquiring- and transportation approach and their associated costs will however need to be further evaluated, see the future recommendations in Chapter 8.2.

5.2.2 Strategies for selling refurbished systems

Table 5.1 shows a morphological matrix of possible sales strategies that has been discussed internally with Modul-System.

Online store	Outsource	Business as usual	
Sub functions	**Sub solutions**		
Sell system	Same as existing (Internal and with partners)	New partner, specialising in low price segment	Online sales through Modul-System
Install system	Existing network (Internal + partners)	New partners who only do second hand	

Table 5.1: Morphological matrix for sales and installation solutions

Three different approaches were identified. The first one was to sell refurbished systems through an online store and offer installation as a service. This would be in line with the approaches of some competitors, especially Work System and Sortimo (with the exception of new systems instead of refurbished ones). The advantages with this approach would be high accessibility and visibility for customers, meaning that they would not need to contact Modul-System for consultation. With this approach Modul-System could lower their sales costs since they would not need to have close interactions with their customers during sales. This however could also be a disadvantage; the possibility to have close customer relationships. On the other hand these customers might return to Modul-System for future upgrades, hence strengthening the relationship between the two parties.

The second identified approach is to outsource the whole sales function for refurbished systems to already existing partners. These partners would also be able to provide installation. For Modul-System the advantage would be minimize their sales costs for refurbished system by only taking orders from their already existing partner network. The negative

aspect with this approach is the fact that the customers might return to the partners for future dealings, instead of directly to Modul-System. Another disadvantage would be that the partners might find it difficult to reach out to customers that normally buy new systems.

The third identified approach would be to sell the refurbished systems to a specialist within the second hand sales. The advantage with this approach would be that these partners could reach out to customers willing to buy second hand systems. Similar to the previous approach customers might chose to buy additional products at that partner rather than at Modul-System.

Chosen sales approach: Online ordering system of racking system kits

Based on the discussion in Chapter 5.2.2 the choice of sales approach was the online ordering system. This was mainly because of the simplicity and accessibility for customers, low sales costs and the possibility to incorporate new customers to Modul-System's eco system. It also helps distinguish the two different offerings (new and refurbished) in the beginning, with the new system offering a higher amount of personal, exclusive service. This is in line with what the low price competitors do, as described in Pre-study Chapter 3.2.4. Further developing the online sales tool will in a long term perspective aid Modul-System to increase their online sales for their whole product line-up.

In order to compete within the low end racking system market a similar online ordering system was chosen. Here standardised reused racking systems will be offered. Modul-System already have some standard kits adapted for specific vehicles and customer trades. These kits could be used as a basis in the online shop. To make the ordering more transparent toward the customers price and weight can be shown throughout the whole ordering process. These are functions that exist in both Sortimo's and Work System's ordering tools, see Appendix A.1.2. Additionally the potential cost saving could be shown compared to an identical but new system. The following steps will be included during an online order:

1. Chose vehicle brand
2. Chose vehicle model, year and configuration
3. Chose trade (this could include carpenter, painter, electrician etc, similar to Sortimo's online tool)
4. Receive a suggestion of a finished kit and the possibility to modify it, add accessories and installation as a service.

Figure 5.2 shows an illustration of how the ordering system could look like with the above mentioned steps.

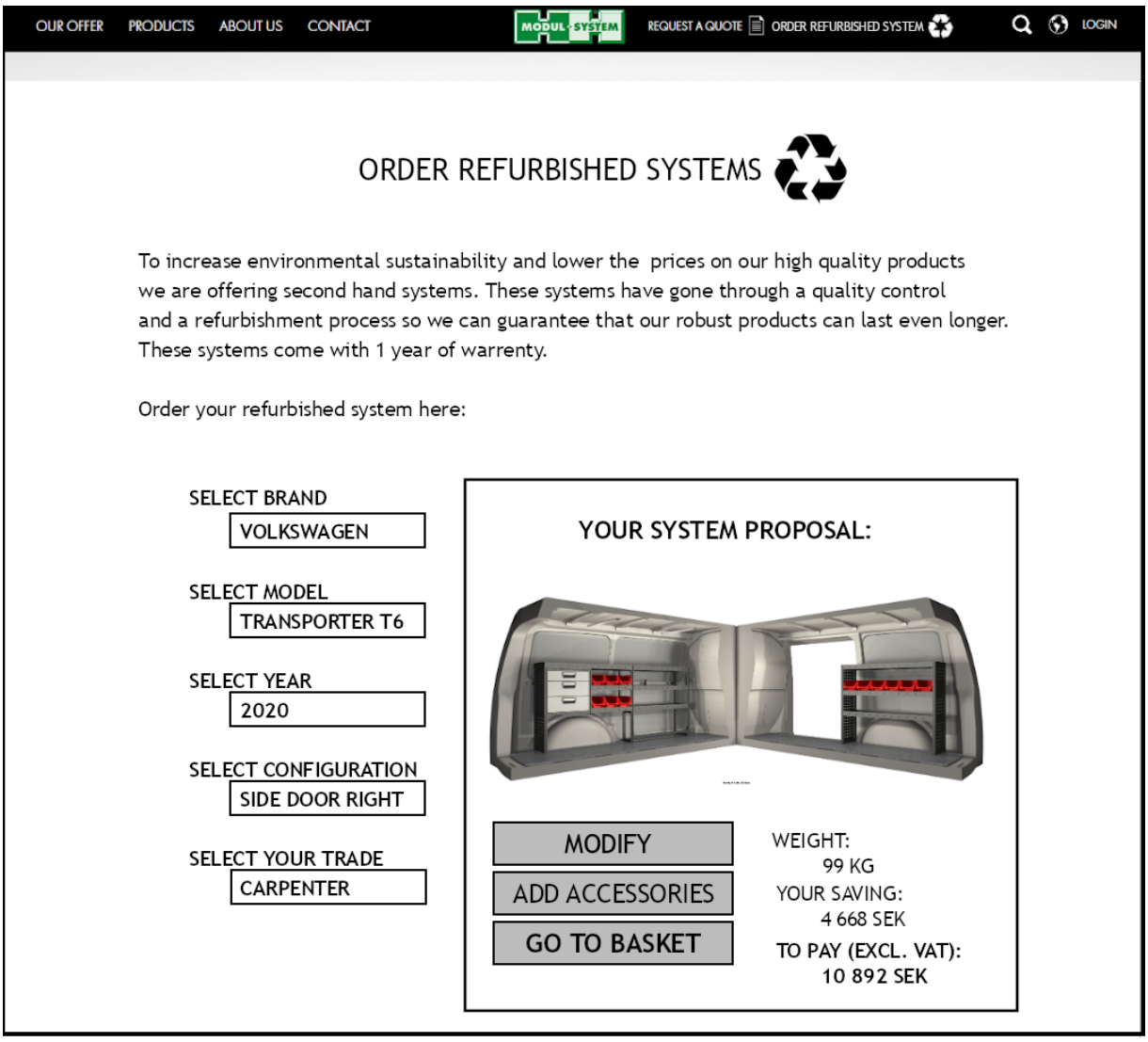

Figure 5.2: A webpage mockup that illustrates the online ordering system

With a sales system in place it will make it easier for the customer to order the system. The price to aim for would be 10-20% lower than what the competitors offers for their low end systems (Vice president of Modul-System, April 2020). Although for the customer to want to buy the system full functionality of it needs to be ensured. Therefore the sold systems will have a one year guarantee, that covers the functionality of the system (Vice president of Modul-System, April 2020). If anything brakes (excluding user error) during that time period, they will swap it for free. Furthermore, Modul-System can ensure the customer that they will support that product line for x amount of years, making them confident they can replace the faulty components with original parts. This could be accommodated for since Modul-System don't see any signs of the platform needing to be largely upgraded yet.

5.3 Final Requirements Validation

Throughout Chapter 4, a conformity check, per iteration, between the requirement specification and the concepts was conducted. In addition this current chapter has emphasized some additional aspects which means that the following requirement is considered fulfilled:

- Req 2.2 - Easy to order solution
  The ordering system described Chapter 5.2.2 will simplify the ordering process for the customers. Here they will get an instant racking system suggestion with a corresponding price. This will make the process faster and simpler compared to booking consultancy with Modul-System's sales staff.

5.3.1 Compilation of all requirements and their fulfillment

Here all the requirements that have been regarded throughout Chapter 4 and 5 will be compiled to see which of the two concepts Reuse and Optimise use that fulfill a certain requirement. Table 5.2 shows a compilation of all requirements and indicates which requirements that are fulfilled by either Optimise use, Reuse or by both of the concepts. A green marking means that the requirement is fulfilled, and a yellow marking means that the requirement is not considered fulfilled/needs to be further investigated.

As seen in Table 5.2 all requirements are considered fulfilled except two. These are:

- Req 1.16 - Inverters and electrical systems interface with main battery system
  This requirement is related to electrical vehicles, hence the Optimise use concept. Further investigations needs to be conducted to see if it is possible to interconnect inverters and electrical systems to an EVs main battery system. This could vary between different car manufacturers.

- Req 3.9 - Life span: 14 years
  For brand new systems this requirement is definitely fulfilled. Modul-System claims that some of their customers want to transfer systems that can be up to 20 years old. For the reuse concept which include second hand systems, a further investigation needs to be conducted to investigate if such a system generally can last another 14 years. Here Modul-System's maintenance proposal will be a key aspect. This is also touched upon in Chapter 7, Discussion.

	Requirements		Goal	Mainly regarded by Optimize use	Mainly regarded by Reuse	Regarded by both concepts
1.	**Product specific**					
	1.1	Vehicle payload capacity after racking installment	>500kg			
	1.2	Enable use of electrical equipment such as powertools in vehicle				
	1.3	Scalable solution	Fit all common EV-vans			
	1.4	Rugged solution	Withstand vibrations during driving on rough roads			
	1.5	Non destructive installation	No drilling or velding in vehicle during installation			
	1.6	Overview of fleet, position, battery, inventory etc.				
	1.7	Area efficient solution	Organize in volume rather than area			
	1.8	Large storage capacity				
	1.9	Allow space for different sized tools/equipment				
	1.10	Have dedicated space and fasteners for large equipment				
	1.11	Not increase vehicle drag				
	1.12	Easy accessible locking mechanisms for withdrawebles				
	1.13	Easy to locate tools/material				
	1.14	Driver should be safe from loaded material during a crash	Approved after crash test			
	1.15	Minimise change in vehicle dynamics	Approved after vehicle inspection			
	1.16	Inverters and electrical systems interface with main battery system				
	1.17	Low drag solution	Should not affect vehicle aerodynamincs			
	1.18	Functionality of refurbished product should be the same as the new version	>1 year			
2.	**Service specific**					
	2.1	Solution should be adapted for EV:s	Increase resource utilization efficiency of EV:s			
	2.2	Upgradable solution	Both hardware and software			
	2.2	Easy to order solution				
	2.3	Provide all material and equipment management needed to operate				
	2.4	Provide fleet management system	Service by M-S			
	2.5	Install solution	Service by M-S			
	2.6	Move solution between vehicles	Service by M-S			
	2.7	Maintain solution	Service by M-S			
	2.8	Dismantel solution after end of use	Service by M-S			
	2.9	Continually update software				
	2.10	Payment as monthly fee				
3.	**Environmental specific**					
	3.1	Environmental friendly solution	Should increase resource utilization			
	3.2	Re-sell complete products as second hand				
	3.3	Re-use components together with first hand solution				
	3.4	Re-cyclable materials				
	3.5	Low weight solution				
	3.6	Aid low wear impact and energy usage in vehicle				
	3.7	Aid lower wear impact and energy usage in vehicles in fleet				
	3.8	Life span	>7 years (one car lifecycle)			
	3.9	Life span	>14 years (two car lifecycles)			
4.	**Business and cost specific**					
	4.1	Profitable short- and long term				
	4.2	Short implemetation time				
	4.3	The solution should not require a large change for Modul-System	It should be based on current product platform			
	4.4	The solution should be accepted among customers in present time				
	4.5	Low bound capital	As low as possible			
	4.6	Cost efficient solution	Same value for money as current solution			
	4.7	Cost efficient solution	More value for money as current solution			
	4.8	Second hand system affordable for customer	20% cheaper than new system			
	4.9	Standard price (cost for M-S) lower for second hand system then for new system	30% lower in Sweden and 40% lower offshored than new system			
	4.10	Standard price (cost for M-S) as low as possible				

Table 5.2: Compilation showing which requirements that are fulfilled by the two concepts

5.4 Summary of Detailed Design

This chapter has further elaborated on functions for Re-use that were not focused on during Chapter 4 concept generation. There were two main parts, *Refurbishment process and factory layout* and *Sales strategies*.

Refurbishment process and factory layout - The factory layout was described with quality controls, disassembly and assembly being performed in house, with the refurbishment outsourced to a local Reconditioning firm. The factory space was concluded to require 40m2.

Sales strategies. The sales was decided to be through an online media, owned by ModulSystem. It would focus on selling standardised kits and have a comprehensive and intuitive way to customise them. This was concluded to reduce costs and would be similar to how the competitors in the low price market sells their products.

Finally, this last chapter in the development phase summarised and checked for conformity between the requirements and the concepts. It was concluded that all but two were fulfilled, with the two unfulfilled having to be further investigated.

Chapter 6

Final Design

With the development of the two concepts, Re-use and Optimise use, having been concluded for this report a gathered, concrete description of the two concepts is in order. This chapter will describe each concept as a whole and also elaborate on how they complement each other.

6.1 Concept 1 - Re-use

The concept is at its core inspired by circular economy, focusing on closing the the first, second and third resource loop (Maintenance, Re-use/re-distribute and Refurbish), as has been described in Chapter 3.1.2. This enables an increased lifespan for the product, which is the racking system, and an increase in resource utilisation. The concept has two parts: *1. Prolong the useful lifespan of the racking system for the first hand customer* and *2. Sell used racking system to a new customer base*. Below is a detailed description of how these two will be realised.

6.1.1 Part 1. Prolong the useful lifespan of the racking system for the first hand customer

The racking systems that Modul-System provide are considered internally to be very durable, hold for a long time and are easy to swap out faulty components such as drawers and boxes. Several recounts of how systems that are 10-20 years old come into the workshop to be swapped between vans have been made. The racking system outlives the life-cycle of the vehicles, which typically ranges between 5-7 years. Currently the common practice for Modul-Systems bigger customers is to purchase a new racking system for each time they switch cars, resulting in that the racking system is discarded without fully utilising its potential lifespan. Some special deals have been made were the racking systems are transferred between cars, but it is currently not common practice. To combat this the closing of the first and second resource loop is proposed. Upon making a purchasing deal, the transfer between the agreed upon amount of cars (typically 2-3cars) is included in the purchasing price, together with Modul-System guaranteeing that they will maintain the systems over this time-period. If something needs to be swapped then Modul-System will perform this maintenance and ensure that the items are stocked. Due to the longevity and modularity of the product platform and the fact that this is already done means that it just needs to be communicated more clearly to the customer. If the customer decides

to switch car model or wants to upgrade some parts, then due to the high component compatibility of the racking system this is easily achievable.

Figure 6.1 shows functions/processes needed to be in place to realise the first part of the concept. As Modul-System already has a network for selling and installing systems, the integration of this concept would not require a big change. The main parts would be to shift the installation of new racking systems into transferring them (dismantle and install). As fewer new systems would be sold and the dismantlement of a system, comparatively to installation, is short, the existing network should cope with this.

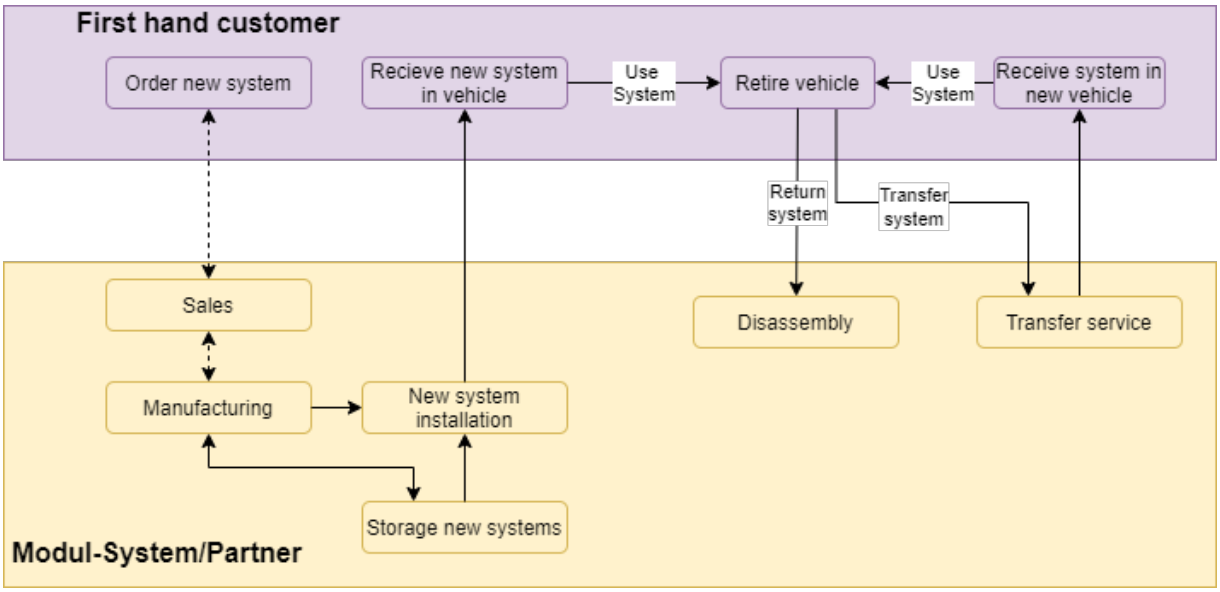

Figure 6.1: Flow chart of functions/processes for Part 1 of Re-use

It might seem that, from a business perspective, this will reduce the profitability for Modul-System, but this is not considered the case. The sales from one racking system will be lower due to it being re-used, but there are many other components that are not as easily re-used. Such as electronics, floor and lining. These costs account for between 30%-50% of the price. Furthermore, with Modul-System being in competition with other companies, the possibility for the customer to save money on the purchase will increase the competitiveness for Modul-System, enabling an increase in market share. Another factor to consider is that the customer will stay with Modul-System for several car life-cycles, further securing market share. It also gives the opportunity for Modul-System to sell other services, such as the second concept, Optimise use, described later on in this chapter.

One of the main costs is to sell the system to a customer, it is a process that takes up a lot of resources from the sales team. Both the time to specify the highly custom systems and to negotiate price. If the customer reuses the racking system and then orders an almost identical specification for the other parts of the van (floor, lining, electronics etc.), these costs will be reduced. To further incentivise the customer to invest in a new racking system, when they are done with the first one, Modul-System will offer the service of dismantling and taking care of the racking system. Also at the same time giving them a discount upon the purchase of a new system. The used racking systems will then be

refined and sold to a new customer base, which will be further elaborated on in the next section.

6.1.2 Part 2. Sell used racking system to a new customer base

This is the part were the third resource loop is closed, refurbish. The racking systems that have been gathered from the dismantlement service, described in part one, will be refurbished and then sold on the low price market. This is a market that Modul-System, with its high end systems, currently is not active. Thus, entering this market with refurbished systems would be a way for them to not have to manufacture new products, but re-use existing ones. One of the enabling factors is the long life-span of the racking systems and the long life-cycle of the highly modular product platform. Figure 6.2 shows the functions/processes required to realise this concept. Worth noting, is that the transfer of systems could also apply to the second hand customer as well, which is why it is also in this flow chart.

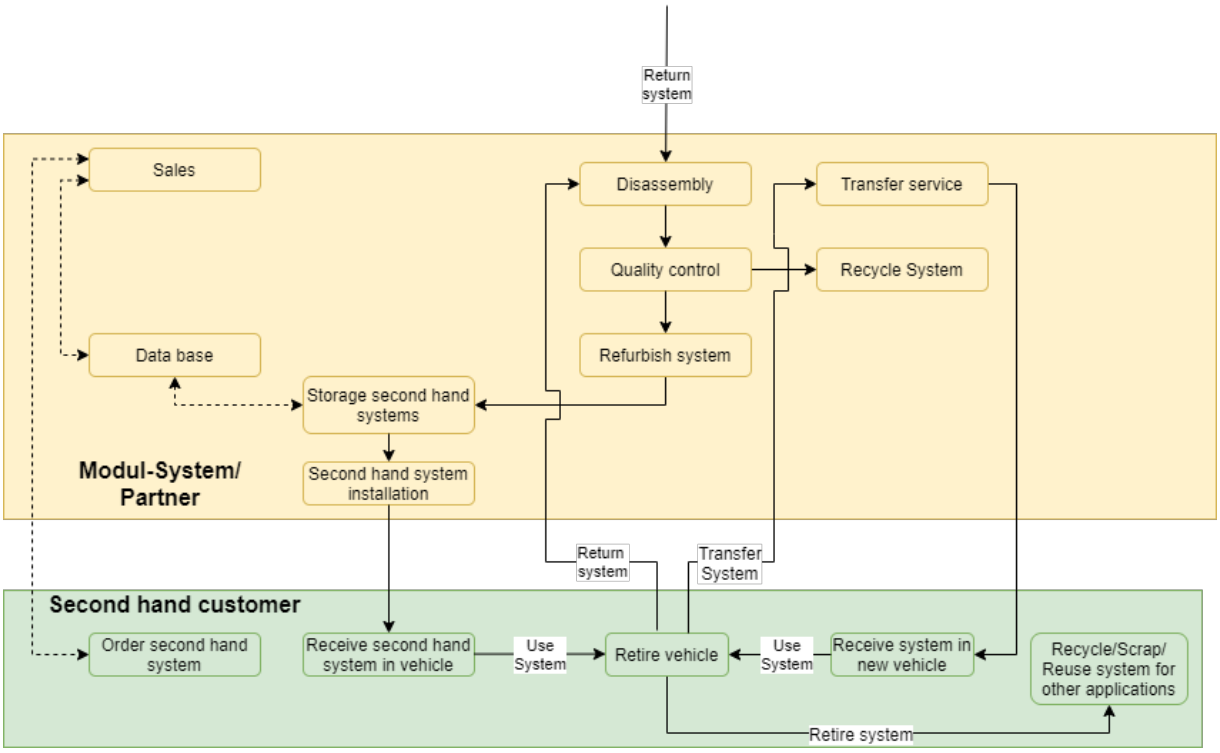

Figure 6.2: Flow chart of functions/processes for Part 2 of Re-use

This process starts in two ends. The first is the refurbishment of the second hand systems. Here the systems acquired from the dismantlement and bonus service from first part in the concept will be quality controlled, refurbished and then stored. The second part of the process is the sales, were the customer wants to buy a second hand racking system and install it into their vehicle. Below these two processes will be described in more detail.

Refurbishment of the Racking systems

To refurbish the racking systems there are a number of processes that need to be realised. Figure 6.3 illustrates the inputs, outputs and the functions that converts the inputs into

outputs. Now, we will only look at the process until storage and assembly, discussing the other part in the sales section.

Starting at *Remove system from car*, here the system will be dismantled at a Modul-System's service center or partner, then *package and shipped* to the re-manufacturing facility (which will be in Mullsjö). The facility will be in the same building as the current manufacturing plant. Here the *first quality control* of the system will occur, in tandem with the *dismantlement* of the system. The parts that are in to bad of a condition will be removed and *recycled*. The end goal is to refine the system so that is functionally the same as when it was new and visually not to worn. Figures 4.17 and 4.18 in Chapter 4.3 show results with a to worn finish, especially in terms of scratches. The Module-boxes will be removed and recycled due to the low price of attaining new boxes, enhancing the look of the racking system. Each system will be dismantled into a standard configuration or a sub-frame, such as a drawer or shelving module.

Then the system will be degreased and reconditioned which will be outsourced to the local reconditioning firm. Here the system will be cleaned, degreased and polished and in some cases coating scratches.

The racking system will return to the factory were a *second quality control* will take place, inspecting the finish of the product and adding new components to the ones that were removed. The most common things to change is estimated to be the ball bearing sliders and front of drawers. Lastly there is the *assembly* process and *storage*. Some standard configurations will be pre-assembled and stored together to quickly be able to be shipped. Other modules/sub-frames will be put together in storage until they are sold.

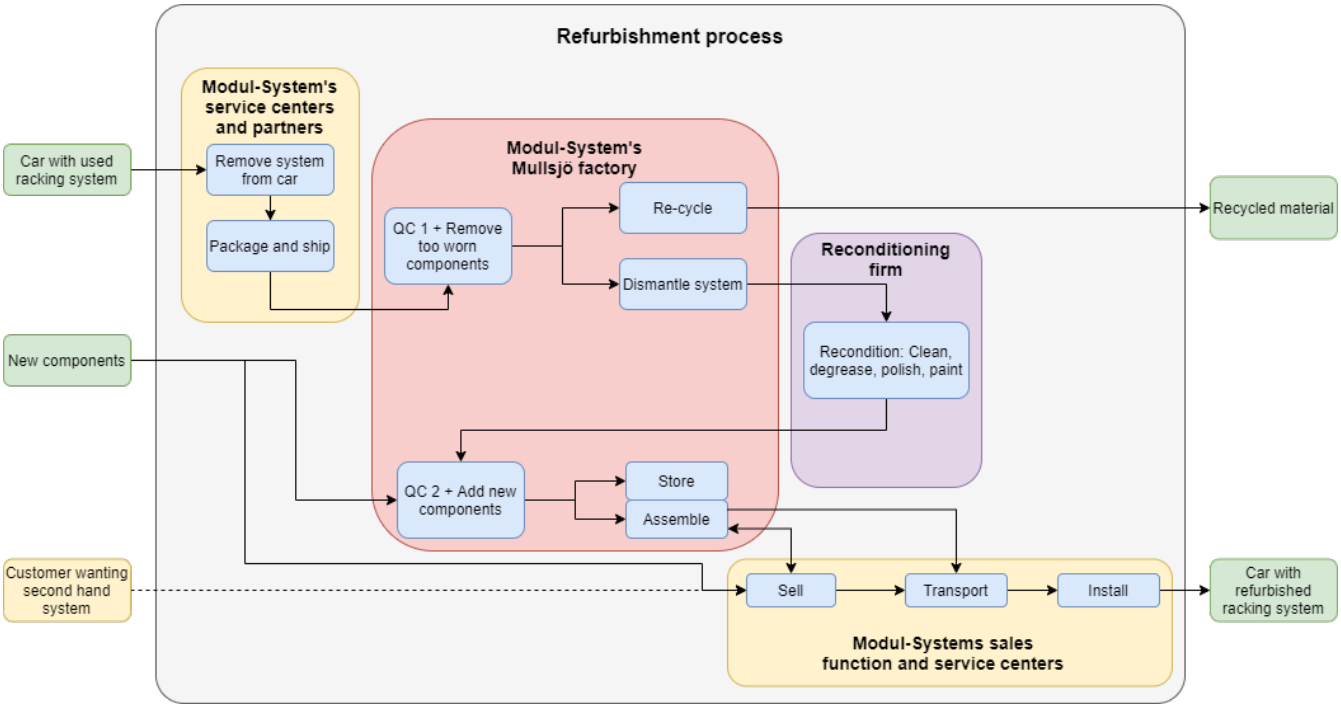

Figure 6.3: Flow chart of refurbishment process

Sale and installation of second hand racking system

Picking up from the last section, the *sales* of the refurbished racking systems will be done in combination with new parts, such as floor, lining, electronics and other services. In contrast to selling a high end high customisation and service product as the new systems, this sales process needs to be less resource intensive to be able to be cost competetive with the other low price competitors, such as Work System. To reduce the sales cost, a online ordering system with standardised packages and a configurator will be implemented. The initial goal is to have a more basic assortment of second hand products, making it easier for the customer to spec out a system. Each car model will have some different configuration and upgrade options.

When it comes to the cost and pricing of the system, the estimate is that the standard cost for modul-system will be 62% of the price for the same new racking system. Pricing of the system will be in relation to the competitors in this segment. The plan is to be 10%-20% below the competitors pricing. This is due to ensure competitiveness and compensate for the perceived value loss in a used product. Along with selling the used systems, new products will be offered within the same sales tool. This will enable the customer to more freely customise their systems and utilise the large range of products for the racking systems. It also functions as a stepping stone to invest in new, more high end systems in the future and other services such as Optimise use.
To then *install* the system, the existing network will be utilised and expanded if necessary due to the existing logistical solutions and expertise for installing the systems. Furthermore, new components such as electronics and floors will need to be installed, which can be sent together with the refurbished systems from the factory.

6.2 Concept 2 - Optimise use

Optimise use is a concept where Modul-System provide a turn key solution for customers that use EVs through a combination of hardware, software and consultation. The concept is a combination of a Product- and Use oriented product service system (see Chapter 3.1.1), which helps the customers to optimize their business once they introduce EVs. Although EVs have both long term economical and environmental benefits, they come with some barriers that must be taken into consideration by the customers. This is were Optimise use will help. To summarize, the identified barriers with EVs are:

- Limited range
- Varying range (depending on payload, climate, temperature, usage of cabin heating/cooling)
- Long charging times
- Limited payload capacity
- Requires non destructive installation (Due to high voltage cables and batteries)

To tackle these barriers, Optimise use has been developed with the functions "Increase EV range" and "Increase EV utilization efficiency" as the foundation. This has resulted in a

broad concept that includes and integrates both hardware and software solutions, forming a turnkey solution, setting Modul-System apart from the competition. By integrating physical products and services Modul-System can increase the brand loyalty of their customers. Monthly payments for the software services will facilitate customer payments and allow Modul-System to continually update their services to increase customer satisfaction. Optimise use will also be a natural development of the already existing software service "Modul-Connect". Implementation of Optimise use in the near future will be a strategic step by Modul-System, since the trend shows that more companies implement EVs into their fleets. This will also put Modul-System one step ahead of their competitors.

6.2.1 How it works

As stated previously the focus of this concept has been to increase range and utilization efficiency of the EVs. In order to minimize weight three sub functions has been used: (1) Minimize weight, (2) Minimize energy usage and (3) Provide additional energy. In order to increase utilization efficiency four aspects has been used: Increase utilization efficiency for (1) single EVs, (2) entire fleets, (3) during charging and (4) during work. Here the different solutions will be presented for each category respectively.

Increase EV range (Minimize weight) - through a material management system

The goal with the material management system is to ensure that the driver only brings what he/she needs based on the work that will be carried out. This will be done through a combination of both hardware and software. Firstly, the system will tell the driver what equipment that will be needed for a specific work task, through an online check-list. This will be based on work orders that will specify the needed material for each work task. The second step will be to load the specified equipment into the vehicles. The equipment will be placed in already sorted kits, where one module might include one type of tools or expendables. To facilitate this, Modul-System's "Multi-boxes" (removable trays) or larger mobile racking systems will be used. Figure 6.4 shows this step. Here, Modul-System will also have a consultancy service to help their customers to sort their equipment in the most efficient way.

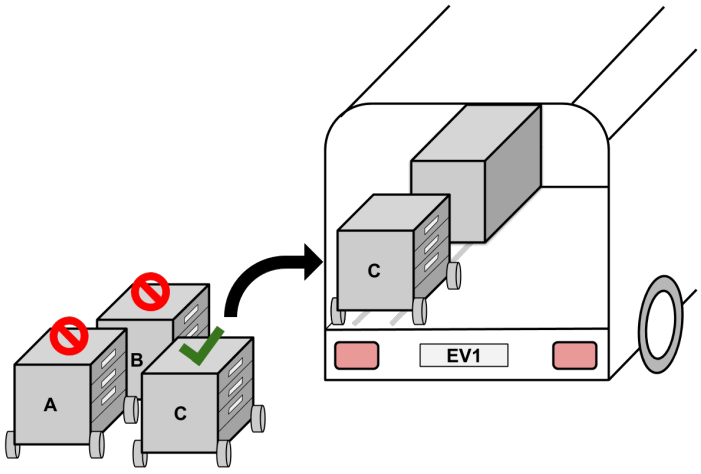

Figure 6.4: Loading the right equipment module(s) into the vehicle

In addition to the material handling system weight sensors on the vehicle's axles will

inform the driver which payload the vehicle is loaded with and how the vehicles range will be affected. This will give an indication if the driver will be able to reach the work site with the loaded equipment on the current charge level. Figure 6.5 illustrates how the driver might be informed. Each module will also have a RFID or Bluetooth sensor attached to it, meaning that the loaded equipment will be linked to the vehicle in a system. This information will also be available for fleet managers making it possible to allocate work based on the available material in the vehicles, see Figure 6.5. Work allocation will be further presented later in this section.

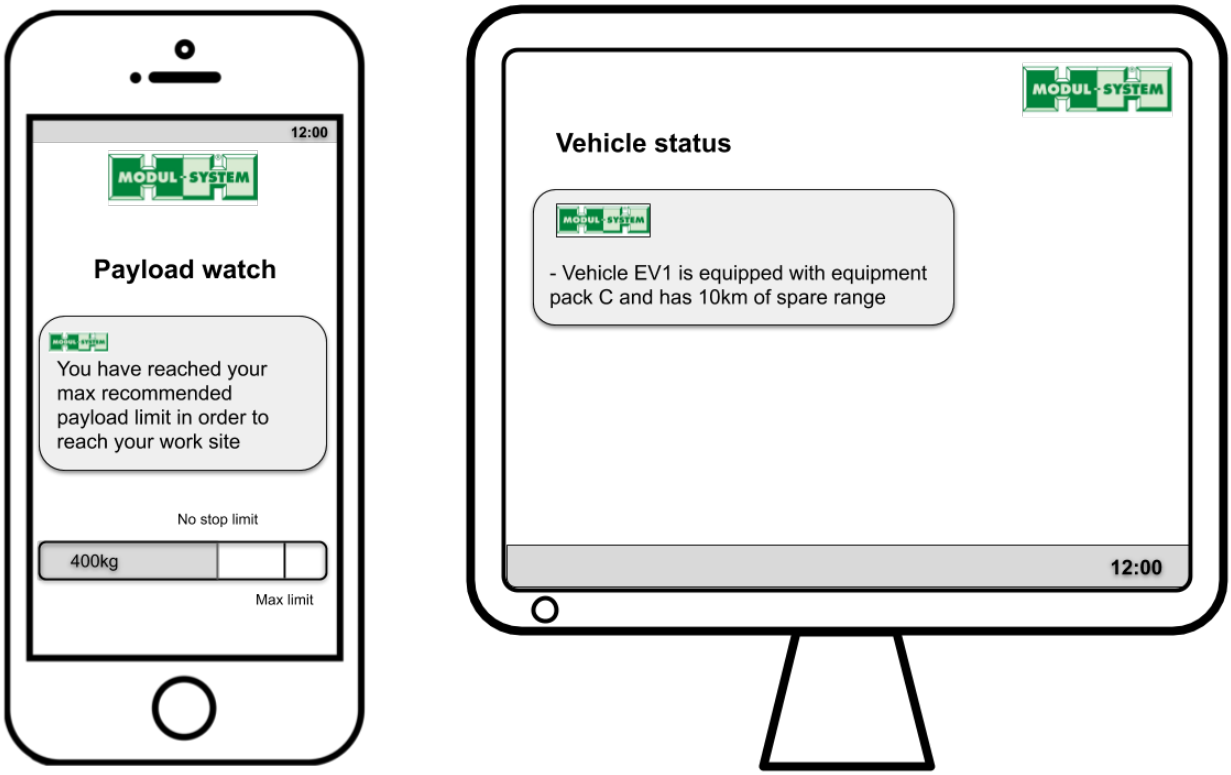

Figure 6.5: Proposed interactions for drivers and fleet managers respectively

Increase EV range (Minimize energy usage) - through insulation and a timed heating system

An issue with EVs are that their heating and cooling systems are directly linked to the main battery. Therefore the range will be reduced the more internal heating and cooling systems are used. To cope with this problem Modul-System could provide an insulation option for their customers, where either the the driver cabin or whole vehicle could be insulated with for instance PU foam. As stated in Chapter 4.4.5 PU insulation with only a thickness between 5 to 10mm could have a significant impact on the range of EVs during winters in colder climates, hence especially suitable for the Swedish and Norwegian market. Insulation will also fit well in Modul-System's Modul-Floor segment, where flooring and lining is offered to the customers.

Another solution to minimize energy usage could be to provide a function where the vehicle heating system would be controlled by a timer. This would especially be important for customers who uses their vehicles as a rolling office, such as telecom customers working

in rural areas. This would mean that they could make sure that their vehicle is heated only when it needs to, for instance during lunch breaks.

Increase EV range (Provide additional energy) - through portable batteries or generators

Modul-System is already offering inverters to customers with regular vehicles to allow them to use electrical equipment and tools in their vehicles. For EVs the corresponding solution will be to offer portable battery packs or generators, meaning that the main battery of the EVs will not be affected while the customer use power tools etc.

Increase EV utilization efficiency (for single vehicles) - Through a range prediction system

To better make use of the vehicles and avoid unnecessary charging and lost income for the customers a range prediction system will be offered by Modul-System. The algorithm for this system will be based on parameters such as payload, outside temperature and driving behaviour. This will facilitate the drive route planning based on the vehicle's current status. The system will also give warning notifications to the driver and tell when to head of to the nearest charging station.

Increase EV utilization efficiency (for entire fleets) - through driver monitoring

Installed sensors in the vehicles will make it possible to monitor individual drivers in a fleet, both in a live set up and over a certain time span. This will make it possible for the company to identify the drivers that drive efficiently and the ones who does not. This information could then be used as a reference to guide the drivers in how to adapt their driving behaviour and be more efficient during their work. Some examples of generated data could be average payload, average range per charge and cost per km for each driver, Figure 6.6 illustrates this.

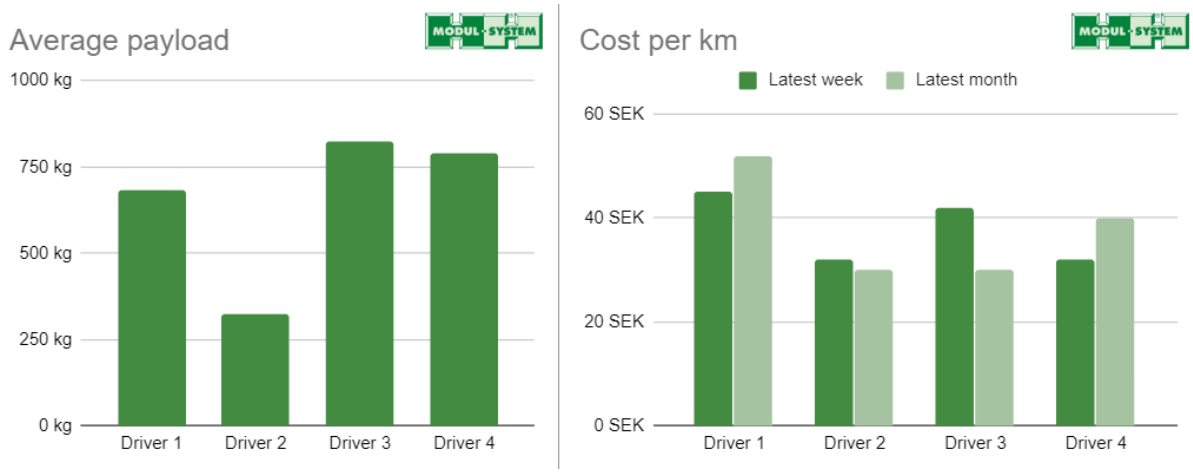

Figure 6.6: Examples of driver data that can be generated with Optimise use

Increase EV utilization efficiency (for entire fleets) - through a fleet management system

To efficiently allow fleet managers to allocate work tasks to different drivers, various aspects needs to be taken into consideration. The optimal situation would be to allocate work so that the vehicles do not have to be charged during working hours, leaving the drivers stranded. An other important factor would be to ensure that the right equipment arrives at each work site, while minimizing the trips to the company's supply storage or material suppliers. Once again, the material management system would be useful here. To sum up, the information that will be available for fleet managers with Optimise use are:

- Vehicle positions
- Proximity to work sites
- Available charge/predicted range
- Proximity to charging stations
- Driver competence
- Loaded material/equipment

Figure 6.7 illustrates an example of how an interactive map for a fleet manager might look like.

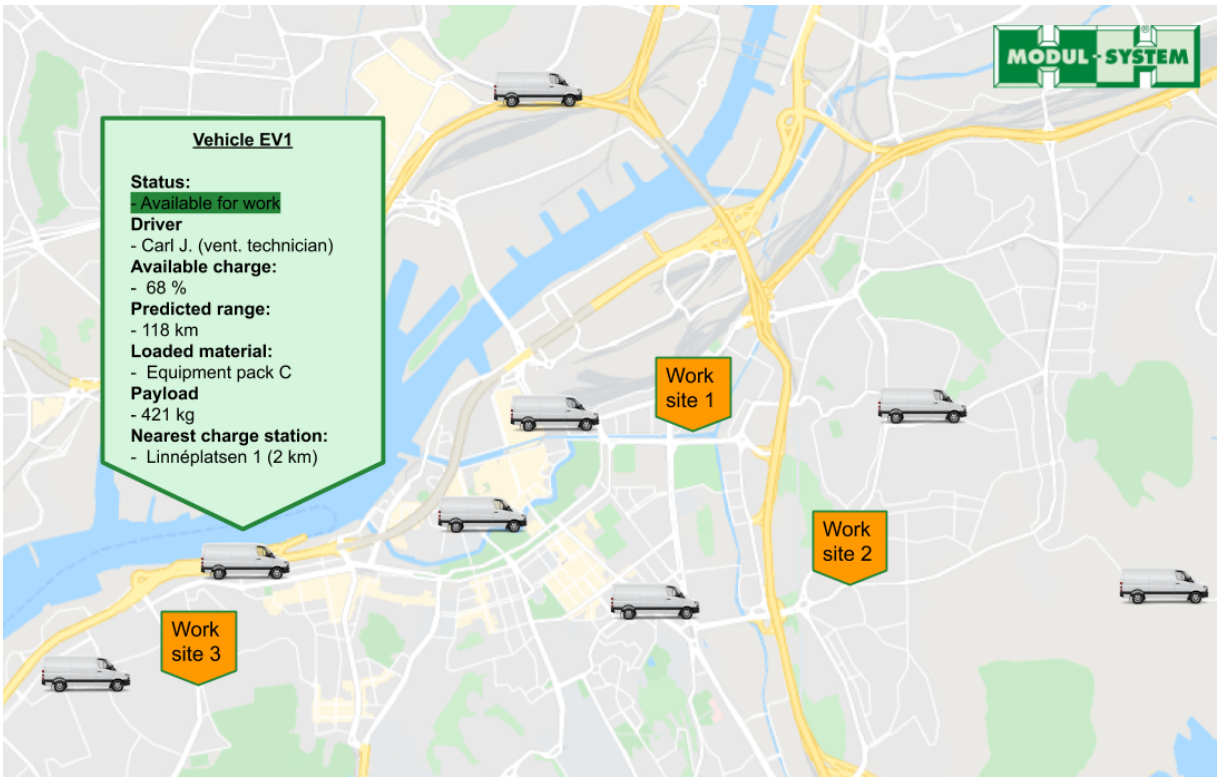

Figure 6.7: Example of interactive map for fleet managers

Increase EV utilization efficiency (during charging and work) - through mobile racking systems

To facilitate charging while the drivers (service personnel or craftsmen) conduct their work at their customers a solution could be to provide mobile racking systems. This will make it possible for the drivers to drop off their needed equipment at the work sites and then park at the nearest charging station and walk back to the work site (if it is within close proximity). By having mobile racking system the driver will no longer be dependent on the vehicle as a storage unit during their work tasks. To achieve this Modul-System can further advertise their existing products such as the "Multi-boxes" and trolleys (see Figure 4.23 in Chapter 4.4.4) or develop something in line with Sortimo's mobile work stations, similar to the racking systems in Figure 6.5, previously shown in this section. Mobile/removable racking systems will also make it possible for the drivers to leave their equipment at the work sites during longer projects. This means they will not have to commute back and forth with the equipment in their vehicles, minimizing their payload. In addition, by being able to charge at charging stations during work, and not directly at the customer sites, Modul-System's customers will give a more professional appearance among their own customers.

6.3 How the concepts complement each other

These two concepts both try and enhance the customer experience and reduce the environmental impact. Re-use focuses more on the business side, together with an increase in service, while Optimise use is more product focused, with heavy emphasis on servitization. What they have in common is that both concepts aim to increase the time a customers stays at Modul-System, which helps both concepts:

- The transfer of systems between cars, secures the customer for a longer time. If the customer also uses the Optimise use package, it ensures that they will keep on using and paying for that service, due to the hardware and software dependencies.
- Optimise use has industry unique features which, if the customer needs this service, will incentives them to stay. Thus increasing the possibility to procure used systems from them. This is especially important since the Re-use concept needs the rails solution in Module-Floor to cost efficiently dismantle the systems. This type of floor is a requirement for EV's making it a good match.

For a customer to invest in Optimise use, they will have to invest in more expensive electronics and pay a monthly fee. To reduce some of that up-front capital investment, they could utilise the transfer service between cars, re-using the racking systems. This is especially useful if they have bought the removable racking system solutions, since they will be more expensive. Another way these concepts complement each other is that the sales of second hand products can become a stepping stone for the customer to buy new components and other services from Modul-System. The increased brand awareness in that market space will help get those customers to buy more expensive products and services when their companies grows. One of these services would then be Optimise use.

Chapter 7

Discussion

With all the development work being concluded, it is time to discuss the way the project was tackled, the used methods and their effectiveness and the results.

7.1 The Project Task

The task was very broad and in its essence an exploratory one. Service development is something that Modul-System already work with, but are in the early stages of and circular economy is barely explored within the company. Furthermore, the implementation of electrical vehicles upsets the current norm on how to use racking systems and material and fleet management. We therefore set out to explore the possible solutions, that within the industry are not considered traditional. It was also imperative that the project was firmly anchored in increasing the environmental sustainability compared to the current offering, whilst still being economically sustainable and profitable.

7.2 The Project Work and Methods

This project has been challenging when it comes to applying methodology, due to its open and broad scope. The solutions took turns, that needed a change in how to evaluate and screen the concepts further. A more traditional narrow product development scope uses a more standardised path, helping to structure the work in that manner. We felt that this stricter methodology path would have narrowed the possible solutions to more physical, tangible product solutions, disregarding the more abstract business concepts that could emerge. By using a more dynamic and holistic product development approach, where the methods were adapted for servitisation and sustainability, we were able to include aspects which a traditional methodology would have overseen. We believe that by not using a broad approach, the Re-use concept would probably not have come up as a solution due to its more abstract nature. However, one issue with using a dynamic methodology is that the output is much less predictable and will deviate from what might have been expected from the beginning. Modul-System though have been very understanding regarding this and have also encouraged us to pursue the paths that seemed the most promising, even if they deviated from the initial plan.

Furthermore, the iterative approach has helped considerably due to the fact that it encouraged the development of one part, in one type of abstraction level, starting with more

business oriented and then going into more and more detail, each time looking at a different perspective/abstraction level. It has also been easier to write down the development phase and explain it with its clear steps and outputs. One issue, though was which parts of the development should go into which iteration. It forced us to prioritise which parts were the most important to develop and show. Some parts of the concept like the sales strategy did not fit into the iterations and had to be dealt with in detailed design. This put less focus on the sales strategy, but with Modul-System having a whole department and experts dedicated to this part, it might be a good thing that more emphasis was put on the refurbishment process.

7.3 The Result of the Project

With the Purpose and Objectives (Chapter 1.2) and Clarifications as Research Questions (Chapter 1.4) as a basis we can conclude that all but one goal was achieved, being the Norwegian market. This market was explored initially, especially in terms of the regulations and subsidies for EVs and one interview with the Norwegian side of Modul-System was also conducted. The goal was to continue interview more stakeholders and customers in Norway but due to the Covid-19 pandemic, this halted these plans. Thus, the main part of the market analysis on the Swedish market.
Looking at the project task, discussed in Chapter 7.1, the aim was to come up with a concept that was environmentally sustainable, through a circular economy and service innovation perspective with the future of EVs in mind. The result was two concepts, one focusing on circular economy (Re-use) and one focusing service innovation to cater towards the new EV market (Optimise use). These two concepts as, mentioned in Chapter 6.3, complement each other to a degree but are in their essence two separate concepts. The project was not able to consolidate all the goals into one concept. With that said, the output now gives the possibility for simultaneously catering to the EV market and enter the lowend one. This low end market is one that Modul-System have been looking to enter for a while, but have found different difficulties (Ones which this report will not cover).

The possible reduction in environmental impact will still be significant with these two concepts. If Modul-System can enable more companies to go over to electric cars, this will have a positive impact, especially in terms of emissions. The optimisation will also aid in reducing wear of the vehicle, increasing its lifespan and thus increase resource utilisation efficiency. While on the subject of resource utilisation, the Re-use concept takes this to another level. Both increasing the first users utilisation efficiency and also issuing a new lifespan for a second hand customer. The refurbishment of the product, which consists of replacement of faulty components, cleaning and scratch removal, gives this solution at least one more car life-cycle in time. This is a relatively small environmental investment for re-using all the other refined materials in the racking system. Since many customers, in the low price-segment, work on a tighter budget they will probably also make sure to use the systems as long as possible. The frames of the racking systems are made out of ultra high strength steel and with the relatively low amount of stresses they have to endure their lifespan will be long, assuming they have not been crashed with. We therefore believe that if a customer wants they can keep on using those systems for several car life-cycles, swapping out the drawers and adding new modules as they need to. This is based on the assumption that Modul-System will keep on using and supporting this platform for that long of a period, which they have stated that they plan to do.

Looking at the actual end result of the project, there are loose ends that have not been detailed to the maturity for release on the market. The findings in this report are in our opinion instead supposed to give a basis for were and what Modul-System should focus on in the future. It has shown a way in how one can consolidate an environmental and business sustainable model through circular economy through the Re-use concept. Furthermore, the Optimise use concept also highlights the value of increasing services into ones offering as a tool to increase customer satisfaction and loyalty. As stated in the beginning of the chapter this has been an exploratory project and report, which we believe will give fruit to several, more detailed projects in the future. We definitely see the potential for several thesis assignments based on our findings. This will be elaborated on in the future recommendations section in Chapter 8.2.

Chapter 8

Conclusion and future recommendations

This chapter includes the conclusion of the project, summarising the answers to the research questions posed in Chapter 1, and what aims to be a comprehensive recommendation for future development of the two concepts Optimise use and Re-use.

8.1 Conclusion

This report has been the documentation of the master thesis project, conducted by two Chalmers students from the Master program product development (MPPDE) in collaboration with Modul-System. The purpose of the project was to develop a new service concept for racking systems, used in light commercial vehicles, that meets the future needs for electrification of power trains and to lead the way into a more sustainable future. Further elaborating on the purpose, six research questions were posed. Below, the answer for each question, that has been detailed in the report, will be summarised.

RQ1, How does the Swedish and Norwegian market for racking systems for service- and transport vehicles look like?
The literature review found that both Sweden and Norway have a penalising taxation system for vehicle emissions and subsidies for EV's. The market was found to be a customer centered one with the customer interacting will all different parties, which were the racking system providers/manufacturer, car retailers, racking system retailers and leasing companies. In Sweden Modul-System has two main Swedish competitors and two international competitors, were one of the companies focuses on the low cost segment. This is a segment which Modul-System currently does not focus on.

RQ2, What are the current trends in society and how will they impact the market in the near future?
To answer this query a PESTEL analysis was conducted, resulting in that several main trends were found. Sustainability is becoming more attractive and important to both consumers and investors, too the degree that is affects their purchasing/investment decisions. In Sweden a majority of the population was found to believe that societal intervention is needed to decrease climate change. This is also evident when looking at the policies being put in place. The European union, Sweden and Norway are putting in measures to discourage the use of CO_2 emitting vehicles and even subsidising EVs. Sweden has

furthermore set the goal to live up to the Paris agreement with <2°C in average global temperature increase. Furthemore, Sweden wants to achieve zero sum emissions by 2045.

RQ3, What are the customer needs?
Through interviews with Modul-System and their customers a large variety of needs were found. These were sorted into the categories product-, service-, environmental- and business specific. Some of the most occurring needs were "low weight solution", "robust solution", "non destructive installation" and "complete/turnkey solution". All needs can be found in the the customer needs list (Table 3.2) and the requirement specification (Table 3.3) in Chapter 3.

RQ4, What are the requirements that must be met in order to increase sustainability?
Through the literature review the findings to increase sustainability was to increase utilization of resources. Three main perspectives were explored. These were the adaptation towards a circular economy and adaptation towards EVs. The heart of incorporating a circular economy was found to be to take responsibility for the life cycle of products, with the main focus being on increasing the life span of the products. Requirements related to this were found to be increased maintenance proposals, product reuse and refurbishment/remanufacturing and increased product life spans.
Adaptation towards EVs was found to increase sustainability in itself from an emission point of view. Compared to conventional vehicles EVs has some barriers that must be taken into consideration during a transition from conventional vehicles to EVs. Especially the limited range and decreased payload capacity was found to be issues. Requirements that were introduced to cope with these barriers were low weight, aid low wear and energy usage for single EVs and vehicle fleets.

RQ5, How has Modul-System fulfilled the customer needs in their current offering and how will the use of electric vehicles affect this fulfillment?
Modul-System's current solution fulfills many of the customer needs, especially in terms of the hardware. Their racking system's are competitive on the market due to their low weight and robustness. There were some aspects that Modul-System would need to work on to meet the new requirements that comes with EVs. It seems especially important that Modul-System help their customers to use their EVs in a more efficient way, not only to reduce payload but to provide solutions that allow customers to reduce energy consumption in their EVs and increase range. Here it was found to be important to work towards a more service oriented solution rather than product oriented.

RQ6, How can a new product-service system be formed to fulfill the customer and sustainability needs/requirements?
Two main concepts were developed in this project to cope with the two main environmental perspectives (increase the product life span and adaptations towards EVs). The first, most developed concept, called "Reuse" was developed to incorporate a circular economy into Modul-System's business. The essence of this concept is that Modul-System prolongs the life-span of their products by offering repurchasing of old systems as a service. The current hardware that Modul-System provide have very high robustness, hence is suited for using over several car life-cycles. Old obtained racking systems will go through a refurbishment process and be resold on the market at a lower price, reaching another customer segment. As a compensation, the first hand customers will get a bonus discount once they

buy their next new system.

The second concept called "Optimise use" is a product-service solution with the aim to help Modul-System's customers to introduce EVs into their fleets. The concept consists of a combination of both software and hardware with the goal to change the customers' behaviours. This is to make sure they can drive a longer distance per charge and increase their resource utilization efficiency.

8.2 Future Recommendations

To increase Modul-System's image as a sustainable company with products adapted for a circular economy and EVs this section will present future recommendations. Here, recommendations for the two concepts will be presented separately.

Before the recommendations for each concept will be elaborated on, it is deemed necessary to emphasise that both of the concepts are highly recommended to pursue further. Optimise use is relevant now and if developed swiftly can gain a large proportion of the EV market in Sweden and Norway. It also takes another step towards more of a product service system, co-creating value with the customer and also unifying Modul-System's product segments. Re-use mandates a greater change but also has the possibility for larger long term gains, with entering a new market and taking a first step in the direction of a possible societal shift towards re-manufacturing and circular economy.

8.2.1 Future recommendation for Reuse

The Re-use has a lot of potential to become a viable part of the business but there are a number processes, relationships and problems that need to be further evaluated for it to work. Below a recommendation for how to tackle these issues will be described. It will be divided into four parts. The first three are concerning the sales and refurbishment of racking systems and the last one describes what to do in the transfer part of the concept: *1. What needs to be in place for a pilot programme*, *2. what needs to be in place to do this full scale*, *3. what could the future development of this concept be* and *4. which steps should be taken to increase the transfer of racking system between cars*

Pilot program

The first recommendation is to develop the concept so far that a Minimum viable product (MVP) can be released and tested. This would be a type of pilot program were Modul-System focuses on learning the processes, the average state of a used racking system and how the customer reacts to a refurbished system. To maximise the use-fullness and learning outcome, this would be implemented as early as possible into the project. A result is that this program will most probably not be profitable but to be seen as a development and marketing tool. To achieve this the following steps are suggested:

- Define one or several service centers to operate from - This would be locations were Modul-System could find customers interested in refurbished systems and ones willing to hand in their used ones. It also needs to be easy to transport the systems to the factory in Mullsjö so the service Center in Mölndal, which is also located next to

the developing department is a prime subject. A next step could be to implement this program in a service center in Stockholm as well.

- Acquire used racking systems - Here one can further define and test the bonus system as a useful tool for acquiring second hand systems. It is also an opportunity to learn and log how the condition of the used systems are.

- Transport racking systems to the factory - There is a lot transportation between the Service center in Mölndal and the factory in Mullsjö, which could be utilised as a means of transport for the used racking systems. Initially, they could be loaded into the back of vans and transported with the personnel driving up to Mullsjö.

- Refurbishment of system and the customers perception of a used system - The output of the refurbishing process needs to be more defined before pilot project is started, so that the customers get a consistent product. To accomplish this a thorough investigation into how the customers will react to different levels of surface finish and find a compromise between this and the price of the system. This could be a possible future thesis project, including customer analysis and definition of refurbishment process.

- Sales of the system - For the beginning of the pilot project the sales, contradictory to what is defined in Chapter 5, is suggested to be through the internal sales team at the service center. This to quickly set it up but also for the sales personnel to be able to sell in this concept and get nuanced feedback from the customers. It becomes a way to directly hear from the customer what works and what does not.

Towards full scale release

In tandem with running the pilot program, the following steps would be necessary for the long term product/service launch:

- How to acquire and transport the used systems to the factory at scale - The results from the pilot program would lay the foundation for how to effectively incentivise the customer to hand in the system. What then remains is to find a cost effective way to transport the system to the factory. From the cost analysis, it was evident that this was a large part of the cost.

- Gather data on the condition of used systems - This will be achieved through the pilot program.

- Outline how to in detail refurbish the system - From a manufacturing perspective, define what processes should be in place and how they can be optimised. Questions that should be asked: How can the processes be implemented so that they are scalable? Are there ways in which the processes can be optimised? Which processes can be further introduced to increase the amount of re-use of products? The basis for this would come from the preliminary mapping of the refurbishment process in the Pilot program.

- How to sell the refurbished racking systems - As suggested in Chapter 5, detailed design, the sales would be mainly through online sales. This would be a new process

for Modul-System to have and is an area that needs to be studied and focused on to be competitive. Looking at how the competition achieves this but it is also important to look at how to outperform them in this area as well, to increase competitiveness. Some questions that could be relevant to ask: How do we form standardised kits for the customer to choose? How do we, in an easy way enable the customer to customise the system without making it incompatible? How will the refurbished systems interact with new ones?

Looking forward

The two previous steps are required to develop the concept as envisioned in the report, this section will focus on how to further evolve this concept in the long term.

- Go international - If this concept is successful in Sweden a logical next step is to investigate if this could be implemented in other parts of the world, with Europe being the closest candidate. This would include acquiring and selling the racking systems in said countries. Upon doing this, it could be worth considering moving the re-manufacturing to a more central location, such as to Poland, as suggested in iteration 2 of the development phase. Lower wages and a central location could be beneficial at scale. Another alternative could be to have several refurbishment sites, minimising the transportation distances.

- Increasing re-manufacturing efforts - Even longer in the future, Modul-System could continue the development of their racking systems to be more suited for re- manufacturing. Moving away from traditional production of new components and re-using components in their regular product line-up. This could be started with the current product platform, but when it comes to developing a new platform, it would be a good point to design it with re-manufacturing in mind. This could be things such as working with different layers, only replacing the outer one etc. With the trend of services playing a more important role, and the physical products only being a part of this, this re-manufacturing plan would be very beneficial, with the main value creator being the service and software.

How to institutionalise the transfer of racking systems between vehicles

As described during the concept development phase, the transfer of racking systems can benefit Modul-System in the long run, with longer customer relationships and the possibility to sell more services to them. This practice has turned out to already be performed today, but at a small scale and in a non standardised way. To further detail and standardise how to do this would increase the possibility to implement this across the different sales teams. In order to achieve this it is recommended to focus on how to plan the purchase across several cars and also detail how to charge for and change/upgrade components during the transfer. A deeper analysis into which other services could be included is also encouraged. For example, packaging the Optimise use service during that time period or including the dismantlement and return of the systems in that price. This would help secure used racking systems. There are certainly other possibilities that can be seized upon further inspection.

8.2.2 Future recommendations for Optimise use

Optimise use consist of a wide variety of sub solutions, both hardware and software based. Therefore an initial recommendation for Modul-System would be to evaluate which of these solutions that has the most potential from a business point of view to pursuit. Here, it is important that the customers are well integrated in the development, and early adopters of could review the different aspects of Optimise use. This would be to make sure that Modul-System is on the right track.

Here, recommendations for each sub solution is presented in a more detailed level:

- Material management system - Here, Modul-System would need to examine how to best ensure that the right equipment/material are loaded into each customer vehicle, what type of sensors to use etc. Additionally, Modul-System would have to explore how to best sort equipment into equipment packs and guide their customers to do so in the most efficient way, through consultancy for instance. Another aspect is to examine how the status of expendable materials can be monitored. Here, a possibility could be to introduce a stock status system for each vehicle.

- Removable/mobile racking systems/modules - Here, Modul-System would have to investigate if there is a need for additional removable/mobile hardware solutions other than what they are currently offering. These hardware solutions could then be a part of the above mentioned material management system. Once again, a close customer interaction would be needed here to examine how the customers prefer to load their vehicle with the right equipment. Preferably, a customer survey would need to be conducted to see if the customers are willing to bring their equipment packs directly to the work sites while their vehicles are parked at the closest charge point. Related to this, Modul-System would be recommended to explore alternative ways in how to make charging possible during the time the craftsmen/service personnel conduct their work tasks. The possibility to leave the equipment modules on the work site during longer time periods would also have to be further explored. Here, theft security would be a key issue.

- Vehicle insulation and a timed heating system - To minimize the energy consumption within the EVs, Modul-System would have to explore feasible insulation materials and thicknesses. Real tests would be preferred to see the effects of different insulation concepts. This could also be compared to theoretical findings, such as the article by Wirth et al. (2014). Accessibility to different EVs internal software would also have to be explored to see if a timed heating system could be directly connected to the vehicles' inbuilt heating systems.

- Battery packs/generators - Battery packs and generators lies outside the scope for what Modul-System currently is producing. They would therefore be recommended to outsource the production of these products. Close collaboration with a potential partner would be preferred to make sure that the batteries/generators are compatible with the racking systems' interfaces.

- Range prediction and warning system - Here, Modul-System would be recommended to explore the possibility to get access to EVs internal software to get access to data such as current battery charge, average energy consumption etc. This data could

then be integrated with the data gathered from the weight sensors to predict the range.

- Fleet management - Modul-System would be recommended to release a beta version of the fleet management system that is described in Chapter 6.2. Early adopters could then test the system thoroughly to see potential errors and missing functions. Additionally Modul-System could develop different packages for different customers depending on their needs, similarly to their current Modul-Connect service.

The authors strongly believe that a material management system and removable racking systems/modules are something that Modul-System should focus on to further develop. By integrating these two solutions and help the customers to change their habits regarding what to bring, a lot can be done to minimize the payload of their vehicles. Here, Modul-System has the possibility to offer a turn key solution that help the customers to extend the range of their vehicles. Another aspect, and possibly a low hanging fruit, that the authors believe Modul-System should focus on is the Fleet Management system. Here, Modul-System can continue to build on their Modul-Connect/Fleet-service and add the functions needed for EVs.

References

Accenture. (2014). Circular advantage innovative business models and technologies to create value in a world without limits to growth. Retrieved from https://www.accenture.com/t20150523t053139__w__/us-en/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/strategy_6/accenture-circular-advantage-innovative-business-models-technologies-value-growth.pdf

Allabolag. (n.d.). *Bolagsöversikt.* (https://www.allabolag.se/)

Almefelt, L., Rexfelt, O., Martin, K., Zackrisson, D., Hallman, T., et al. (2009). Methodology for service innovation in a multi-disciplinary context. In *Ds 58-5: Proceedings of iced 09, the 17th international conference on engineering design, vol. 5, design methods and tools (pt. 1), palo alto, ca, usa, 24.-27.08. 2009.*

Almefelt, L., Rexfelt, O., et al. (2017). A tool for assessing customers' barriers for consuming remanufactured products. In *Ds 87-1 proceedings of the 21st international conference on engineering design (iced 17) vol 1: Resource sensitive design, design research applications and case studies, vancouver, canada, 21-25.08. 2017* (pp. 011–020).

Bott. (n.d.). *Bott.* (https://www.bott-group.com/)

Carlgren, F. (n.d.). *Reporäntan.* (https://www.ekonomifakta.se/Fakta/Ekonomi/Finansiell-utveckling/Styrrantan/)

Elbil.no. (n.d.). *Fordeler med elbil.* (https://elbil.no/elbil-fordeler/)

ENOVA. (n.d.). *Støtte til kjøp av elektrisk varebil.* (https://www.enova.no/bedrift/landtransport/nullutslippsfondet/stotte-til-kjop-av-elektrisk-varebil/)

EuropeanCentralBank. (n.d.). *Euro foreign exchange reference rates.* (https://www.ecb.europa.eu/stats/policy_and_exchange_rates/euro_reference_exchange_rates/html/eurofxref-graph-sek.en.html)

EuropeanCommision. (n.d.). *Technology readiness levels (trl).* (https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf)

Figenbaum, E. (2018). Can battery electric light commercial vehicles work for craftsmen and service enterprises?. *Energy Policy*, *120*, 58 - 72. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edselp&AN=S0301421518302866&site=eds-live&scope=site&custid=s3911979&authtype=sso&group=main&profile=eds

Gottfredson, M., Puryear, R., & Phillips, S. (2005). Strategic sourcing from periphery to the core. *Harvard Business Review*, *83*(2), 132 - 139. Retrieved from http://proxy.lib.chalmers.se/login?url=http://search.ebscohost.com.proxy.lib.chalmers.se/login.aspx?direct=true&db=buh&AN=15906490&site=ehost-live&scope=site

Guldmann, E. (2016). Best practice examples of circular business models. Retrieved from https://www2.mst.dk/Udgiv/publications/2016/06/978-87-93435-86-5.pdf

Isaksson, O., Larsson, T. C., & Öhrwall Rönnbäck, A. (2009). Development of product-service systems: challenges and opportunities for the manufacturing firm. *Journal of Engineering Design*, *20*(4), 329-348. Retrieved from https://doi.org/10.1080/09544820903152663 doi: 10.1080/09544820903152663

Karlsson, A., Larsson, L., & Öhrwall Rönnbäck, A. (2018). Product-service system innovation capabilities: linkages between the fuzzy front end and subsequent development phases. *International Journal of Production Research*, *56*(6), 2218 - 2232. Retrieved from http://proxy.lib.chalmers.se/login?url=http://search.ebscohost.com.proxy.lib.chalmers.se/login.aspx?direct=true&db=buh&AN=129867201&site=ehost-live&scope=site

Mcavoy, K. (n.d.). *Research: Actually, consumers do buy sustainable products.* (spendmatters.com/2016/07/20/investors-increasingly-care-about-a-companys-sustainability-practices)

Miljöfordon. (n.d.). *Bonus-malus.* (https://www.miljofordon.se/ekonomi/bonus-malus/)

Modul-System. (n.d.). *Om oss.* (https://www.modul-system.se)

Morganti, E., & Browne, M. (2018). Technical and operational obstacles to the adoption of electric vans in france and the uk: An operator perspective. *Transport Policy*, *63*, 90 - 97. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edselp&AN=S0967070X1730224X&site=eds-live&scope=site&custid=s3911979&authtype=sso&group=main&profile=eds

Naturskyddsföreningen. (n.d.). *Faktablad: Cirkulär ekonomi.* (https://www.naturskyddsforeningen.se/skola/cirkular-ekonomi?gclid=Cj0KCQjw0pfzBRCOARIsANi0g0swbJlV-KvcbPDqApGp0lvPyR0FYccYPVx9744nTLV_HHvgPIZGWiEaAjJMEALw_wcB)

Naturvårdsverket. (n.d.). *Allmänheten om klimatet 2018.* (https://www.naturvardsverket.se/attityd-klimat-2018)

OCM, O. C. o. M. (n.d.-a). *How to undertake the perfect swot analysis.* (https://blog.oxfordcollegeofmarketing.com/2016/05/26/undertaking-a-swot-analysis/)

OCM, O. C. o. M. (n.d.-b). *What is a pestel analysis?* (https://blog.oxfordcollegeofmarketing.com/2016/06/30/pestel-analysis/)

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K.-H. (2007). Product planning, solution finding and evaluation. In *Engineering design: A systematic approach* (pp. 63–124). London: Springer London. Retrieved from https://doi.org/10.1007/978-1-84628-319-2_3 doi: 10.1007/978-1-84628-319-2_3

Rexfelt, O., Almefelt, L., Zackrisson, D., Hallman, T., Malmqvist, J., & Karlsson, M. (2011, Jul 01). A proposal for a structured approach for cross-company teamwork: a case study of involving the customer in service innovation. *Research in Engineering Design*, *22*(3), 153–171. Retrieved from https://doi.org/10.1007/s00163-011-0104-y doi: 10.1007/s00163-011-0104-y

Scupin, R. (1997, 06). The kj method: A technique for analyzing data derived from japanese ethnology. *Human Organization*, *56*. doi: 10.17730/humo.56.2.x335923511444655

Sortimo. (n.d.). *Sortimo.* (https://www.mysortimo.se/)

SwedishGovernment. (n.d.-a). *Mål för miljö och klimat.* (https://www.regeringen.se/

regeringens-politik/miljo-och-klimat/mal-for-miljo/)
SwedishGovernment. (n.d.-b). *Mål för transporter och infrastruktur.* (https://www.regeringen.se/regeringens-politik/transporter-och-infrastruktur/mal-for-transporter-och-infrastruktur/)
System Edström. (n.d.). *System edström.* (https://systemedstrom.com/)
Transportstyrelsen. (n.d.-a). *Bonus malus-system för personbilar, lätta lastbilar och lätta bussar.* (https://www.transportstyrelsen.se/bonusmalus)
Transportstyrelsen. (n.d.-b). *Personbil.* (https://www.transportstyrelsen.se/sv/vagtrafik/Fordon/Fordonsregler/Personbil/)
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. doi: 10.1002/bse.414
Tukker, A., van den Berg, C., & Tischner, U. (2006). Product-services: a specific value proposition. *New business for old Europe. Greanleaf Publishing Ltd, Sheffield*.
Ullrich, K., & Eppinger, S. (2016). *Product design and development.* 2 Penn Plaza, New York, NY 10121: McGraw-Hill Education.
Uppsala Bilgalleri. (n.d.). *Skräddarsydda skåp och inredningar.* (http://uppsalabilgalleri.se/sektion/skraddarsydda-skap-och-inredningar/)
VW-transportbilar. (n.d.). *Abt e-transporter.* (https://www.volkswagen-transportbilar.se/sv/innovationer-och-teknik/elbilar/modeller/abt-e-transporter.html?gclsrc=aw.ds&gclid=CjwKCAjwwMn1BRAUEiwAZ_jnEv1cfjYgAJG0x5oPQpBBnOCad7nfwVL6GvnyOaWX8-6UsjRluF1hcBoCwHUQAvD_BwE&gclsrc=aw.ds)
Wallin, J., Parida, V., & Isaksson, O. (2015). Understanding product-service system innovation capabilities development for manufacturing companies. *Journal of Manufacturing Technology Management*.
Weimer, G., & Seuring, S. (2009). Performance measurement in business process outsourcing decisionsinsights from four case studies. *Strategic Outsourcing (17538297)*, *2*(3), 275. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edb&AN=70875962&site=eds-live&scope=site&custid=s3911979&authtype=sso&group=main&profile=eds
Whelan, T., & Kronthal-Sacco, R. (n.d.). *Research: Actually, consumers do buy sustainable products.* (https://hbr.org/2019/06/research-actually-consumers-do-buy-sustainable-products)
Wirth, S., Eimler, M., & Niebling, F. (2014). Thermal insulation of electric vehicle cabins. *Auto Tech Review*, *3*(1), 44. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edo&AN=ejs31960568&site=eds-live&scope=site&custid=s3911979&authtype=sso&group=main&profile=eds
WLTPFacts. (n.d.). *What is wltp and how does it work?* (https://www.wltpfacts.eu/what-is-wltp-how-will-it-work/)
Work System. (n.d.). *Work system.* (https://www.worksystem.se/)
Wątróbski, J., Małecki, K., Kijewska, K., Iwan, S., Karczmarczyk, A., & Thompson, R. G. (2017). Multi-criteria analysis of electric vans for city logistics. *Sustainability*(8), 1453. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&AuthType=sso&db=edsdoj&AN=edsdoj.91f1b746d5c497498a767be8d89a605&site=eds-live&scope=site&custid=s3911979&authtype=sso&group=main&profile=eds

Appendices

Appendix A

Appendices

A.1 Pre-study

A.1.1 PEST

Figure A.1: Eur vs NOK (2020-02-04)(EuropeanCentralBank, n.d.)

Figure A.2: Eur vs SEK (2020-02-04)(EuropeanCentralBank, n.d.)

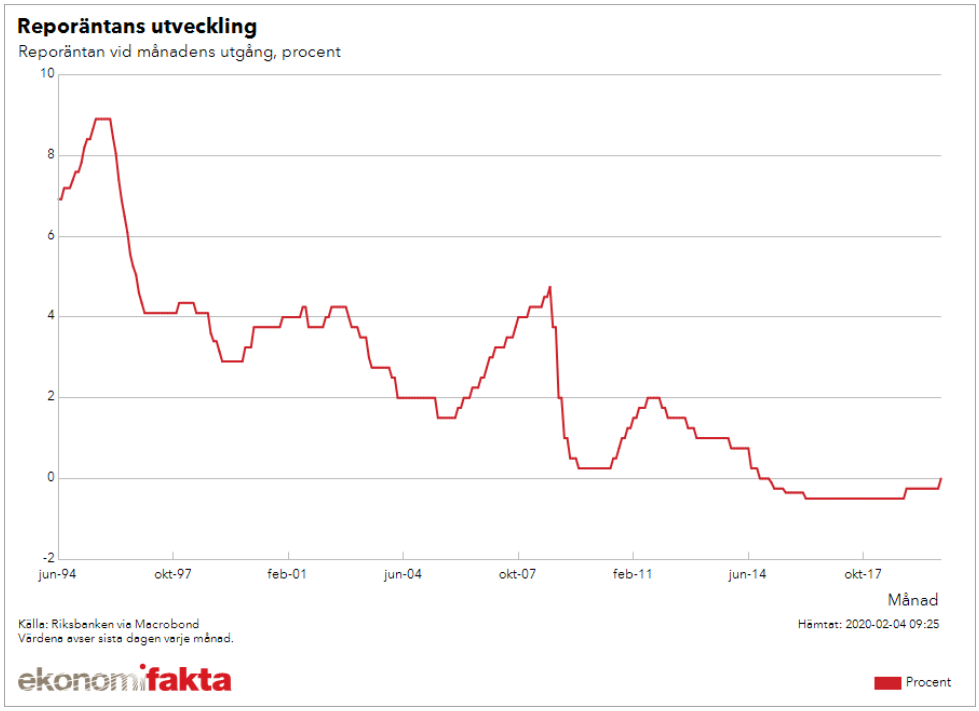

Figure A.3: Prime rate (Reporänta) Sweden (2020-02-04) (Carlgren, n.d.)

A.1.2 Online sales tools of the competitors

Here, the different sales tools of the competitors are described.

Work System's online order system

On Work System's website (www.worksystem.se) it is possible to quickly order a system directly from the front page. The first step is to chose car brand, model, year and possibly door configuration. After this step different standardized kits are shown for the left and right side of the vehicle respectively. At this page various accessories can also be added to the cart. All kits and accessories have clearly specified prices as well as weights. In the cart the customer can also chose additional services such as system pre-mounting and installation in the vehicle. (Work System, n.d.)

System Edströms online drawing tool

On their website (www.systemedstrom.com) it is possible for the customer to use a drawing tool in order to visualize and measure different racking/shelving configuration in a 3D set-up. In the tool the first step is to choose the right vehicle brand, model and door configuration (right, left or both). From this point the customer can choose different already finished racking configurations and place them on the left or right side in the loading compartment. Some finished configurations also exists that are placed underneath the floor. Once the right configurations have been chosen the customer can mark each component in the configuration and see its dimensions. From this point the customer can also modify the configurations and for instance add shelves and additional equipment. (System Edström, n.d.) .

Sortimo's Online configurator tool

The tool consists of the following steps: 1. Chose car brand and model, 2. Add vehicle details (door configurations, vehicle length, height etc.) and 3. Chose profession (carpenter, painter, electrician etc). Once these three steps is done one can chose to either get a van racking configuration suggestion based on the first three steps or to begin with an individual customized configuration. If you chose the later one you will start to see the loading area of the van as a 3D-model. There are now there are 4 tabs you can select: 1. Loading area - Here you can select if you want to have a customized floor 2. Configuration - Here you select the were you want to have the base of your racking system (left right). Once this is done each racking system can be modified with different shelves, boxes etc. You drag and place them were you want to have them. 3. Accessories - Here you can add and place additional equipment to your van. 4. Overview - Here you will see all equipment you have selected and the specified and total price. The total weight of all equipment can also be seen in this tab. (Sortimo, n.d.).

Bott's Online tool

The first steps in Bott's online tool is similar to the tools above. First vehicle brand, model and configuration (door left or right) is selected. Then the customer can either get a standard racking system package depending on the trade (plumber, electrician and more) or chose to do a custom racking system. Once this step is done additional accessories

can be added. The last step is then a summary which shows the specified prices for the racking system (Bott, n.d.)

A.2 Concept generation

A.2.1 Iteration 2

Re-use

Sub functions	Sub solutions				
Service-specific					
Sales new system	In house				
Sales old system	Same function as new system sales	Different function but in house	Outsource	Utilise existing online marketplace	
Manufacturing	Same as before, in house + outosurce				
Storage of new systems	Outsource + in house				
Storage of second hand systems	Outsource	In house	At old customer		
Second hand system installation	Utilise same in house resources	Utilise same partner resources	Develop new inhouse resources	Create new partner relationships	
New system installation	In house + partners				
Disassembly	Utilise existing in house installation resources	Utilise existing partner installation resources	Develop new inhouse resources	Create new partner relationships	
QC used product	Ín house	Outsource	Let hand in customer QC	Let buying customer QC	
Touch up used product	In house	Outsource			
Transfer old product	Utilise existing in house installation resources	Utilise existing partner installation resources	Develop new inhouse resources	Create new partner relationships	
Recycle old product	In house	Outsource	Customers responsibility		

Table A.1: Morphological matrix for sourcing options re-use