Reverse Logistics in Supply Chain Management

Assessment of Reverse Logistics Maturity Level at Ericsson

Master's thesis in Supply Chain Management

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SUMMARY
The world is facing a climate change and actions to tackle this challenge must be taken. The currently dominating, linear, take-make-dispose business model, leading to resource depletion must be avoided to start respecting the planetary boundaries and acting more sustainable. Actions to close the supply chain loop and transform towards circular business to become more sustainable, has recently gained increased attention. Reverse logistics is a key enabler to make such transition.

This master's thesis aims to investigate how the reverse logistics can be improved at Ericsson, in order to reach a higher level of circularity. The higher level of circularity should decrease the environmental impact without negatively affecting the business. The study relies on a qualitative approach aiming at identifying the current reverse logistics process and at suggesting improvement areas for Ericsson to reach a higher level of maturity. To enable a transition from a linear business approach, several improvement areas have been taken into consideration. The findings indicate that a radical organizational change is needed. Instead of focusing on fragments of circularity, transformation into a circular business approach requires a holistic perspective. This also includes a more use-oriented business approach with increased reuse and refurbishment requiring local market presence. Additionally, to achieve the Circular Business goal, Ericsson's internal processes and units need to focus on developing an integrated approach aiming at adapting the modular product design to reduce waste.

Based on the conclusions, Ericsson is suggested to advance the aim of its Circular Business initiative into:

To find synergies in minimized waste, scrap, and consumption, to enhance a long-term strategy with product modularity integrated in the product design, and to simultaneously increase the performance of buy back, take back, reuse and refurbishment activities.

Keywords: Circular economy, Sustainability, ICT industry, Reverse logistics, Maturity level, Refurbishment, Use-oriented business model, Modularization, Cross-functional teams, Integration of Business systems

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1 Introduction

This master's thesis has been performed in collaboration with Ericsson AB, specifically the division Ericsson Networks which is one out of four divisions at Ericsson AB. Ericsson Networks is one of the leading actors in the information and communication technology (ICT) industry, and provides both hardware and software to a global market, with competitive performance. Ericsson AB and the division of Networks will throughout the report be denoted as Ericsson.

As sustainability has become an increasingly critical area in managing supply chains globally (Boström et al., 2015), Ericsson invests greatly in aligning their business strategy to also be competitive in field of sustainability. This organizational effort has so far resulted in being awarded the 12^{th} most sustainable organization in the world by the Wall Street Journal (Ericsson, 2021). The effort regards the triple bottom line consisting of environmental, economic, and social aspects (Mariadoss et al., 2015). The internal sustainability target is to be carbon footprint neutral at latest 2030. To increase the sustainability focus in the entire supply chain and develop its role as a leading actor within the field of sustainability, Ericsson wants to investigate the reversed flow of goods from its customers.

1.1 Background

Since 1987, when the Brundtland report was published, sustainability has gained increased attention (Barkemeyer et al., 2011). The ongoing emissions of greenhouse gases are threatening the climate and thus negatively impact the humanity (Mora et al., 2018), in combination with increased awareness of the environmental crisis and the Paris Agreement of reducing the greenhouse gas emissions by 30 percent from 2005 until 2030, has increased the focus of sustainability even more (Horton & Horton, 2019). Some of the greatest potential contributions to sustainability have been found in supply chain management which can be seen by the large number of articles that has been produced and published within this certain field (Quarshi et al., 2016).

The world is changing due to a rapid increase of population globally, which has resulted in accelerating development of technology as well as production and consumption of products with short life cycles (Waqas et al., 2018). These changes can also be noted in the industry for ICT products and services and Karlsson and Torfgård (2020) state that the demand, consumption, and use are increasing in this industry.

Ericsson has today a broad global customer base with varying demand. Some customers in developing countries still require cheaper and well-tried alternatives such as 3G solutions, while other customers in more industrialized countries to a greater extent demand the newest contribution of technology to the market, i.e. the faster 5G solutions. As customers demand new products with higher speed and better technology, products get outdated faster. Due to this change in customer behavior, Ericsson has started to replace the traditional, linear business model and moving towards a circular model including reuse, refurbishment, and recycling of products in order to become more sustainable. Vereecken et al. (2010) mean that the circularity has high relevance in the ICT business as the products contain heavy metals as well as other scarce natural resources. This is further where Ericsson has noted the largest numbers of carbon footprint throughout the supply chain and thus want to reduce.

The environmental opportunities from a circular approach is however not only reduction of primary material consumption, but also reduced emissions, and especially carbon emissions (Ellen MacArthur Foundation, 2015). Ericsson aims to reduce its environmental impact in the supply chain as well as increase the sustainability awareness, by adopting a circular economy approach. To implement a circular business model will moreover be a step in the right direction and contribute to Ericsson's overall sustainability target of becoming carbon neutral in 2030. In order to reach the overall sustainability target, Ericsson has set up yearly objectives for 2020, 2021 and 2022 within three areas, namely *Engagement*, *Climate Action* and *Circular Business*. The most relevant objectives for this thesis, presented in *figure 1*, are related to the area of *Circular Business*.

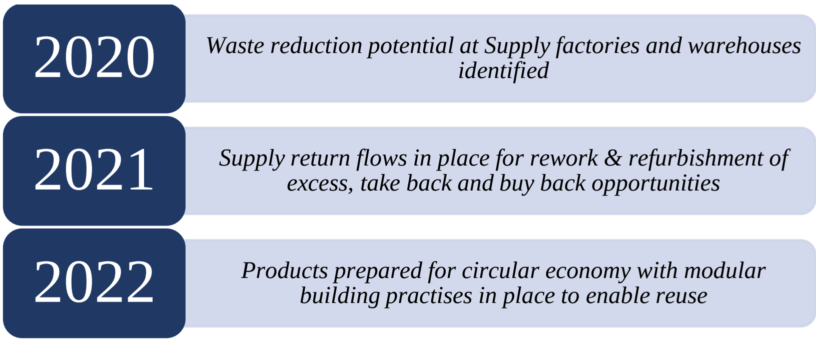


Figure 1: A presentation of the yearly circular economy objectives until 2022

Ericsson started to offer their customers refurbished spare parts in 2019 to both create customer value and increase the possibility to become more sustainable through increased circularity. The offer is focusing on excess of inventory, reuse, take back, buy back, and refurbishment of spare parts from already used equipment, in order to utilize materials in a more efficient way and thus supporting the *Circular Business* initiative. Currently, product recovery practices and development of supply chains with no waste have gained increased attention from many companies (Waqas et al., 2018). Waqas et al. (2018) further explain that many companies are encouraged to produce more environmentally friendly products due to globalization policies and to entail more sustainable competitive advantages. However, a circular business model brings higher pressure on the reverse logistics (Waqas et al., 2018), which is an unexplored area at Ericsson, however a key enabler when moving from a linear to a circular business model (CE100, 2016; Waqas et al., 2018).

Waqas et al. (2018) state that reverse logistics is an essential part of businesses, but also to the society as a whole from a sustainability perspective. The reverse logistics considers the flow of used products from the point of consumption, back to the production site (Waqas et al., 2018) and is thus closing the supply chain loop. As reverse logistics is considered to be a key enabler to enhance as well as accelerate and scale up the circularity (CE100, 2016), improvements in this area would be helpful to reach a higher maturity level of the circularity as well as reduce the carbon footprint. As the reverse flow of refurbished spare parts at Ericsson is in its infancy and not yet fully aligned into the overall business strategy, there are various challenges to overcome to move towards a higher level of maturity.

1.2 Aim

The aim of this master’s thesis is to investigate how the reverse logistics can be improved in order to reach a higher level of circularity. The higher level of circularity should decrease the environmental impact without negatively affecting the business.

2 Framework

The framework is based on previous research within the identified key areas needed to fulfill the aim of the thesis. The chapter starts with an overview of sustainability, circularity, reverse logistics followed by a model to identify the maturity level of the current reverse logistics as well as possible improvements. Thereafter, theoretical areas that could enhance the circularity is covered. The framework ends with a synthesized problem discussion followed by three research questions.

2.1 Sustainability

The area of sustainability has gained increased attention during the recent years and is currently further increasing. Already in 1987, the Brundtland report published a definition of sustainable development which is still used today.

"Sustainable development is a development that meets the need of the present without compromising the ability of future generations to meet their own needs"

Sustainable development is largely incorporated into the idea of triple bottom line described by Elkington (1998). The triple bottom line includes three different aspects of organizational sustainability, namely environmental, social, and economic performance. Where these three overlaps, see *figure 2,* the company fulfill sustainability in all the three aspects simultaneously.

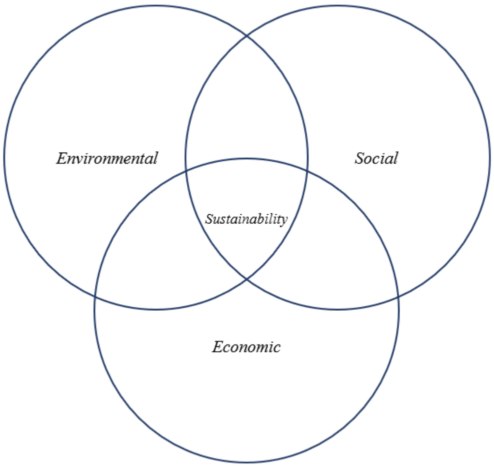


Figure 2: The Triple bottom line

The need of a transition to more sustainable systems are urgent (Geissdoerfer et al., 2017). The environmental aspect is covering challenges including loss of biodiversity, pollution of water, air and soil, resource depletion and excessive land use. Related to the social aspect many of the societal expectation are not met globally. Lastly, there are economic challenges related to for example problematic owner structures and supply risk. One potential way to address these and other sustainability challenges is through circular economy, a not entirely new but arising concept which has recently gained increased attention (Geissdoerfer et al., 2017). However, Kircherr et al. (2017) mentions that the main focus in circular economy often is limited to the environmental and economic aspects, and thus most often not covering the social aspects.

2.2 Circular Economy

The topic of circular economy has gained increased attention in the last years and has become a way for companies to act more sustainable (Urbinati et al., 2017). The purpose of the circular economy is to transform the traditional, linear, take-make-dispose consumption model (CE100, 2016; Ellen MacArthur Foundation and Material Economics, 2019), into a closed system where resources are reused, refurbished or recycled where energy can be conserved (Urbinati et al., 2017). CE100 (2016) explain the linear model to be directed towards resources depletion. The planetary boundaries must be respected, and the choice of materials must be rethought (CE100, 2016)

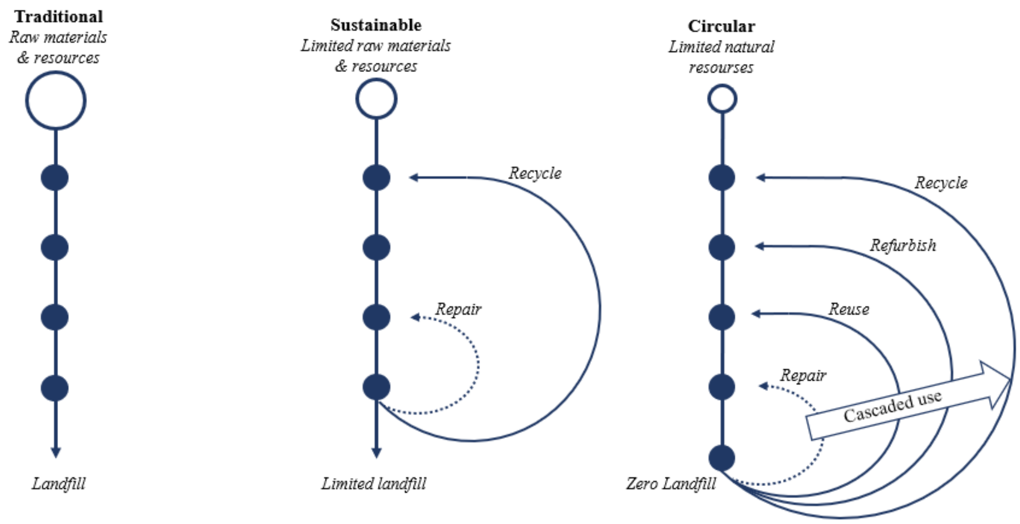
Defining the concept of circular economy has been proved to be a challenging task with no single common definition (Kirchherr et al., 2017; Merli et al., 2018). Merli et al. (2018) states that the continuous development of a rather new concept is a possible explanation to the large amounts of definitions of circular economy. Additionally, the concept is used by a range of various stakeholders in different industries and in academia. However, it is important to have a common definition of circular economy adapted to the context where it should be used (Moraga et al., 2019).

For this thesis, the definition of circular economy developed by Geissdoerfer et al. (2017) combined with a definition from de Angelis et al. (2018) will be used, since these definitions are based on contributions from several different authors in order to capture different perspectives of the concept, and thus to make it suitable for the case company. Geissdoerfer et al. (2017, s. 759) describe circular economy as:

"A regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling".

This definition corresponds to the definition of de Angelis et al. (2018), which yet includes an extensive elucidation of multiple elements that creates value in circular economy and thus what opportunities and challenges a transition from a linear or sustainable economy brings. *Figure 3* shows how the traditional, sustainable, and circular economy differs. However, it is argued that circular economy is about elimination of waste, where material can be handled in biological- and technical cycles. The transition from a traditional and thus from the sustainable supply chain is vast (de Angelis et al., 2018).

The aim of accomplish a transition from a linear- to a circular economy is to enable increased circularity of materials, which involves prolonging the life span of materials in use. By extending the duration of the products and extend the number of cyclic iterations, the possibility to remanufacture, repair, refurbish and to recycle the products increases (de Angelis et al., 2018). Further, de Angelis et al. (2018) express that the *"powers of the inner loop and of circling longer"* are of importance when managing the products containing serviceable-, yet also consumable components. Achieving a circular economy with consumable components with short life cycles, requires the material to originate from elements that easily can return to nature without damage, i.e. non-toxic and biological substances. However, the possibility to extend the life span for several durable materials such as metals, which are not able to return to nature to the same extent as the consumable ones, are enabled through reparation, reuse, recycling, refurbishment (de Angelis et al., 2018), as shown in *figure 3*.



	Traditional supply chain	Sustainable supply chain	Circular supply chain
Strategy	Component price	Cost of ownership	Leasing and service outcome
Structure	Linear and open	Partially closed	Closed, short and cascaded loops
Flow	Input-output	Mixed throughput	Biological and technical cycles
Focus	Efficiency	Customer effective	Collaborative value capture
Scale	High volume	High-medium volume	Medium-low volume
Scope	Global	Global and regional	Regional and local

Figure 3: Traditional, sustainable and circular economy, based on de Angelis et al. (2018)

Correspondingly, to reach a higher level of circularity in the business model of the durable products, leasing-, sharing- or renting offers must be introduced. This implies going from a linear approach with traditional sales offerings, towards a circular business approach where the customers solely pays for what they get, and the company possess the ownership that comes with costs of maintenance and repair (de Angelis et al., 2018). Yet, consequently of the costs, new opportunities of development and system upgrade comes, leading to increased efficiency of material usage and prolonged life span of products.

Owning the products further gives the advantages of established control of the material flow, which today's highly advanced technology (de Angelis et al., 2018) such as ERP systems, RFID, and IoT (Tavana et al., 2020) can facilitate and support in large scale (de Angelis et al., 2018). These systems have the ability to monitor performance during the product's life cycle as well as tracking (Wortmann & Flüchter, 2015; de Angelis et al., 2018) and tracing (Tavana et al., 2020) and can also facilitate increased usage of resources throughout the supply chain. Correspondingly, increased control could give the benefits of firmer relationships with customers resulting in long-term recurring business deals as a competitive advantage (de Angelis et al., 2018).

Urbinati et al. (2017) mention four different key principles of circular economy, which are extending the product lifetime, reuse and redistribute, remanufacturing and refurbish and lastly, recycling. Product life extension reduces consumption through designing more durable products with longer lifetime. If redistributing or reusing a product, all added value is instead preserved within the product. Remanufacturing or refurbishment of a product refers to products that cannot be directly reused but must go through a series of manufacturing steps to become as new or an even better product with the same warranty as a new product. Further, recycling refers to the process when used materials are processed to make them both possible and suitable to reuse in a new product. Urbinati et al. (2017) further explains that the most sustainable products are the ones that are already produced.

In contrast to the linear consumption model, where products are considered to be waste after being consumed, the four principles explained above underline the aim of the circular economy, namely how to use products and material efficiently in order to keep them in the economy for as long as possible and thus minimize waste (Urbinati et al., 2017). When having a closed loop instead of an open loop system, resources are maintained in then loop and generate more value in a longer period.

Further, when a company decides to implement circularity in their business, it is not only the business models but also the entire supply chain that have to be changed (Lüdeke-Freund et al., 2018). As mentioned above, a circular business model is about closing the traditional open consumption model. The same goes for the supply chain, when going towards a circular business model, the supply chain-loop must be closed. Therefore, not only the forward, but also the reverse supply chain, must be considered, which is referred to a closed-loop supply chain. In *figure 4,* not only the forward, but also the reverse part of the loop is considered. The figure further shows how the already used products, components and materials that in the linear model was considered to be waste, can be taken back, be processed and act as an alternative supply source in the production process (Habibi et al., 2017).

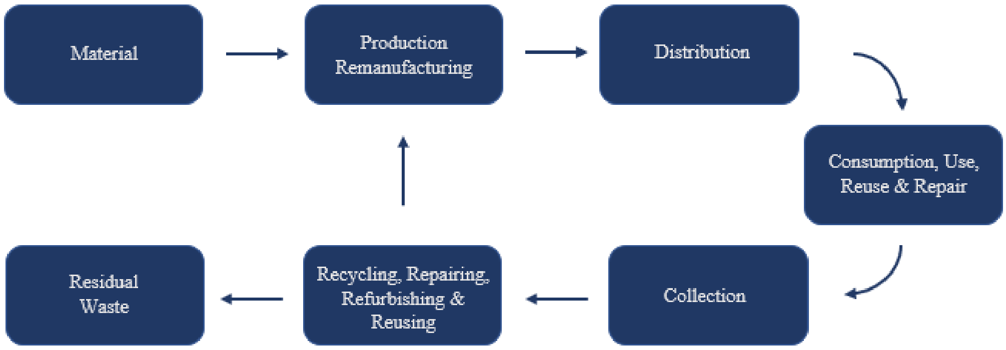


Figure 4: Cycle of Circular Economy based on (Habibi et al., 2017)

Circular economy offers integration between sustainability and business development and is currently very attractive to industrial companies. According to Ritzén and Sandström (2017), such integration is critical to many companies due to the ongoing and extended resource consumptions above the world limits and that are creating negative environmental impacts (Ritzén & Sandström, 2017). However, the circular economy is rarely implemented in practice, and often only fragmentally, if at all, implemented. This is probably due to that the transition from a traditional linear model to a circular economy model requires radical changes, time and effort (Ritzén & Sandström, 2017).

2.2.1 Closed-Loop Supply Chain

When integrating the traditional forward supply chain with the reverse supply chain, i.e. the supply chain for product returns, a closed-loop supply chain is created (Schenkel et al., 2015). Thus, Schenkel et al. (2015) argue that a closed-loop supply chain is created when the forward and reverse supply chain get incorporated and interacts. Govindan et al. (2015) explain the concept of closed-loop supply chains similarly to Schenkel et al. (2015), as when the forward and reverse supply chains are simultaneously considered. To further explain the concept of closed-loop supply chain Guide Jr. and Van Wassenhove (2009, s. 10) define it as:

"The design, control, and operation of a system to maximize value creation over the entire life cycle of a product with dynamic recovery of value from different types and volumes of returns over time"

The closed-loop supply chain aims to close the resource loop to reach higher material efficiency as well as create and capture additional value (Guide Jr. & Van Wassenhove, 2009). The closed-loop supply chain can thus be considered to be sustainable in both the environmental and the economical aspect (Guide Jr. & Van Wassenhove, 2009).

2.2.2 Reduce emissions through Circular Economy

The linear, take-make-dispose business model is heavily extractive, resource incentive and produces greenhouse gases which in turn negatively affect the climate and contributes to the climate crisis (Ellen MacArthur Foundation and Material Economics, 2019). The linear companies extract materials from the earth and uses energy and labor to manufacture the products. The products are then sold to the end-users who scrap the product when it is no longer needed or not fulfill its purpose.

The public awareness of the global climate change has recently increased (Kannan et al., 2012). Thus, industries must have proactive policies and action plans in place to handle the climate change. The principles related to having a circular economy entails unique opportunities to tackle the current climate crisis. The movement towards a more circular model reduces the greenhouse gas emission along the entire supply chain, both through preservation of energy by using already produced products and material, and by minimizing waste through higher utilization of the materials and products (Ellen MacArthur Foundation and Material Economics, 2019). More specifically, Ellen MacArthur Foundations and Material Economics (2019) explain that when having a circular approach, energy is sourced from renewable sources, materials are increasingly sourced from renewable sources and lastly, through superior design of not just materials and products, but also the business model, waste can be avoided.

The ongoing climate crisis that are characterized by issues related to resource scarcity and climate externalities have been worsened by companies and entire industries that have adopted linear models (Ellen MacArthur Foundation, 2015). Furthermore, companies that use the traditional linear model, contribute to landfills and emission that not only hurt the planet, but also the people. Ellen MacArthur Foundation (2015) instead argues that companies should strive to adopt the circular approach that bring opportunities for reduce emissions, especially carbon emission, and primary material consumption. Furthermore, the circularity would help to preserve and improve land productivity as well as reduce the negative externalities.

2.3 Reverse Logistics

Looking back a few decades, Rodrigue et al. (2001) describe the traditional management of logistics to predominantly focusing on the forward flow facilitated for manufacturing to consumer. As the environmental issues started to come to light in view of global warming and pollutions, companies have started to include environmental aspects in their priorities due to legal reasons but also to get competitive advantage. This has resulted in new markets of disposals and recycling and opened for a new component in the supply chain, i.e. reverse logistics (Rodrigue et al., 2001). De Brito and Dekker (2004) argues that reverse logistics is a key component to succeed in a modern supply chain, where some companies are forced to introduced take back processes and others implement reverse logistics in order to act proactively and not lose the value of material that are sent back. Reverse logistics is according to CE100 (2016) considered to be a key enabler in transforming into a circular business and requires the flow of material and products as well as the management of waste to be performed efficiently. Sun (2016) agrees with this argument by correspondingly describe the reverse logistics to be optimal when utilizing all the resources and can be a vital component in the development of becoming more sustainable. Thus, sustainable reverse logistics is described by Sun (2016) as:

"Sustainability-oriented reverse logistics refers to the reverse logistics system that regards sustainable development as its aim and relies on the circular economy framework and green logistics to recycle and reprocess the waste in an efficient and circular manner"

According to Guide Jr. et al. (2003), Blackburn et al. (2004), and Defee et al. (2009), reverse logistics is considered to be one of the five main processes of a reverse supply chain, namely *product acquisition, reverse logistics, inspection and disposition, remanufacturing* and *remarketing*. Fleischmann et al. (2000) instead described the activities in reverse logistics to be *collection, inspection and separation, reprocessing and disposal* and *redistribution*. Other authors, as for example Govindan et al. (2015) use the concept of reverse supply chain and reverse logistics interchangeably. However, in this thesis the reverse logistics activities described by Fleischmann et al. (2000) has been adopted.

2.3.1 Driving Forces

Reverse logistics is becoming a more commonly used practice in order to close the loop and become circular. However, due to different contexts there are several reasons for why companies implement such activities into the supply chain (de Brito & Dekker, 2004), e.g. different types of material requirement but also the willingness to reuse, dispose, get rid of excess inventory (Akdoğan & Coşkun, 2012). De Brito and Dekker (2004) mentions three main categories of driving forces included in reverse logistics, illustrated in *Figure 5*. These are economic benefits, legal reasons or by contributing to a better future, i.e. social and environmental matters denominated as corporate citizenship. These categories are partly overlapping and not distinctly separated (de Brito & Dekker, 2004). As companies are responsible for their own activities and actions, and thus the consequences of them (Akdoğan & Coşkun, 2012), these areas of driving forces are important to consider.

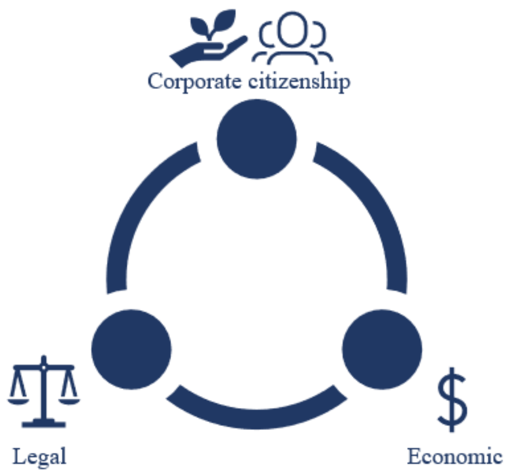


Figure 5: Driving forces of Reverse Logistics

Economic benefits

The economic benefits can be both short- and long-term and can thus, depending on the situation, differ in what strategy to utilize (de Brito & Dekker, 2004; Akdoğan & Coşkun, 2012). The short-term gains can result from decreased utilization of raw material, as well as through diminishing the cost of disposal or by reusing components with value from returned end-of-life products. The long-term benefits are rather a strategic move to prepare for the future (de Brito & Dekker, 2004). Akdoğan and Coşkun (2012) agrees with this, and further argue for several factors affecting the economic aspects of the business. These can be to obtain spare parts that holds value, by assimilating the products and components on the secondary market with indirect financial gains, or to meet the market expectations of having an environmentally conscious image for long-term competitive marketing strategies (Akdoğan & Coşkun, 2012). Further, Sun (2016) argues that reverse logistics more lately has gotten increased attention, as it can be utilized to gain competitive advantage in image, especially in monetary terms. However, to invest in reverse logistics can be for competitive reasons, as competitors can take advantage from the company's products on the secondary market (Akdoğan & Coşkun, 2012). When supplying a global market, Akdoğan and Coşkun (2012) argue for the importance of taking environmental legislation as well as upcoming legislation into account for long-term strategic and economic reasons, as several countries charge manufacturers if not having take back possibilities in place. Yet, Blackburn et al. (2004) argue that executive management in companies predominantly focuses on the forward flow to gain competitiveness. It is thus a missed opportunity to gain from the reversed flow of products, which could increase profitability if managed efficiently. However, to gain from the reverse supply chain, the remanufactured products and spare parts must decrease in price at the same time as the value of the goods decreases due to the long lead time of the reversed flow. However, it is possible to affect and shorten the lead time of the reversed flow which can contribute to increased recovery of assets in terms of reducing the loss of time and thus counteract the products becoming obsolete (Blackburn et al., 2004).

Legal reasons

Currently, manufacturing companies are held responsible for take back activities to a large extent due to environmental legislation (de Brito & Dekker, 2004; Akdoğan & Coşkun, 2012). As legislation can cause higher costs for companies when enter into force, customers can be required to cover these costs as companies often treat environmental aspects as cumbersome activities, not as opportunities to gain competitive (Guide Jr. et al., 2003). Legislation of environmental aspects can thus be a vital necessity or even a must in those cases where companies put effort into becoming viable in their business models without success (Guide Jr.

et al., 2003). From 1990 until 2018, the EU with its framework of comprehensive regulations and policies has reduced pollution and emissions by 23 percent and at the same time enabled the economy to grow significantly (European Commision, 2020). However, to reach the goal of Europe becoming a climate neutral continent by 2050, EU has a long journey ahead (European Commision, 2020). The goal is supported by the European Council, The European Parliament and also goes in line with the objectives of the Paris agreement (European Commision, 2020) which enhance the process of becoming climate neutral.

Corporate citizenship

As reverse logistics has gotten increased attention the last decades, corporate citizenship has become more important and refers to what companies' value and what principles they have in order to act responsibly (Akdoğan & Coşkun, 2012). Acting responsibility includes subordinate to the law as well as meeting the consumer requirements in terms of being environmentally friendly. To have higher awareness of the customers with regard to the reversed flow of refunds or customer returns gives greater opportunities to affect the business positively in image (Akdoğan & Coşkun, 2012).

2.3.2 Reasons for Customer Returns

There are several reasons for customer returns. Roughly the returns can be divided into returns of products that no longer function properly or returns as the product's function no longer is needed (de Brito & Dekker, 2004). Furthermore, there are different reasons for companies to take back products, some companies are forced to take the products back and some take- or buy back the products as there is still a high value to profit from.

Customer returns are initiated by the end customer and can occur due to different reasons. De Brito and Dekker (2004) mentions five different types of customer returns, namely B2C commercial returns, warranty returns, service returns and returns due to products have reached the state of end-of-use or end-of life.

2.3.3 Reverse Logistics Activities

Fleischmann et al. (2000) describes the different activities that are included in reverse logistics in order to recover the value of the returned products. The activities further explained below are collection, inspection and separation, reprocessing and disposal, and redistribution.

Collection

The first activity is the collection, covering all steps that are necessary to collect the used products as well as physically moving these products to a point where further treatment is performed (Fleischmann et al., 2000). The most common components included in the collection activity is purchasing, transportation and storing. These activities can partly be established due to certain legislation such as company responsibility for packaging material or take back obligations.

Goltsos et al. (2019) describe three important dimensions of the collection, firstly to incentivizing returns, secondly to design the channel for the collection and lastly, presorting of the goods. Incentivizing the returns is important to receive products to the supply chain and back to the company again. It could however be challenging to persuading customers to return the products and if the customers discard the products or keep and never return the products to the supply chain, the value of designing for reuse and recovery is very low (Ellen MacArthur Foundation, 2020). Reward and convenience are two commonly used key motivators to incentivize customers mentioned by Malmgren and Mötsch Larsson (2020). Related to reverse logistics this could be interpreted as a system where customers are getting rewarded for returning products or a convenient process making it as simple as possible for the customer to return the product.

Goltsos et al. (2019) describe designing the collection activity as a challenging task due to uncertainties both in terms of when and if products will be returned and how many that will return. Furthermore, to design and operate efficient collection process both quantity and timing of the returns must be estimated or, if possible, tracked.

Presorting of the goods is to assess the product quality and then divided them into different remanufacturing options to make recovery process as efficient as possible. The presorting could either be a part in the collection activity or in the following step of inspection and separation (Goltsos et al., 2019).

Inspection and Separation

The inspection and separation activity includes all needed operations to assess the current quality of the returned product and determine if the returned products are reusable and, in that case, how the products could be reused (Fleischmann et al., 2000). In order to perform an accurate inspection, operations as disassembly, shredding and product testing might be needed. When the quality and reusability of the returned products has been measured and assessed the flow of returned products are separated into the recover or disposal option considered to be the most suitable (Fleischmann et al., 2000). According to Blackburn et al. (2004) the separation activities aim to make the most profitable and suitable option of disposition. The separation of the flows might include activities as sorting and storage of the products or components. The inspection and separation activities can be made at different points in the reverse flow, often it depends on the centralization or decentralization in the flow. When having a more centralized model, the phase is carried out later than if instead having a more decentralized model.

Evaluating the products at an early stage in the return process could be helpful to limit the reverse logistics flow to only include materials and products that can be recovered (Ellen MacArthur Foundation, 2016). By performing an in-depth inspection at this early step would enable separation of the products to handle the flows more efficiently and use operations adjusted to the characteristics of that specific flow. Blackburn et al. (2004) however argue that the inspection could be performed either at an early or a late stage depending on what type of products that is handled. The products are divided into functional and innovative products. Functional products are less time sensitive than innovative products and thus has a lower marginal value of time. The nature of innovative products is instead short life cycles and high time sensitivity. For the functional products an efficient reverse supply chain is beneficial even though speed is lower prioritized to reach cost efficiencies while for the innovative products a responsible reverse supply chain at higher speed but achieved at a higher cost is favorable. In an efficient reverse supply chain, the inspection should be performed centralized at a later stage to gain economies of scale in both transport and reprocessing of products while a responsive reverse supply chain requires decentralized inspection at an early stage to gain responsiveness and quick reprocessing of the returns (Blackburn et al., 2004).

Reprocessing and Disposal

The activity of the reprocessing refers to the actual transformation from the returned, used product into being a “new” usable product (Fleischmann et al., 2000). Based on the previous phase, different recovery options including, refurbish, repair and recycling could be considered more or less suitable. Additionally, Sahyouni et al. (2007) and Thierry et al. (1995) mentions reuse and repackaging as different recovery processes. Fleishmann et al. (2000) further mentions cleaning, reassembly and replacement as activities that are performed in this step.

Disposal are needed for products that for some reason cannot be recovered or recycled. The reason for a disposal could be either technical or economical (Fleischmann et al., 2000). Products that are rejected due to excessive requirements in the recovery or has no or low level of potential in remarketing. This step might include activities as incinerations, landfilling and additional transportation.
The aim of the circular economy is to recapture value from returned products and to avoid improper disposal. Fleischmann et al. (2000) argue that companies mut have resources to handle lager volumes of products and the ability to recapture value in an efficient way. The quality of the products is a determining factor in what recovery option is most suitable, and thus the inspection of the quality and separation of products into different flows is a prerequisite to perform the reprocessing activity in a proper and efficient way.

Redistribution

This activity aims to bring the reused products to the potential market by activities as sales and leasing, marketing, transportation, and storage (Fleischmann et al., 2000). The redistribution is, just as the traditional distribution networks in a forward flow, characterized by few origins and many destinations (Fleischmann et al., 2000). In order to decide the value of the product recovery, the company have to make sure that there is a market for the recovered product, and thus, the remarketing of the recovered products is included in the redistribution phase (CE100, 2016). It is important to understand that customers will perceive the value of the recovered products in different ways, affecting their willingness to pay. If using recovery and remarketing data the remarketing process could be improved and variations could be predicted (CE100, 2016). By using the understanding of customer value, and the recovery and remarketing data, the remarketing planning can be performed properly, recovered products can quickly be returned to the market and the customer behavior could positively be affected (CE100, 2016). Additionally, recovered products can be offered to a lower price which provides the company with an opportunity to reach a new customer segments of more price sensitive customers.

2.3.4 Reverse Logistics Challenges

Reverse logistics is not as simple as just to manage the forward logistics in the opposite direction and brings great challenges that must be tackled in order to become successful (Sangwan, 2017). Tibben-Lembke and Rogers (2002) further underlines this statement by explaining that reverse logistics is not just about driving the trucks in the reverse direction.

Defee et al. (2009) presents the five key processes in a reverse supply chain and highlights the challenges related to each of these processes. First in relation to the collection, there is a high uncertainty both in timing and volume of the returns, which further leads to the next challenge that it is difficult to forecast the returns (Tibben-Lembke & Rogers, 2002; Defee et al., 2009). The difficulty regarding forecasting is not only due the high uncertainty, but also because it is the customer who initiate the return (Tibben-Lembke & Rogers, 2002; Srivastava, 2013). However, in some cases the reverse flow of products can be predicted from the forward flow with some time-lag. Furthermore, Defee et al. (2009) mean it is difficult to achieve visibility in the returns and it is hard to match the return to an original purchase order.

Further challenges related to the collection is that it is hard to achieve economies of scale in the return flow (Defee et al., 2009), as the goods are flowing from many origins to one destinations (Tibben-Lembke & Rogers, 2002). A solution to the many-to-one transportation could be to combine the transport of new goods with the return of used products, this is however not as simple in a real environment as in the theory. Furthermore, it is often difficult to transport the returned products, as the products most often not are packed in the original packaging or not properly packed and protected to be transported (Tibben-Lembke & Rogers, 2002; Defee et al., 2009). This complicates the handling of the return products during the transport. Tibben-Lembke and Rogers (2002) also mentions that shipping of single products is more difficult due to no standardization when combining with other shipments. Additionally, the products are of varying quality (Srivastava, 2013), both because of the improper packaging that possibly could damage the products during the transport, but also the condition of the returned sent back from the customer could be of varying quality (Tibben-Lembke & Rogers, 2002). Another challenge related to the reverse flow is that information systems are slow to incorporate the reverse flow activities (Defee et al., 2009).

Challenges related to the inspection and disposition phase is that this process is very labor intensive (Defee et al., 2009). Furthermore, there is a challenging value trade-off regarding how much time and material the company must put into a restoration of the product versus the value from reuse or recycle individual parts or materials.

Regarding the recovery, including remanufacturing, refurbishing and repair of products, these processes must be coordinated with the manufacturing and procurement schedule for the new products (Defee et al., 2009). Additionally, both the inventories of new and recovered products must be maintained. The challenge of slow incorporation of reverse activities in the information system, mentioned in relation to the reverse logistics process, is also challenging regarding the recovery process.

In the remarketing activity, the major challenge according to Defee et al. (2009) is to find the new market for the recovered products or components. It is very important that the new channel and markets do not cannibalize on the primary markets. Tibben-Lembke and Rogers (2002) further mentions non-uniform pricing to be a challenge in this process. The pricing for these products is not uniform due to varying quality of the products. The remarketing process becomes even more challenging due to uncertainties in supply (Tibben-Lembke & Rogers, 2002).

According to Tibben-Lembke and Rogers (2002), the reverse flow is not as extensively tracked as the forward flow, and thus, low visibility is a challenge related to the entire reverse supply chain. This makes the planning more difficult to handle which complicates all involved processes. Another challenge mentioned by Tibben-Lembke and Rogers (2002) is the lower importance of speed in the reverse supply chain compared to a forward supply chain. This is as the forward flow it is important to fulfill the customer needs and deliver the goods when the customer wants it. If the delivery is not fast enough, the customers will complain. This is not the case in the reversed flow, since it is the company itself that has placed the order, is waiting for the goods and is responsible for transporting the goods to the origin. The reverse flow will thus, not be as prioritized as the forward flow and the speed will not be as important. CE100 (2016) mentions another challenge related to the circular economy and especially the reverse logistics is to preserve the residual value of the products that are returned. However, it is further explained that this challenge can be overcome by a highly optimized logistics process.

2.4 Reverse Logistics Maturity Model (RLMM)

The model presented below is developed in CE100 (2016) and provides a foundation for how to assess the current level of maturity in the reverse logistics, and thus also the circularity, as well as to find improvement areas for how to reach the next level of maturity. As reverse logistics is a key enabler in the transition to a circular business, the improved reverse logistics will be an enabler for the circularity to accelerate and scale-up.

2.4.1 Archetypes

There are various ways for a company to become and stay circular, mostly depending on the company products and business model attributes. In the Reverse Logistics Maturity Model, three different demand driven archetypes has been developed to get an understanding of the company journey to mature in the reverse logistics as well as develop the circularity. The archetypes are based on the company's products portfolio and are divided into *low value extended producer value, service parts logistics* and *advanced industrial products.* The different archetypes have different requirements on the reverse logistics set up. Furthermore, a set of success factors are related to each archetype. When a company are moving towards a more circular approach it is thus important to understand what archetype their products are related to. However, a company might be categorized as more than one archetype to find the right archetype for their products.

The three archetypes are presented in *table 1*, in terms of product attributes and examples, requirements and implications on reverse logistics, a suggestion to a reverse logistics solution along the key components in the circular supply chain, including return, recovery and remarketing. Furthermore, the key success factors related to each archetype will be presented in terms of key levers of network design, incentivizing returns as well as capabilities to remarketing.

Table 1: The three archetypes in the RLMM, based on description from (CE100, 2016)

Archetypes	**Archetype 1**	**Archetype 2**	**Archetype 3**
Name	*Low value producer responsibility*	*Service parts logistics*	*Advanced industrial parts*
Product attributes	• Mass production • Distribution through retail networks • Comparably low residual value at the end of product life cycle	• Comparably higher residual value, with moderate expected return rates • Often needed to ensure smooth production or service provision	• Comparably complex • High residual value and relatively low return volumes
Example of products	• Tires • Shipping pallets • Consumer electronicts	• Machinery • Automotive parts	• Information and communication technology (ICT) • Medical equipment
RL logistics requirements & implications	• Subject to increased extended producer responsibility legislation • Return volumes maximization and RL process standardization in order to get best value retention at lowest possible costs	• Combine return of used parts and supply of new or refurbished parts to have a seamless replacement of the service parts • Get transport flows optimized	• High-touch requirements regarding safety, accountability and careful handling of return products • Product return value must be preserved and maximized • Combine collection with replacement of the asset with new or refurbished products. Respective products are often crucial for key operations processes
Suggestion for RL solution	Centralized collection scheme, with consolidated handling of the returned products through a recovery service provider	Service partner collects parts from different cusomer or collection through customers-dedicated transports	Direct or trusted collection through the service partner
Key success factor	Realize economies of scale	Combination of pick-up of the products that should be replaced with delivery/installation of new refurbished service parts	Transparency and trusted or direct return
Design of RL network	• Consolidating return products for a cost-effective collection from large geographical areas • Leveraging existing and under-used forwrd logistics network capacities to enable recovery of returned goods and waste • Adapting RL solutions to different geographical areas and regional conditions to be effective	• Tracking of service parts and their condition during use phase for return and replacement planning • Leveraging capacities in combining delivery of new service parts with pick-up of return parts and packaging	• Establish forecast and inventory control for return items to enable fast redeployment or resale • Asset and condition tracking during use and return • Proper handling and packaging of to be returned assets • Leveraing capabilities in combining delivery of nre industrial product with pick-up of product and packaging
Incentivicing returns	• Building capability to recover different brands' products as well as similar product types • Establishing collaboration programs to increase return volumes • Implementing incentives for customers to return products	• Partnering with logistics providers for an integrated delivery and RL • Enable easy returns and exchange of service parts for customer	• Partnering with logistics providers for integrated delivery and RL • Direct or trusted delivery and return for customers
Recovery & remaketing capability	• Pre-sorting products to limit the RL flow to usable materials only • Outsourcing the processing of returned products to recycling providers for secondary market purpose beyond own company's business models	• Expanding transport to additional logistics service such as de-/installation or packaging • Outsourcing the processing of returned products to remanufacturers and recycling providers for secondary market purposes beyond original, new OEM parts sales	• Expanding transport to additional logistics service such as de-/installation or packaging • Leverage results from assets and condition tracing for product design and production planning

2.4.2 Reverse Logistics Components

In order to get a holistic view of the design of reverse logistics, not just focusing on transports and logistics, three components in the circular economy value chain are considered to be relevant (CE100, 2016). The components included in the model are *Front end*, *Engine* and *Back end*, see *table 2*. *Front end* refers to the reverse logistic processes as well as the logistics network, including the planning and monitoring related to these. *Engine* refers to the recovery of the used, returned products, including strategy for the recovery, controlling of inventory as well as evaluation of materials. Lastly, *Back end* refers to the remarketing process of the recovered product into the secondary markets, including activities as market development and planning to monitoring the recovered products. Usually, *Engine* and *Back end* go beyond the strict definition of reverse logistics. However, these two components are included in the Reverse Logistics Maturity Model in order to get the entire picture, and a holistic approach of the reverse logistics, and thus be able to design the reverse logistics better.

Each of the three components are assessed across three dimensions, reflecting the decision-making levels in a company, namely *Strategic*, *Tactical* and *Performance*.

Table 2: Reverse Logistics Maturity Model, (CE100, 2016).

RLMM component	Decision dimension	Areas to assess
Front end	Strategic	Reverse logistics strategy
	Tactical	Reverse logistics network structure
	Performance	Responsiveness and visibility of items in RL flow
Engine	Strategic	Recovery strategy
	Tactical	Returned product inventory control
	Performance	Returned material evaluation
Back End	Strategic	Remarketing in secondary markets
	Tactical	Remarketing planning for secondary markets
	Performance	Remarketing data

Front end

In the *Strategic* dimension of this component the model identifies the maturity, main drivers as well as the functional and business integration of the reverse logistics strategy.

The *Tactical* dimension considers the planning and network structure of the reverse logistics as well as the definition of objectives and requirements for the product returns.

In the *Performance* dimension the responsiveness and visibility of the returned items in the reverse logistics flow are measured.

Engine

In the *Strategic* dimension of this component the model aims to capture the strategy of recovery as well as the alignment with the business goals.

In the *Tactical* dimension the model is helpful to assess the inventory control for the returned products.

The *Performance* dimension for this component assesses the evaluation process of the returned products and how it affects both the recovery process and product design.

Back end

In the *Strategic* dimension of this component the model aims to evaluate the business knowledge for remarketing the recovered product in a potential secondary market.

The *Tactical* dimension covers the planning of remarketing and the pricing of the recovered products.

In the *Performance* dimension the availability and use of secondary markets' demand as well as the remarketing data are assessed.

2.4.3 Maturity Levels

Five maturity levels are considered in the Reverse Logistics Maturity Model, ranging from *Initial level* to *Optimizing level*, where the initial level is characterized by informal and ad hoc processes while the optimizing level is characterized by continuous improvements of the processes. In between the two maturity levels already mentioned, there are a level with basic project management, called *Managed level*, a level characterized of standardized processes, called *Defined level*, and a level of measurable and controlled processes, called *Quantitatively managed level*, see *figure 6.*

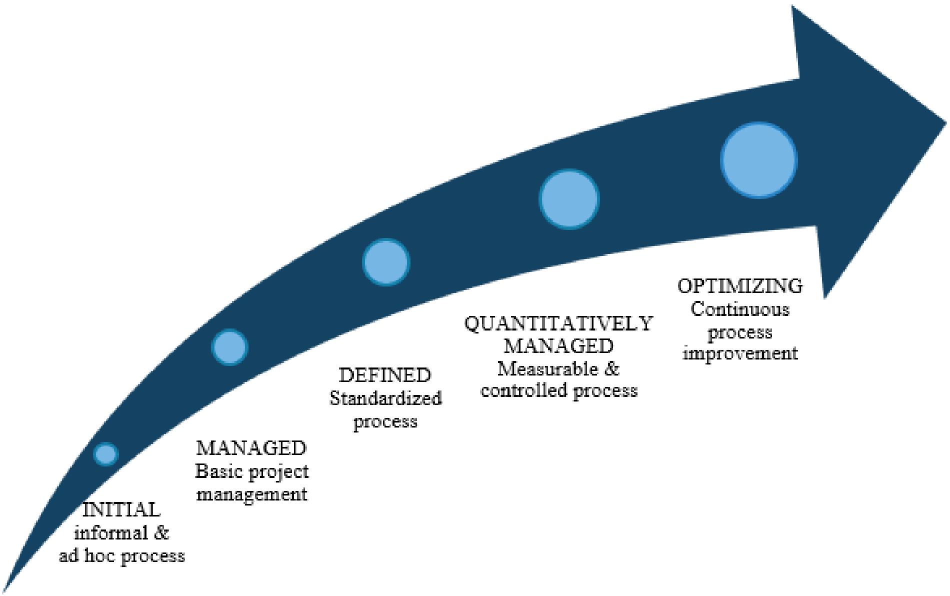


Figure 6: Maturity levels in the RLMM

In *table 3*, the maturity levels are combined with the three components in each decision dimension presenting the characteristics within each of these.

Table 3: Describe the characteristics of each maturity level and performance dimension based on a model in CE100 (2016).

		Initial	Managed	Defined	Quantitatively managed	Optimized
Front end	Strategic	Standalone RL with business goals limited to cost minimization	Basic strategy in place to manage RL	RL strategy aligned with supply chain strategy, defined RL process in place.	RL is integrated with supply chain strategy driven by profit generation	RL is integrated as cross-functional process within different business units. RL is driven by profit generation and is aligned with business goals
	Tactical	RL network is not well defined and is managed reactively	RL network is planned and established	RL network is standardized. Return agreements or contracts in place for proactive collection	RL network and flows are planned through collaboration agreements with stakeholders to define performance requirements	RL network and flow is optimized through defined performance objectives in collaboration with logistics provider
	Performance	Items are collected with no record of lead time, return rate and volume	Items are collected and traditional measurements are available (lead time, return rate and volume)	The RL time and flow are measured. Also, items qualities are measured	Item's traceability metric is well defined and used, coordinated in shared system across value chain to monitor and assess return agreements	The RL process is monitored and responsively updated, with real time exchange of value chain information on returned items between logistics provider and company
Engine	Strategic	Asset's recovery program in operation but not directly aligned with strategy	Recovery strategy in place based on economic and technical viability of recovery options	Recovery strategy is aligned qualitatively with RL strategy and business strategy	Recovery strategy stated and quantitatively driven based on economic, technical, and environmental viability of recovery options	Fully aligned recovery strategy in place, including innovative product design which considers product recovery
	Tactical	Inventory control for returned products is unstable	Returned products inventory control is planned and visible to management	Returned products inventory with standardized processes and ability to forecast returns amount	Returned products inventory process performance is established and prediction of returns condition is available through monitoring assets on the use stage	Returned products inventory process is continuously improved based on quantitative understanding of the process and can respond to change in product mix, volume, equipment, sourcing, planning
	Performance	Returned material data not or only partly in place (quantitative and qualitative)	Process in place to measure returned material data	Returned material data is measured for pre-sorting and evaluating recovery options	Returned material data is assessed and used for controlling recovery processes	Returned material data is used for product design and recovery processes
Back end	Strategic	Knowledge about secondary markets for recovered assets is not in place	Knowledge on secondary markets is available and understood	Knowledge about demand markets for recovered assets is used during return processes	Knowledge (e.g., demand forecasting) about secondary markets for recovered assets is integrated in management decisions for reverse flows	Recovered asset demand and product development are integrated to identify new products, markets and business models
	Tactical	Remarketing planning and pricing are not well established	Remarketing planning and pricing are performed with limited transparency on demand	Remarketing planning and pricing are performed and controlled through standardized processes with transparency on demand	Remarketing and recovery data is used to measure and control the remarketing process and predict variation	Recovered products are returned to market swiftly through proper remarketing planning and influencing customer behavior
	Performance	Market data is not in place to assess recovered products' potential for secondary markets	Recovered products' market share data is available	Recovered products' market share data is used for remarketing analysis	Recovered products' market share data is used to expand market segmentation. Products value decline rate is monitored and controlled along product and technology life cycle	Market analysis is underpinned by full transparency on recovered products' market share and secondary markets

2.4.4 How to apply RLMM

CE100 (2016) explains how the Reverse Logistics Maturity Model should be applied in seven steps. By following these steps to assess the maturity of the reverse logistics, the company could start to scale up the circular capabilities.

The first step is to select which product or product group that should be assessed. Secondly, the archetype should be identified. The two first steps are followed by an identification of all stakeholders, partners and functions that control or depend on the reverse logistics process and to consider all these. The fourth and fifth step is to map the *Front end, Engine* and the *Back end* of the specific case followed by mapping the *Strategic*, *Tactical* and *Performance* dimension of each of these. The next step is then to assess the maturity by matching the company's current maturity level, in the different components and within each of the dimensions. The last, and most important step is to identify possible areas for improvements and select which areas that are most important to focus on in order to reach a higher maturity level.

2.5 Servitization and Product Service Systems

Companies could sell products or services, considered to be a product- or use-oriented company. The main difference is that a product-oriented company focuses of selling physical and tangible assets while a use-oriented company focuses of creating value out of intangible assets. A product-service system can be described as means for a company to adopt a circular business approach (da Costa Fernandes et al., 2020). Da Costa Fernandes et al. (2020) argue that a product-service system can enhance the circularity as it aims to offer solutions with an integration of products and service to fulfill requirements from the customers and generate higher value, compared to a pure product offering. Mastrogiacomo et al. (2018) denominate the gradual shift of offering pure product-centered value to offering complex product-service systems as servitization. Further, to make this a more extended definition, the level of servitization within the company is considering how much product- versus use-oriented the company is.

Product-service systems are described as means to realize circular economy leading to reduced resource consumption and at the same time promoting economy growth, yet, such system is not always circular nor sustainable (da Costa Fernandes et al., 2020). A product-service system is not a guarantee for a circular business since for example labor cost could increase and thus resulting in a higher and too expensive cost of the life cycle (Ellen MacAurthur Foundation, 2017). However, offering additional services or product as a service could contribute to the circular economy and be sustainable if the value propositions are based on circular principles and strategies. Thus, there is a need of balancing economic and environmental incentives by focusing on resource efficiency and longevity which require life cycle thinking, involving stakeholder as well as understanding the customer value of access rather than ownership of a product (da Costa Fernandes et al., 2020). Customers' definition and perception of value of a product has changed. Some customer neither expect nor want to get the ownership of a product but instead want access to the product when they need it or get access to the results that could be offered by the product (Ellen MacArthur Foundation, 2020).

Two different types of product-service systems, namely product-oriented and use-oriented will be presented below, especially focusing on how each of these affects the reverse logistics. Redesigning company offerings towards a product-service system is challenging and require comprehensive changes (Kaddoura et al. 2019). However, size and complexity of the challenge is relatively dependent on the level of integration between the product and the service. A use-oriented product-service system with service offering instead of product offering will require a larger change in the company compared to the initial state, than a product-oriented company where services are added to the original product offer (Kaddoura et al. 2019).

2.5.1 Product-Oriented

The product-oriented product-service system refers to a system where the ownership of the tangible products is transferred to the consumers, while the additional service as for example maintenance contracts are provided (Mastrogiacomo et al., 2018).

The product-oriented services can be divided into transaction-bases and relationship-based services, where the transaction-based services are described to be more basic services, for example transport, installations, repair and spare parts while the relationship-based services are described as maintenance services, for example monitoring, preventive maintenance and spare part management and service contracts (Chesbrough et al., 2013). As mentioned above, the change from a traditional linear model to initiate a product-oriented product-service system is not as big as the transformation to a use-oriented system (Kaddoura et al. 2019). Thus, many companies make such change as a first step to become more circular.

2.5.2 Use-Oriented

The use-oriented product-service system refers to a system where the ownership of the tangible products is remaining at the service provider that instead of selling the physical product sells functions of the products (Mastrogiacomo et al., 2018). This is done through changed distribution and payment systems, as for example leasing, sharing, and pooling.

Selling services rather than products provide the manufacturers with more control of the products, and by keeping the ownership of the products, tracking of product location and usage will be simplified (TU Delft: Online Course, 2017). Sundin et al. (2008) argue that data collection of products and usage could be valuable information both improve product design and the activities in the reverse logistics.

A service-based business model could improve the product circularity significantly if keeping the ownership at the producing company as it creates incentives for the producer to design the product for easy recovery, recyclability, durability and longevity to minimize the total cost of ownership throughout the life cycle (European Environment Agency, 2017). Additionally, a use-oriented business model will be beneficial in the customer perspective since they only pay for the actual use. Furthermore, the customers often receive better service as the manufacturers want the product to last for as long as possible and thus continuously maintain and update the product (Philips Lighting Holding B.V., 2017).

A common culture within many companies are the traditional "sell more and sell faster"-culture. However, to facilitate a transition from product offering towards service offering, companies must forego this traditional culture and instead see the profitability and revenue streams beyond the core product. To enable the transition and implement a use-oriented business model, companies has to change their way of thinking about reuse and repurposing of products to not see it as cannibalization, but instead as an additional type of sales (TU Delft: Online Course, 2017).

Transforming from a company with a focus of selling pure products to offering products as a service could be challenging and problematic. One such challenge is related to the financing of such offering. In service agreements the customers pay for a certain amount of time or use, and thus the selling company have to pre finance the product chain, in contrast to when a product is sold, and the customer pays all at once (TU Delft: Online Course, 2017). A use-oriented system further leads to significant changes related to the cash flow characteristics, affecting the balance sheets negatively due to investment requirements for the producer and the way to consider the residual value of assets (European Environment Agency, 2017). Furthermore, the financing mechanisms in the traditional linear economy are not adapted to the service-based models. This challenge is problematic for all companies to overcome, but especially challenging for small companies and for companies selling products with large initial investments. Another challenge is related to infrastructure and processes that must be built, developed, and adapted to organize maintenance and repair of products at the customer and collection of the product when the customers no longer need it. Transforming the business from selling products to selling services thus requires changes in the entire supply chain (TU Delft: Online Course, 2017).

According to Ellen MacArthur Foundation (2017) there is an unfamiliarity in the use-oriented business models, creating skepticism to both the focal company and the customers. This is due to that it is a relatively new concept, there is a preconception of it being a more expensive alternative and lastly since it creates inconvenience through lack of ownership. However, in many cases, the opposite is true as this type of business model incentivize better support and maintenance throughout the life cycle and thus decreases the total cost of ownership. Furthermore, in the new economy, product ownership is getting less important to customers, while accessing products are of growing importance (Philips Lighting Holding B.V., 2017).

2.6 Product Design for Circularity

Recently, the role of product design has been positively trending, focusing on alternative ways to design products for less environmental damage (Moreno et al., 2016). This is often discussed in terms of *design for environment*, *eco-design*, *sustainable* or *green design*, etcetera. It is however important to focus on the product design from a holistic system perspective and consider factors such as reusability, disassembly and, recyclability to reduce the environmental impact and not just focusing of develop less bad products than earlier (Geldermans, 2016). Most products today follow the traditional model of take-make-dispose and are far from being ready for circularity (Moreno et al., 2016). Thus, designers have an important role to design products that can easily be reused, disassembled, recovered, or recycled in order to tackle potential environmental problems, as for example, loss of biodiversity, climate change, finite resource depletion and conflict over energy and resources.

2.6.1 Modularization

Modularization has gained increasing attention from manufacturing firms during the recent years and is described to be a way of grouping different components into modules with common interfaces between different modules (Holmqvist & Persson, 2003). The grouping of components should be done in a way that hinders design decisions in one module to affect other modules.

Modular design is a small, niched trend, not very common in companies today and it is hard to predict the growth of the trend (European Environment Agency, 2017). Nevertheless, the growth of the trend, using a modular design of products could simplify the repair and remanufacturing process and thus extend the product lifetime. The purpose of the modularization could either be to become more sustainable, provide customers with mass-customized products, from a business perspective or, a combination of the two (European Environment Agency, 2017).

Modularization enables platform design, which is commonly used to reduce both manufacturing costs and waste and further simplifying the product development (European Environment Agency, 2017). In this process, products can be customized at the latest possible stage in the production chain, while having a uniform production upstream. Thus, a large number of variants could be offered but with standard modules (Holmqvist & Persson, 2003). If including possibilities and limitations of recycling systems in a platform design as part of the modularization work, separation of components in terms of recycling or energy recovery could be enabled and be useful in tackling the negative effect on recycling efficiency brough from an increased material complexity (European Environment Agency, 2017). Further, a high degree of modularization, could lower the inventories and the risk of product being old and obsolete, thus also reducing the cost related to inventory (Hsuan Mikkola & Skjøtt-Larsen, 2004). Additionally, offering complex and customized products is likely to counteract the circularity work as it brings more complicated recycling, repair and reuse processed (European Environment Agency, 2017).

2.7 Cross-Functional Teams and Integration

Turkulainen and Ketokivi (2011) describes that organizational cross-functionality can be created in several different ways. One way to look at it from an organizational design perspective, which is beneficial in order to understand the performance of the organization. Cross-functional teams and its integration creates contingency which is needed in environments with high uncertainty and is advantageous from a strategic point of view (Turkulainen & Ketokivi, 2011). Henke et al. (1993) describes that the uncertainty in development processes of advanced innovative products accordingly is highly complex as the dynamic market can rapidly change direction. The ability to cross the traditional hieratical structure in such environment becomes a necessity in order to be responsive with short lead times to market. Henke et al. (1993) further described that companies for many years have utilized cross-functional teams in order to reduce the lead time of development as well as increase performance and obligations of the products.

Recently, there has been a substantial increase of cross-functional and multifunctional teams due to its positive effect. Yet, to utilize cross-functionality in a to high extent can lead to the opposite, focusing on wrong activities and attending meetings outside the scope of the assignment. This can result in extended lead times with lacking quality and performance in the development process (Henke et al., 1993). Proehl (1996) further argues for cultural clashes to be a challenge related to cross-functional operations as the teams about to collaborate are from different homogenous units. Another challenge is related to combining several teams, where all members have other responsibilities connected to initiatives outside the common task in the cross-functional team. This can result in individuals dropping out due to too high pressure, and thus the team loses competence (Proehl, 1996).

Turkulainen and Ketokivi (2011) argues that the positive effects differ in performance depending on in what dimension the integration is performed. Thus, a dependency between the level of integration and performance within an organization and its design can be noted. When a high integration level is achieved, the organization starts to operate as a whole, without friction between different units and functions internally, where the ability to process, transmit and to have the same interpretation of information is greater (Turkulainen & Ketokivi, 2011).

Furthermore, it is evident that a high level of integration results in less sub optimization which thus implies for an increased focus is on the overall performance and common goals. However, starting to operate with cross-functionality does not by itself create operational efficiency as the channels to support this way of working have to be well established and support the expected outcome of the cross-functionality (Turkulainen & Ketokivi, 2011). Henke et al. (1993) argues for the positive effects when operating cross-functional as several teams are aware of each other. The awareness leads to the possibilities of direct communication and knowledge sharing without crossing through the vertical structure of authority, and the ability to take decentralized decisions.

Knowledge sharing across different areas of experience within the organization is argued by Hong et al. (2004) to be a critical and valuable asset in order to have a competitive advantageous position on the market. Since there are differences in the sub units internally with regard to knowledge possession and how to process information, integrative cross-functionality is an advantageous approach as the possibility to combine these different competences in order to create synergies with higher performance, i.e. combined *"idiosyncratic knowledge"* can be achieved (Turkulainen & Ketokivi, 2011). Yet, Turkulainen and Ketokivi (2011) argues that it is of great importance to direct this combination of knowledge in the operation, as it can generate a significant increase in profit if managed and integrated in the right manner.

2.7.1 Performance Dimensions of Cross-Functionality

Performance of a focal operation can be divided into six fundamental dimensions as these are identified to be the main areas to enable increased processing of integrated information within the functions of operations, product development and design, and marketing and sales, namely; *"manufacturing cost, conformance quality, design flexibility, volume flexibility, development lead time, and product innovativeness"* (Turkulainen & Ketokivi, 2011).

Manufacturing Costs

The *manufacturing costs* are argued to be heaviest in the stage of product development, where the flow of processed information across internal functions must be precise and reliable in order to operate efficiently and to be aware of internal capabilities, initiated changes in product design and its consequences. To include several functions in cross-functional teams, e.g. operations, can lead to valuable information and knowledge sharing resulting in reduced costs and increased flexibility in the manufacturing process, that otherwise would have been missed if having excluded other units (Turkulainen & Ketokivi, 2011). Hong et al. (2004) correspondingly argues for the importance of including several teams in the development process, as the initiation stage are the time and place for knowledge sharing of internal capability and external capacity and requirements from customers, as detection of defects otherwise can occur later on in the development process to the consequence of high costs. The same goes for late costly adjustments in the product development process, where marketing and sales can provide unique information about requirements from the market early in the development stage, which in turn generates lower development costs and thus manufacturing costs. It can therefore be concluded that it is advantageous in operating with integration and cross-functional teams with the result of reduced manufacturing costs (Turkulainen & Ketokivi, 2011).

Conformance Quality

Conformance quality is related to on what level the product corresponds to the specification of product design, where e.g. the function of product development benefits from insight of capabilities in manufacturing as well as in what requirements there are from the market (Turkulainen & Ketokivi, 2011). It is further of great importance that the unit of marketing has internal knowledge of what actual capability the focal organization has, to produce when determining specifications towards the customers. If missing the opportunity of integration, there can be a miss match and thus create maladaptation when lacking or not having the adequate information and knowledge as a base for decisions. This can in turn generate inability to enable correct production, and thus not meet the design specifications set up for the product, i.e. less conformance in quality of product and ability to manufacture (Turkulainen & Ketokivi, 2011).

Design and Volume Flexibility

The design flexibility is about being able to act fast with efficiency when small adjustments in product design are needed, whereas volume flexibility refers to enable fluctuating demand regarding the internal processes and outputs (Turkulainen & Ketokivi, 2011). Cross-functionality between the units of marketing and sales and operations is a vital factor, as the information about market requirements regarding demands in product variety and required volume will enable the unit of operations to adapt the required internal capacity as well as the attributes of flexibility in design and volume. Further, the importance to integrate operations with the unit of product design is vital as such cross-functionality can lead to increased possibility create product designs containing several varieties, e.g. the possibility of modular product design, and thus also to enable efficiency in fluctuating demands (Turkulainen & Ketokivi, 2011).

Development Lead Time

Units outside research and development can have a considerable role when designing innovative products (Turkulainen & Ketokivi, 2011). To early include the unit and function of operations the development stage could have a significant positive impact in reducing the lead time of development and its production. It can also be seen that if having an extended lead time in the development stage, can have negative impact on the quality, which in turn leads to a chain of several deficiencies and negative aspects such as inactive iterations in prototyping and its continuous tests which in turn can lead to longer time to market (Turkulainen & Ketokivi, 2011). Being responsive towards the market in terms of a fast process in product development related to the product design and its quality to an affordable cost, is of great importance in order to stay competitive (Henke et al., 1993).

There are further benefits of integrating other functions in a cross-functional manner, where e.g. by including the unit of operations can generate elimination of stages in the process which enhances the ability to deliver faster to market. To work cross-functional in multi-functional teams with the inclusion of marketing can also reduce the number of stages, as information flow of requirements from the market can create higher efficiency and thus can result in decreased lead times of development and early detection of defects (Turkulainen & Ketokivi, 2011)

Product Innovativeness

Integration of teams is evident to be of advantage when there is a need of being innovative in product development, where capabilities of introducing new functions and features into the products are possible in the function of product design and research and development where innovative ideas are generated to the greatest extent (Turkulainen & Ketokivi, 2011). However, as mentioned earlier, to create the best possible solution based on several unique *"idiosyncratic knowledge"* combined from different functions internally such as marketing and operations at an early stage of the development, can generate increased idea generation, and thus result in higher performance of products and internal processes. Yet, the decisive factor here is that if these added innovative ideas are not processed in a cross-functional manner from the other involved units, the possibilities to make use of them are gone (Turkulainen & Ketokivi, 2011).

2.8 IoT integration of ERP and Products

The term Internet of Things (IoT) was invented by Kevin Ashton in 1999 who explained IoT as; *"A world where everything had a digital identity for itself and enabled* *computers to organize and manage things"* and that *"IoT is a tool to overcome the domination of time and place"*. IoT is said to be applicable to a wide range of different areas, where the most common are within the industry to connect sites of production and systems of intelligent production, i.e. Industry 4.0 (Wortmann & Flüchter, 2015). IoT is further applicable to smart transportation, where the possibility to track is enabled in an efficient manner, to monitoring in real time and projects for smart cities, the list is long (Wortmann & Flüchter, 2015). However, Tavana et al. (2020) argues that having RFID as an integrated sensor in the products is a precondition to make use of IoT.

IoT has been defined by the International Telecommunication Union (ITU, 2021) as *"a global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies"*. Yet, related to this master thesis, IoT further possess the capability to integrate different business systems such as ERP systems, with products and with other sources of external information (Porter & Heppelmann, 2014; Wortmann & Flüchter, 2015). Tavana et al. (2020) describes this function to enable detection and control, and to transfer and send unlimited amount of information and data with scalability back and forth between several databases and products.

2.8.1 ERP

Enterprise resource planning (ERP) systems and Supply chain management (SCM) are most often managed separately, in which the effectiveness and efficiency in collaboration between systems are reduced. This is due to different programming, language and interfaces which makes it cumbersome to integrate (Chen et al., 2014). Business systems that are compatible with IoT are e.g. SAP, Microsoft and Oracle, which also are evident to function with technologies such as blockchain, artificial intelligence, machine learning and enable usage of big data (Tavana et al., 2020). To utilize IoT in a cloud-based computer system in the semantic web when wanting to integrate two different systems of distinguishing technology and interface, the resources and data are encapsulated or enclosed to a cloud based service which enables different layers of the organization to speak the same language. Utilizing this solution enables high efficiency in integration to a low cost as well as increased automation and flexibility to have access to quick and relevant data (Chen et al., 2014). Tavana et al. (2020) argues that integrating ERP systems with IoT generates several benefits and gives the opportunity to increase performance of management, a higher degree of automation, ability to trace products to a greater extent. This gives positive effects of lower implementation costs and time with ERP systems, compared to a fully customized application solely developed for a limited integration.

Furthermore, Tavana et al. (2020) presents that the benefits of integrating ERP and IoT in such abstract environment as the semantic web are that it can facilitate and manage stock outs in inventory, replenish and reorder material, orders and deliveries, which is performed by a device or sensor that is directly connected to the internet cloud to report in real time information. The data and information managed by the IoT has to be sorted and analyzed in order to be utilized for its purpose to the fullest extent which can be challenging as IoT can support seemingly unlimited data and information from several sources. Thus, manufacturing companies must perform preparations in such integration where e.g. the currently used ERP size and the capability to integrate and connect with IoT must be taken into consideration. When the systems are integrated, it facilitates interpretation of the data provided, whereas IoT stands for a potential solution. The solution can improve the business performance if this interplay works well (Tavana et al., 2020).

2.8.2 Products

As mentioned, IoT can also be integrated into the products through embedded sensors or devices, to facilitate increased flexibility and efficiency in material flow with e.g. tracking (Wortmann & Flüchter, 2015) and tracing. It can also replace the function of bar codes managed manually, thus resulting in a higher degree of material control and inventory management in real time (Tavana et al., 2020). Tavana et al. (2020) further argues that this real time data can be reported into the ERP systems of all actors involved to facilitate for tracking of interdependencies in the products life span as well as the material flow. The device can further send real time notification with messages of defects in product behavior, usage and wear. This implies for that the customer does not at all times have to take action to the same extent as without IoT. The manufacturer is thus directly provided with well-grounded information to overcome the issue, instead of fixing the problem at site (Tavana et al., 2020). These integrated sensors can further prevent the products from being stolen and can further make sure that prerequisites of transportation are followed, e.g. for fragile, temperature sensitive products, by sending an alert when deviations occur. Thus, it can be ensured that the product arrives in the correct condition and quality and at the right time. IoT can further lead to increased material control by resolving the issue of losing control of the products when dealing with intermediaries such as dealers (Tavana et al., 2020).

2.9 Problem Discussion

Currently, many companies maintain a linear business model, characterized by continuous resources extraction and waste production, which is not sustainable and contributes to the ongoing climate crisis. To cope with this challenge the circular economy offers a solution by focusing on reuse and recycling of entire products, components, and material. The circular economy does not only bring environmental benefits, but also economic and social. Furthermore, companies can be both at the forefront, working proactively with sustainability to gain competitive advantage or operate reactively and be driven by legislation. As the overall sustainability target within Ericsson is to become carbon-neutral in 2030, there is a need to abandon the linear economy, and start working proactively to achieve a higher degree of circularity and be competitive on the market.

Ericsson's journey towards a circular approach includes the implementation in 2019 of the *Refurbished spare part sales*, however, such transition includes several challenges that must be tackled. The forward supply chain at Ericsson is already known and investigated, but the reversed supply chain is a rather unexplored area. The reverse logistics is a key enabler to become successful in the circularity and must thus be further investigated at Ericsson to reach a higher maturity level and improved circularity. However, as the reversed flow is dependent on the forward flow, the flows must be integrated and simultaneously considered in order to close the supply chain loop, see *figure 7*, and thus increase circularity to become more sustainable. To find the balance between achieving a higher maturity level of circularity and at the same time not negatively affect the business is a great challenge, and thus a necessary area to explore for Ericsson.

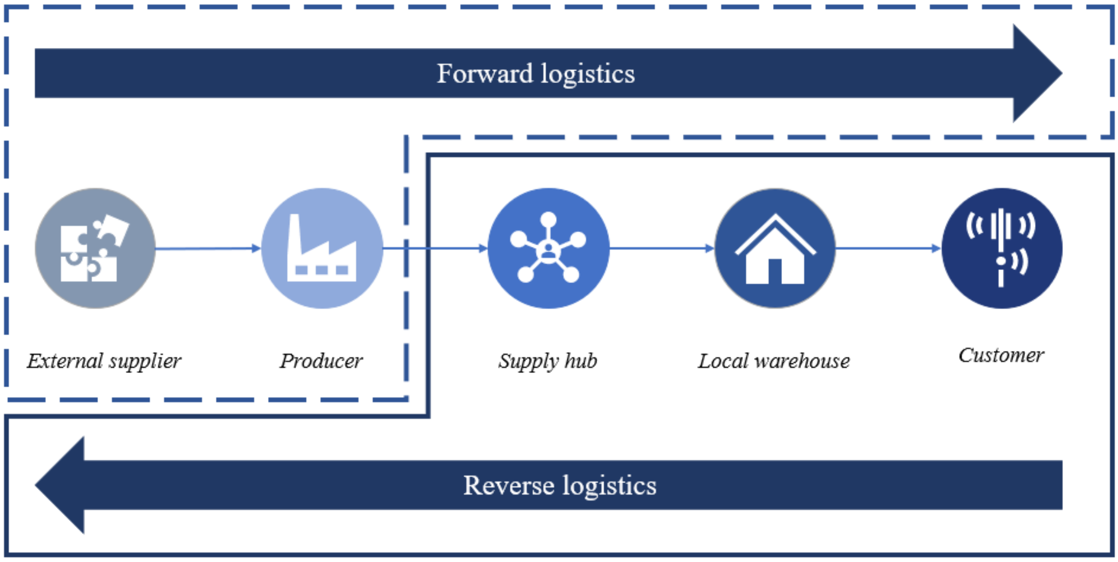


Figure 7: The scope of this master's thesis is limited to the field within the filled solid lined box.

The returns are initiated by the customers and are performed for different reasons, however, requires an established service contract in order for the products to be returned. Ericsson already has an established reverse flow and, in some areas, standardized process in how to handle the returns. However, that flow is currently to handle service contracts to provide customers with replacement units if a product or unit is broken. The newly initiated *Refurbished spare part sales* has been applied into the already existing flow, yet, in practice, it is still a stand-alone process and is not as extensively investigated. Therefore, the primary focus of this thesis is to find improvement areas regarding reverse logistics of *Refurbished spare part sales*.

The aim of recovering products and to integrate the *Refurbished spare part sales* into the overall business strategy is to maintain high value and take advantage of the products that are already produced, and thus refurbished products that are taken or bought back from the customer. The already used products are not always old and obsolete but may have been outdated prematurely due to new technology on the market. This could contribute to that several customers possibly could send or sell back used products to update to the latest technology, in the future.

Replacing the traditional linear business model with a more circular approach however comes with challenges. Both in the product design, to enable recovery of the products, but also in how to handle different recovery options for different types of products. Furthermore, there are challenges related to the design of the reverse supply chain, the handling the customer returns as well as how to mature in the circularity and develop it further.

To reach a higher maturity level, the first step is to understand the current level of the reverse logistics, to then find improvement areas to move on with. An increased maturity level would be helpful for Ericsson in order to scale up and accelerate the circularity and reduce environmental emission, especially the carbon emissions. This would contribute to reach Ericsson's overall sustainability target and to become a leading actor within sustainability. Yet, to reach a higher maturity level, Ericsson will have to consider the internal way of working where cross-functionality as well as integration of business support could support and enhance the *Circular Business* approach to grow faster and to reach the goal of becoming circular. To further support the *Circular Business* initiative, Ericsson will have to adjust the business model with the inclusion of a more use-oriented approach, to gradually remove the take-make-dispose way of operating.

2.10 Research Questions

This master's thesis aims to gain understanding of how the reverse logistics can be improved and thus increase the level of circularity. The higher level of circularity should be reached in order to lower the company's environmental impacts without negatively affect the business. This will be achieved by firstly analyze the current state and performance of the reverse logistics by applying the Reverse Logistics Maturity Model.

RQ1: How is the reverse logistics performed currently?

The Reverse Logistics Maturity Model will then be used to identify which improvement areas to focus on and which challenges that must be overcome to reach a higher level of maturity in the reverse logistics.

RQ2: How can the reverse logistics be improved to reach a higher level of maturity?

When the improvement areas have been identified, the next steps are to find how to actually increase the maturity by overcome challenges related to the setup of strategy and design of the reverse logistics, and to investigate how the increased maturity level will affect the environmental impacts and the business and what possible consequences it would bring.

RQ3: What environmental effects can be achieved by increasing the reverse logistics maturity level and what other consequences may follow?

3 Methodology

The aim of this master's thesis has been to investigate how the reverse logistics could be improved in order to reach a higher level of circularity and thus decrease the environmental impact without negatively affecting the business. The research approach and methods chosen has thus been adapted to this specific purpose. In *table 4*, the research process, in terms of the different phases, procedures and products and how these are connected is presented. The research design, literature review and data collection are explained further below.

Table 4: Methodology description.

Phase	Procedure	Product
Problem Identification	• Clarify topic of the thesis	• Aim, problem discussion and reseach questions
Research Design	• Define reserach approach	• Qualitative, Abductive, Single Case
Literature Review	• Identify key theoretical areas • Perform semi-systematic literature review	• Understanding of topic • Theoretical Framework
Data Collection	• Perform interviews • Study internal documents	• Primary data • Secondary data
Data Analysis	• Analyze current situation • Analyze possible improvements within RL to scale up circularity	• Potential future state • Recommendation
Report Results	• Research report	• Thesis about Reversed Logistics

3.1 Research Design

The study has been conducted with a qualitative research approach, as the data mainly have been collected through interviews and not through quantification (Bryman, 2008). Furthermore, Bryman (2008) as well as Dubois and Gadde (2002) describe three common research approaches to choose from, within the qualitative research (Bryman, 2008): a *deductive*, an *inductive* and an *abductive* research approach. The same authors describe the *deductive* approach as developing initial hypotheses based on available theory to thereafter testing these in a real-world environment. Further, the *inductive* approach is described as starting with extracting data to be analyzed and subsequently developing a theoretical model from the findings. Lastly, the *abductive* approach starts with observing a phenomenon and thereafter seeking to develop theory based on the specific phenomena by interacting between theory and empirical data. Dubois and

Gadde (2002) mention that the abductive approach is useful when the purpose of the research is explorative and aims at discovering new things.

For this study an abductive approach has been adopted by initially developing a theoretical framework, that has continuously been adjusted to the empirical findings from interviews. Furthermore, the interviews have been steered into a certain direction based on what has been found in theory to obtain the data that was needed.

When conducting qualitative research, Bryman (2008) presents a model consisting of six main steps to go through in order to get reliable results. The first step is to formulate the research question(s), followed by step two of selecting where to conduct the study and who to interact with. For this study, there was a selection of both internal and external actors, aligned with the sampling process described below, as the area to be explored concerned a network including the focal firm and its customers. However, stakeholders outside this scope were also included if considered as relevant during the project.

Further, the third step of the model was to collect the data, further described below. The fourth step described by Bryman (2008) is the interpretation of collected data, which in the thesis report is presented in chapter *4 Empirical Findings*. Thereafter, the fifth step is to integrate and analyze the empirical data based on relevant theory concerning the subject, where the process can become a loop, back to step four as additional data could be necessary to collect with a more structured agenda (Bryman, 2008). Bryman (2008) states that the last step in the process is to secure that the overall impression and message is presented with reliability and are derived from the results and also that the conclusions and recommendations correspond.

This thesis was based on a single company. According to Gerring (2004) and Yin (2011) a study focusing on a single setting such as a company or unit is referred to as a single case study. Furthermore, Gerring (2004, s. 341) defines case studies as "*an in-depth study of a single unit (a relatively bounded phenomenon) where the scholar's aim is to elucidate features of a larger class of similar phenomena.".* Thus, this master's thesis is based on a single case study. According to Dubois and Gadde (2002) case studies, and specifically single case studies, have not always been considered as an adequate method for scientific research. The basis for this was that case studies are situation specific and provide a narrow basis for generalization. However, learning from specific cases has later been considered a strength rather than a weakness (Dubois & Gadde, 2002). Furthermore, in-depth case studies provide means to understand the interaction of a phenomenon and a specific context (Dubois & Gadde, 2002). Based on this, case studies have become a common method to use in many different scientific areas. Dubois and Gadde (2002, s. 558) argue that a single case study is preferred *"when a problem is directed towards analysis of a number of interdependent variables in complex structures"*. According to this statement, a single case study was a natural choice for this master's thesis, instead of analyzing a larger number of cases which according to Dubois and Gadde (2002) is a more suitable method when the focus of the research study is to compare a few specific variables.

3.2 Literature Review

According to Snyder (2019) and Linnenluecke et al. (2020) the production of knowledge is accelerating. This is further emphasized by Durach et al. (2017), that mentions the increasing knowledge production in form of articles, especially in the field of supply chain management. The rapid increase in knowledge production contributes to a higher complexity of performing a literature review (Snyder, 2019). According to Linnenluecke et al. (2020) the vast amount of new articles and knowledge makes it hard to find relevant literature as well as to keep track of new developments, which can explain the increased complexity. Literature reviews are thus more important than ever (Snyder, 2019).

In order to achieve high quality and trustworthiness when conducting the literature review, it is important to follow a specific method (Snyder, 2019). Snyder (2019) presents three different approaches to conduct a literature review, *Systematic, Semi-systematic* and *Integrative.* All three approaches are described as effective depending on the aim of the research. Furthermore, the three approaches are described to be wide and may have to be adapted to best suit a specific research project.

Snyder (2019) describes the systematic review to have strict requirements in the search strategy as well as in the selection of which articles to include in the review. This approach is further described to be effective when synthesizing the selected articles and their core messages. The same author describes that a semi-systematic approach is most often used when mapping theoretical fields or identifying literature gaps. The semi-systematic approach is thus more suitable when studying a broader topic that has been studied within different disciplines and that has been conceptualized differently (Snyder, 2019). Lastly, Snyder (2019) describes the integrative approach as a more creative literature review that is more suitable as the review do not aim to cover all articles that have been published within the field but instead combines diverse perspectives and thus, by merging the different perspectives, may contribute to develop new theoretical models. As the aim of the master's thesis has been to study the broad field of sustainability with extensive research and literature available, this study has been conducted with a semi-systematic approach.

3.3 Data Collection and Sampling

In order to explore and understand the sustainability issues with regard to the aim of this study, the research was conducted firstly through snowball sampling. Initially, pilot interviews were conducted, both in order to verify the quality of the questions, but mainly in order to navigate through the organization to get in contact with the right individuals for the project. Utilizing this method enabled a faster selection of few and important individuals in the company that possess core knowledge within the research area, which during the study was widened to a larger network (Bryman, 2008). Correspondingly, Bryman (2008) brings up that purposive sampling is a commonly used sampling method in qualitative studies when selecting e.g. individuals or organizations to be included in the study. This sampling method was chosen as the focal firm has many different actor bonds. Therefore, the scope for the study had to be limited.

The first round of interviews was performed in order to navigate throughout the organization and identify the right people in the organization and are thus not included in the empirical findings. However, these interviews were an important part of the process to find the key interviewees possessing the relevant knowledge and information needed for the study. *Table 5* presents the interviewees in the first round.

Table 5: Initial interviews.

Interviewee role	Organization	Key Topic	Date	Length
Process Manager	Ericsson	Refurbished spare part sales and reverse logistics	2021-02-10	60 min
Process Manager	Ericsson	Refurbished spare part sales	2021-02-11	15 min
Project Manager	Ericsson	Refurbished spare part sales	2021-02-16	60 min

In the second round, interviews with internal employees and consultants at Ericsson who could contribute to different key areas were conducted. The interviewees in the second round are presented in *table 6*. The respondent number will be used in the chapter of empirical findings to present which respondents who have contributed within the different areas.

Table 6: Interviews with the main contributors.

Interviewee role	Respondent number	Organization	Key Topic	Date	Length
Strategic product manager	1	Ericsson	Refurbished spare parts sales+ RLMM	2021-02-19	60 min
Spare part process and performance manager	2	Ericsson	Refurbished spare parts sales+ RLMM	2021-02-23+2021-02-26	60+60 min
Strategic product manager	3	Ericsson	Refurbished products + RLMM	2021-02-24	60 min
Head of global sustainability operations	4	Ericsson	Recycle & recovery options + RLMM	2021-02-25	60 min
Internal project leader	5	Ericsson	Circularity & Reversed Logistics	2021-03-03	30 min
Global supply chain developer	6	Ericsson	Circularity & Reversed Logistics	2021-03-03	30 min
Head of material management	7	Ericsson	Reversed logistics processes + RLMM	2021-03-04	60 min
Technology for good program director + Senior environmental expert	8+9	Ericsson	Circularity and business models	2021-03-08	60min
Head of SAR business operations	10	Ericsson	Internal processes + RLMM	2021-03-09	60 min
Environmental product manager	11	Ericsson	Product design for environment	2021-03-12	30 min
Developer	12	Modular management	Modularization in product design	2021-03-24	30 min

Lastly, two interviews with external actors considered to be "experts" within the field of reverse logistics and circularity have been conducted, see *table 7*. These interviews were done in order to get a broader understanding and to discuss potential improvements and solutions to problems regarding the key areas.

Table 7: Interviews with external actors.

Interviewee role	Respondent number	Organization	Key Topic	Date	Length
Researcher, Environmental systems analysis	13	Chalmers	Circularity & environmental impact	2021-03-22	30 min
Sustainable design expert	14	Forming futures	Scale up circularity & Business models	2021-03-23	30 min

In the first step of the snowball and purposive sampling, unstructured interviews were held in order to grasp the research field more thoroughly. Unstructured interviews are often steered by the interviewee, however with a specific topic explored. Such an interview is more of a dialogue as the order of the questions can vary (Justesen & Mik-Meyer, 2013). Additionally, to have some kind of structure in order to stick to the subject, the interviewer can prepare a set of broad questions with an informational agenda for the theme to be discussed (Bryman, 2008).

To further investigate and add to the data gathered from the unstructured interviews, more specific questions were developed for the semi-structured interviews in the snowball sampling process. As mentioned, semi-structured interviews build on a set of main questions, yet still with a general approach as the sequence can vary and that supplementary questions can arise during the interview in order to increase the understanding (Bryman, 2008). However, there is also room for contingent deviations in the semi-structured interview, as supplementary questions can lead to new interesting points of views which can enhance the information gathering (Justesen & Mik-Meyer, 2013). When these semi-structured interviews were conducted, a selection was performed in a purposive sampling regarding which key actors and organizations that were to be included in the study. From these key actors, snowball sampling could take place as the study proceeded to gather more detailed information within the explored field. When investigating how the reverse logistics currently was performed and to understand the current maturity level of the reverse logistics, the interview template was based on the components and decision dimensions of the Reverse Logistics Maturity Model. Further, to come up with improvement areas and recommendations of how the company should reach the next level of maturity, it was important to capture information about the challenges and issues that the company experiences.

The collected data from the interviews are presented in chapter *4 Empirical Findings*. The answers from different respondents have been merged into a single description of the situation. However, the respondents provided different perspectives on the subjects. The sentences or paragraphs are therefore marked with a number that corresponds to the respondent numbers in *table 6* and *7* above, to clarify what information the various interviewees contributed with. It should be noted that in some cases where citations are used in the empirical findings, there could either be grammar corrections, or transplantations from Swedish to English. All information marked with *15* is retrieved from internal Ericsson documents.

The last step in the data collection phase was to perform follow up interviews with key individuals in the organization to discuss possible solutions. These were made in order to understand the plausibility and the challenges related to the alternative solutions, and to finally come up with recommendations.

3.4 Data Analysis

The data has been gathered from both internal and external interviews as well as from internal documents. Thornhill et al. (2009) argue that to gain a deeper understanding of the collected data, there is a need to compare and analyze the qualitative data with theory.

All interviews were recorded and transcribed. Thereafter, the data were divided into different key areas, corresponding to the areas covered by theory in the framework, to enable a comparison with Ericsson's actions. As pilot interviews were performed, the questions could be tested, assessed and improved before the main interviews were conducted.

3.5 Methodology Limitation

A limitation in this master's thesis regarding the methodology has been the consequences and conditions of interaction with internal as well as with external individuals and actors due to the COVID-19 pandemic. The interaction was limited mostly to the online platforms Microsoft Teams and Outlook, which has restricted the open climate and spontaneous interaction. Moreover, direct observations were not possible to perform. Due to the dependency on Microsoft Teams and Outlook to book meetings, there has been limited space in the interviewee's calendars, as they must book meetings for every interaction with their colleagues. This has at some points delayed the process during the data collection phase, however, never to the point to fall behind in the schedule.

4 Empirical Findings

There are three focus areas within Ericsson related to sustainability, see *figure 8*. These are *Engagement* to involve and engage the employees to contribute with positive impact, *Climate Action* to promote a best-in-industry low carbon emission supply chain and *Circular Business* to minimize scrap and excessive material consumption[15]. This master's thesis mainly contributes to the latter of the three fields

Figure 8: The three focus areas within sustainability at Ericsson

4.1 Ericsson's Circular Business approach

Ericsson has set up a baseline of three main initiatives for the *Circular Business* approach; to reduce waste, minimize scrap and excessive material consumption, to focus on the return flows more extensively and also connected to a long-term strategy, enabling a higher degree of modularization in the product design[5]. It is argued that the core of the circularity work is to find synergies within these three main initiatives, and together with activities related to buy back, take back and refurbishment address opportunities for Ericsson to generate a competitive advantage[6]. When reaching a competitive advantage with these synergies, cost reductions, new income streams and a stronger company image will be enabled[6]. One interpretation of circularity at Ericsson is to have a cyclic thinking, which means to decrease or eliminate the old linear way of thinking of developing, producing, and delivering new products[8]. These products are in best case scenario taken back for scrapping in the end of the life[8]. This means that Ericsson has not taken opportunity to profit from a potential secondary market[8]. Currently, unauthorized actors and independent repair providers on the grey market, are making business out of Ericsson´s products[8].

Ericsson has recently introduced the circular approach into their business model and is still seeking the optimal way to move forward through exploration[5]. This is as the level of complexity of the internal processes are high[5]. However, the fully circular approach is neither feasible nor realistic to apply in all areas internally or externally yet[5]. The overall initiative related to sustainability and the journey towards an increased circular business approach within Ericsson is driven at a high level in the organization[6]. This is done with a clear view of how to put the circular approach into action. The initiatives are related to the strategic long-term decisions regarding the business model, which enables a sustainable proactive approach in the product design. This can in the future generate a higher degree of circular material use, refurbishment, use of more sustainable materials in the products and recycling opportunities in the end of the life cycle[6]. However, as Ericsson is still in the initial phase of the circular initiative and recently initiated actions to become more circular, the outcome is still somewhat uncertain. Ericsson is additionally working actively to ensure the highest energy performance possible during the product life cycle in order to reduce the environmental footprint of products during operations[6]. There is a challenge in how to support a circular business model and simultaneously provide high quality and performance of the products. An important denominator to cope with such challenge is to find the balance between these factors and thus implement the most suitable circular business model, tailor-made for Ericsson[6].

Ericsson is currently offering the customers to buy products, meaning that Ericsson does not possess ownership of the products when arriving at the customer sites and thus loses control at that point[4]. This further implies that Ericsson does not have the right of take back or buy back activities without the customers' approval. This results in products often ending up in the grey market where other actors and competitors can profit from Ericsson's products[2]. In order to minimize or eliminate the product leakage to the grey market leasing options and product as a service are brought up. Leasing is argued to be a necessity as this speaks for a strategic sustainable business model with an innovative approach in order to become more circular, and thus exclude external influence from the grey market[5]. However, to adopt a circular business model creates challenges, as such decision would influence the customers, whom are the most important stakeholders[5,13].

Despite the argued necessity and positivism from employees not in the position of decision making of introducing leasing or product as a service concept into the business model, there are also skepticism and resistance internally in the organization[8,9]. Such solutions would generate increased tied up capital and thus burden the balance sheet negatively compared to solely offer the customers to buy the products[3,4,8,9]. It is also argued that leasing would not be viable in large scale to support or benefit a business case, i.e. to fully replace buying opportunities with leasing opportunities[6]. Yet, introducing it in smaller scale, e.g. for products that Ericsson wants to get back and the refurbished spares could be a first step to take[6]. Finding a suitable and viable business case for such initiatives and setting up deals with the customers to send back the materials could generate a higher degree of returned material, which in turn would enhance the circularity[6]. It is speculated that having such a business case in place could further result in that customers start to prefer leasing over buying which could lead to economic benefits internally and enable a larger scale of returned material as well as including unused material in stock[6]. Though, to include unused or outdated products would require disassembly of the components which currently is a very complex process that requires manual labor[6]. This is currently not an economic viable procedure as it implies for investment in extended resources and capacity, compared to selling new products to the customers[6].

Modularization in product design is argued to be an enabler to enhance circularity of the material flow regarding reuse and refurbishment, i.e. both up- and down streams in the supply chain[5]. Furthermore, it is a necessary action to take to enable long-term benefits in the strategic decision making, thus becoming a game changer for Ericsson[5]. If the right decisions will be made regarding components in terms of energy efficiency and flexibility in product design, while managing a peak in demand, modularization of the products is the right path to take[5]. Though, the challenge lies in the high complexity of the products and that several of the larger customers require customization[5]. To find a standardized modular solution where customization can be made in the latest possible stage to provide a diverse product portfolio, is a comprehensive and time-consuming challenge to tackle[5].

Furthermore, adopting a circular business implies for organizational challenges as the entire company must be onboard, from top management to operative level, to develop a common holistic view[6]. There is further a challenge regarding how to enable a sustainable knowledge integration throughout the organization due to the unclear and undefined meaning of what circularity is at Ericsson[6]. Circularity is a complex concept with various interpretations; thus, it is especially important to have a common understanding throughout the organization in order to move towards a common circular business goal[6]. However, the largest challenge of increased circularity, is that it requires an extensive transformation. The entire organization must be convinced that the benefits in changing for the greater good is the best option, and it is unavoidable to meet resistance to change[5].

4.2 Refurbished Spare Part Sales

Ericsson extended their circular initiative in 2019 by launching *Refurbished Spares*, offering refurbished spare parts through buy back, refurbishment and reuse of already used spare parts[15]. The quality of the refurbished products is comparable with new products with the same warranty and quality assurance[15]. The *Refurbished spare part sales* thus support a circular approach by adopting a more efficient way to utilize materials[15].

The business goal of launching *Refurbished spare part sales* was to provide a more price sensitive customer segment with an alternative attractive offer[15]. Further, the initiative will increase the strategic buy back of material and products from customers and prevent leakage of strategic products to the grey market and thus reach independent repair providers[4]. This could provide Ericsson with an opportunity to take market shares form the grey market[15]. Lastly, the risk related to investment in last-time-buy stock, i.e. products to be phased out, can be reduced by offering refurbished spare parts[15].

4.2.1 Determining Factors to Initiate Refurbished Spares

Refurbished spare part sales were launched as Ericsson saw a business opportunity in selling already used spare parts and to take advantage of the opportunity[3]. It was initiated as a start to become more circular, and from the circular perspective the *Refurbished spare part sales* are meant to reduce the environmental impact by reuse instead of only manufacture new products[10] and by increasing the share of refurbished material in products[15]. The environmental benefits are underpinned as one of the major reasons to the initiation[2,6]. For Ericsson to take responsibility of their own units would further enable a higher degree of control and ensure that products are used in a correct and proper way, not ending up in places where they do not belong[7]. This in turn enables higher standard of testing to ensure the quality standard and more sustainable disposal[7]. Ericsson are currently good at recycling but could focus more on reuse to become more circular[6]. In Ericsson's annual report for 2020, it can be noted that 94 percent of the returned material has been recycled, while only one percent has been reused. The *Refurbished spare part sales* is thus about becoming more responsible as a company and the initiative additionally complements the business goal of becoming more environmentally friendly[7].

The economic aspect is also considered to be a main driver for the initiative, both by bringing value to customer by offering good products at a lower price, but also to the company[10]. The offer of refurbished spare parts brings a lower price to the customers, but are sold at a higher margin, thus the business case implies high profitability[4]. The products are only bought back and recovered if the buy back price is sufficiently low, described in percentage of the original manufacturing cost[1]. The recommended price of a recovered products to the customer are centralized set, considerably lower compared to new products, in percentage of the price for new products[1]. However, the actual prices are then set by the sales units located closer to the customer to get the highest possible margin but keeping the customer demand[1].

The initiative is mainly based on a mixture of the environmental and economic aspects[1]. However, another reason to initiate *Refurbished spare part sales* is to take control of the material and limit the leakage of products[1,2,4,7] and to increase the competitiveness towards the grey market[15]. Furthermore, it seems to be a market for these products, otherwise there should not be a grey market[4,8]. This is additionally strengthened by a study that currently are performed where the preliminary results indicate that there is a market for selling refurbished spare parts and products[8]. Lastly, the competitive advantage and possibility to provide an alternative offer to a possible customer base with such requirements is a reason to the initiation[1,5,7,15].

One of Ericsson's customers' demands even more than refurbish spare parts, the specific customer has set a requirement of a certain percentage refurbished material in entire products[3]. It can thus be assumed that other customer probably will have similar requests and that legal requirements from countries, the EU, etcetera, will move in the same direction[3]. This will probably not be an easy task due to the difficulty of secure material to be refurbished, however Ericsson must start somewhere[2]. Correspondingly, Ericsson is still trying to find out where to fit in the circular strategy as well as what possibilities the circular business approach will bring[5]. The material sold within the *Refurbished spare part sales* is currently sourced by an internal unit within Ericsson called Service Area Repair (SAR)[1] as a side project to their regular business.

4.2.2 SAR and Supply Chain Structure

SAR is an internal unit within Ericsson that provides Hardware support for all Ericsson's customers with service contract and in return takes the defective units back and are thus performing the reverse logistics activities[7]. Even though SAR is an internal unit within Ericsson they use a different business system, Ericsson uses SAP while SAR uses Mercury (M5). Thus, Ericsson has limited insight in how SAR operates, yet, Ericsson is aware of the well-established and standardized processes within SAR[1,2].

SAR provides customers with a replacement product within a certain lead time which is explained to be a kind of warranty[7]. The replacement could either be a new product or a repaired product. The repaired units either comes from deinstallations at the customers or are bought from the grey market[3], additionally the unit possibly could be found internally in lab or inventory surplus[4]. The faulty unit that are brought back from the customer will, if possible be repaired, otherwise it will be scrapped[1]. The flows described are presented in *figure 9.*

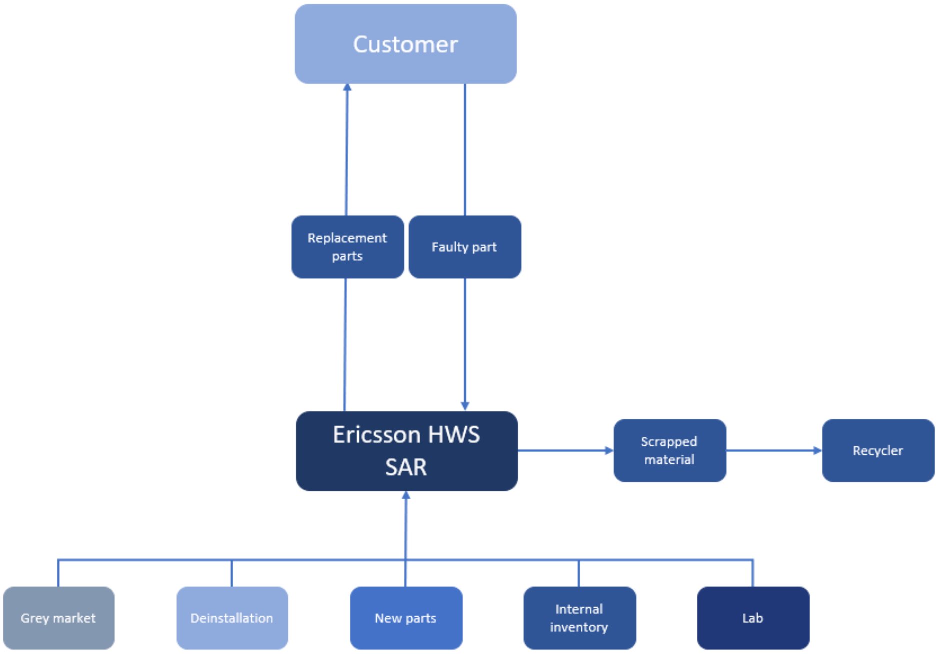


Figure 9: Flow between SAR and customers

Depending on what country the customer is located, the pick-up and delivery of faulty and new unit works differently. There are solutions where the customers have drop-boxes for disposal in order for SAR to pick-up, while other countries have established milk-runs once a week. This is dependent on what the customer requirements are and the best behavior in relation to the infrastructure in each country. Furthermore, there are solutions where the customers return the units to the hubs, and solutions in place for when the faulty units are immediately exchanged with a replacement unit. The replacement unit is delivered before or after the faulty unit is picked up, and the products flow in a loop between SAR and the customers.[7]

SAR includes the global function of material management, which manages the stock levels and dimensions of spare parts in all warehouses in order to be proactive and responsive with regard to the agreed lead times towards the customers' requests[7]. Furthermore, SAR consists of several key-sites globally, in the USA, Europe, Malaysia and in China[7], which is called L2 warehouse[2]. Each of these sites has a site manager in order to follow the evolvement of the strategic business plan of having a function driven organization instead of having separate driven site organizations[7]. This underpins the material management to be a global group and to be steered as such, operating from all sites to manage the global inventory[7]. However, it is argued that; to possess local expertise, knowledge and to have frequent communication is of great importance, which the managers at every site are able to secure and facilitate with this set up of structure and business model[7].

The warehouse structure is designed with a large global warehouse, called L1, located in Sweden, four regional warehouses, L2, warehouses located in several countries, L3, warehouses in larger cities, L4, and warehouses in larger cities, however closer to the sites, L5. The more critical a product, component or spare part is, the closer to site it is located. As L1 is the large global warehouse, it also supports the other warehouses along the value chain with material and products to not run out of stock. Furthermore, L1 is the only warehouse that are currently holding the refurbished spare parts. Thus, the *Refurbished spare part sales* are currently managed from Sweden and all transactions related to this must be shipped through this hub. The next step would be to also use the other hubs to make it possible to do local transactions and not having all transactions flow through the hub in Sweden.[2]

The *Refurbish spare part sale* is a bridge between selling new spare parts and providing services contracts[2], shown in *figure 10*. Furthermore, it is an interesting complement to the already existing offers by giving the customers that are not interested in buying full-service support, an opportunity to buy refurbished spare parts instead of new spare parts[7]. Unlike SAR, that sells a service to the customers, the refurbish spare parts sales instead sells a product[3]. The *Refurbished spare part sales* possibly could be a competitor to SAR[7].

"It is even areas where these two can conflict. If you buy enough spares, you won't buy the service"[7]

If the *Refurbished spare part sales* grow too much and provides the customers with good offerings by getting the customers to buy refurbished spare parts instead of the service that SAR offers[7]. It is thus important to balance these offerings[7].

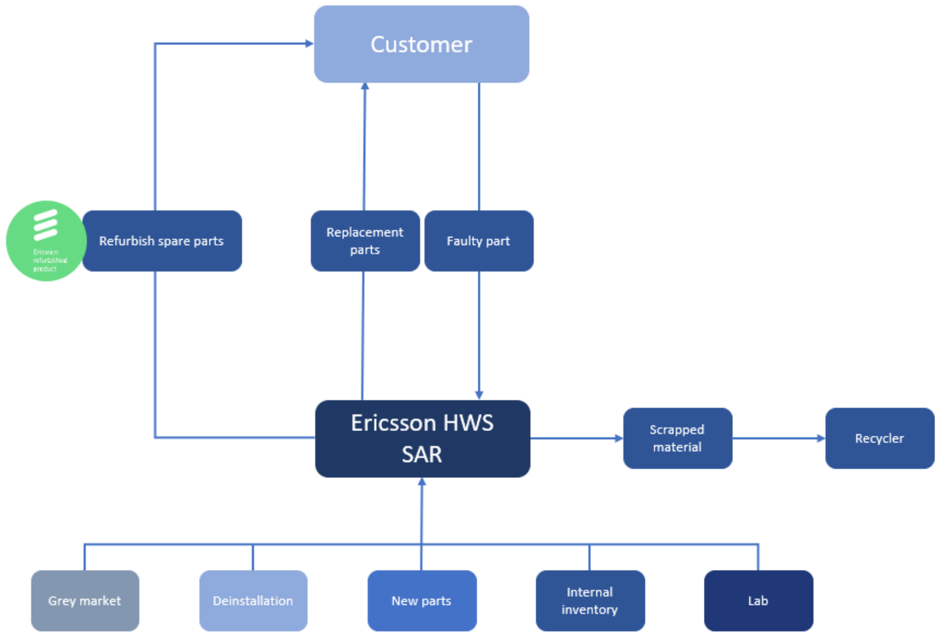


Figure 10: Refurbished spare part sales role in the flow between SAR and the customers

When the *Refurbished spare part sales* was initiated, Ericsson started to build an inventory of products where SAR had inventory surplus[2]. The *Refurbished spare part sales* only have inventory for two different types of spare parts[2]. Spare parts that is not kept in stock by are handled upon customer request[2,10]. If the *Refurbished spare part sales* gets an inquiry from a customer of a certain spare part that is not kept in stock they ask SAR if they have products available in their stock or if it is possible to find the product[1] from deinstallations, at the grey market[3], in internal inventory or lab[4]. The product should then get returned, repaired and delivered to the customer. The refurbished spare parts are thus provided on best effort, since Ericsson cannot guarantee that they get hold of the spare part[1].

Since SAR already have processes to handle, repair, recycle and take care of material as well as find material to use in these processes[1], the reverse logistics activities regarding the *Refurbished spare part sales* are utilizing the back end of the existing reverse logistics flow in SAR[1,7], i.e. existing capacity and resources. For the refurbished spares, this starts with SAR having a unit on the shelf, which is returned from the customer and not needed at the specific time[7]. The unit is thereafter picked from the warehouse to be shipped to one out of several screening centers[7]. These screening centers operates towards agreements of guidelines, which are set up by the Product

Design Units (PDU's), consisting of how to perform validated test procedures and insurances that the systems utilized are certified in a correct manner[7]. If the test is valid, the unit is provided with a new product number in order to clearly show that the unit is refurbished, followed by repackaging and refurbished-relabeling to be shipped to the warehouse from where the unit can be sold as a refurbished spare part[7].

The process is considered to be an ad hoc activity, as this is applied onto existing capacity and managed when requests are placed[7]. Introduction of additional capacity to the flow for *Refurbished spare part sales*, is dependent on if demand arises, and as this is applied onto the existing capacity, there is currently no room for an increased demand from the market[7]. SAR has discussed the issue of returned products in terms of whether to recycle or dispose correctly in a sustainable manner, or to look at the issue from a holistic perspective. This is when looking into buy backs from customers, not solely from a SAR perspective, where the unit directly connected to refurbished spares would be involved in order to support with a holistic view[7]. Yet, as SAR has well-established processes in place, they are not fully aware of the issues of not having enough insight from outside the boundaries of SAR's walls[4], where Ericsson are looking into means of how to integrate the business systems to share information and data in an efficient way[2,6].

4.3 Leakage to the Grey Market

The grey market consists of unauthorized actors and independent repair providers that are making business out of already used products from Ericsson and other actors[4]. The actors at the grey market do not manufacture anything themselves, instead all material comes from deinstallations from Ericsson's and other companies' customers[3]. The grey market actors make business out of selling old Ericsson products to a secondary market and are thus taking advantage from that business opportunity[8].

Ericsson are aware of the grey market's existence, and as there is no way to prevent it, there is no other way than to accept and adapt to it[4]. As already mentioned, Ericsson currently experience a large leakage of products to the grey market, which is of great importance to take control of to ensure that material will be returned to Ericsson[1]. There is a risk related to the leakage of strategic products to the grey market as other actors can get knowledge about these products and thus lead to that competitors get insight of how Ericsson develops its products[2]. Furthermore, the grey market actors possibly could sell to Ericsson's customers, which will make it harder for Ericsson to both sell products and services[8]. When products leak to the grey market, Ericsson lose a business opportunity, they lose control of the material and other actors could take advantage of the products[8]. The aim of becoming more circular is thus to take control of the material and take advantage of the business opportunity that the actors on the grey market currently have[8]. This will further bring new business opportunities by tying customers closer to Ericsson and offer them service contracts for the refurbished products as well[8].

Ericsson are responsible for take back material that the customer no longer wants, called extended producer responsibility. This is based on laws within the EU, but Ericsson have extended it to take the responsibility globally[4]. However, this way of preventing material leakage to the grey market is not a very efficient since many customers wants to take care of the material themselves[11], often to sell it to the grey market[2]. To further prevent the leakage, Ericsson decided that all the customers should be offered take back when buying a product, thus forcing the customers to make an active choice to remove such clause already in the offering process[8]. However, as the customer owns the products and have the right to refuse the take back, there is still a large risk of leakage. One possible reason to why Ericsson in many cases cannot buy back material or components from their customer is that Ericsson might not be interested in buying back the entire product, but only certain parts or components[2]. The customers most often do what is easiest for them and thus selling the entire network to someone who wants it and not disassemble and sell a few parts to Ericsson is a more common way for the customers to get rid of the material[2].

4.4 Refurbished Products

Refurbished spare part sales is currently just a small business[8] handling small volumes[3] of different products[6] which makes it difficult to get scalability[14]. Furthermore, customers only get to the *Refurbished spare part sales* when they cannot find the products in the main flow of new products[2]. Most of the refurbished spare parts are products that are no longer are manufactured, and the main value of this business is that

Ericsson do not have to start up a new production line if the customer wants such spare parts[8].

For companies that are interested in circularity a small project or pilot is a common way to initiate and investigate a circular approach. This is often done in a segment that will not affect the entire company. In this way, the ordinary processes can proceed as usual while the new business opportunity is investigated. It can however be difficult for companies to explore the actual effects of being circular by just initiating a small project that can be done without affecting the entire company. It is hard to predict and evaluate how the initiative will be scaled and what will be the effects of implement. Additionally, it is important to initiate a project that is interesting for the customers in order to build demand. It is very difficult to reach a broad target group if the project is very niched.[14]

To further develop the circularity, Ericsson recently started a trial to investigate the potential to launch refurbished products[8]. This project was initiated from a customer requirement on Ericsson to offer refurbished products or products containing a certain percentage of refurbished components[2,3,4]. Ericsson saw a potential to keep control of the material and take the business case from the grey market. Since there is a grey market of the used products, Ericsson know that there is a market for these products, however with limited data to assess the size of it[4,8]. The market potential for used and refurbished products will thus be investigated throughout the initiated project[8]. Furthermore, Ericsson sees a potential to get the service contracts related to the refurbished products as another positive effect of launching refurbished products[8].

4.4.1 Challenges related to Refurbished Products

Several challenges have been identified related to initiation of refurbished products. A common argument within Ericsson is related to the risk of cannibalization, which means that if starting to sell already used products with the same guarantee and quality as a new product but at a lower price could negatively affect the sales of new products[3]. Another challenge of offering refurbished products is that it will be closer to, what Ericsson call, end-of-support. This could be problematic for both the customers and for Ericsson as it will be harder to get hold of spare parts, maintain, and repair products[4]. This initiative could further be problematic since new products probably will be more energy efficient than already used which implies a higher environmental impact to install such products compared to install new[4].

There are also challenges related to understand the actual environmental benefits. There are many different types of environmental impacts, and often a reduction within one of these mean an increase of another[13]. It is thus important to find a balance between these and decide what to focus on[13]. The environmental impacts could be for example increased material recycling, reduced extraction of scarce material and resources, reduced biodiversity, and climate change[13]. Ericsson largely focuses on tackling the climate change especially by lowering the carbon emissions[15].

4.4.2 Opportunities for Refurbished Products

Despite the challenges mentioned above, several opportunities related to refurbished products has been identified. One of the major opportunities is that Ericsson can capture the business opportunity that the actors on the grey market currently have[8]. Since the grey market exists, there is an existing market for already used, refurbished products. The refurbished products could be sold at a lower price, but with significantly higher margins than of new products, and thus be viable to the company.

Selling refurbished products at a lower price, opens up to reach new markets and customer segments. In some countries, customers cannot afford to invest in an entire new Ericsson network and is thus stuck with very old technology[3]. Accordingly, the refurbished product sales could be an enabler to get these countries and customers to follow the technological leap, however with some delay in comparison to the customers at the forefront of new technology[3]. By selling already used products, the leakage to the grey market could be limited and thus the competition from the grey market would be reduced. Finally, selling refurbished products as a complement to new would bring environmental benefits[8].

4.5 Business Models Supporting the Circular Economy

The product leakage to the grey market will probably be an even larger if starting to offer refurbished products and not just spares. To overcome these problems and to support the circular economy several new business models to ensure that material return to Ericsson when it is at the end-of-use at the customer, has been suggested, both by the employees at Ericsson, but also from the interviewed “experts”. Both business models where customers get the ownership of the material and where the customers get access to the material will be presented. If selling the material to the customer there is a risk of continued leakage, however, the risk could be reduced in different ways. If Ericsson instead keep the ownership of the material, they have full control of it, but they will end up with high tied up capital which will negatively affect the balance sheet[4]. These types of models will affect the balance sheets and entail high tied up capital, but as time goes, companies must rethink the actual effect of this and possible solutions to overcome the problem to gain a long-term profit[13]. One way to overcome or cope with the financial challenge and not have to bear the full cost within Ericsson is to use investment companies[8]. These companies could bear part of the cost, thus taking part of the financial risk against getting a certain return, to help Ericsson spread the liability and balances[8].

4.5.1 Buy Back from Grey Market

Currently, the customers are owning the products and at the end-of-use, the products often end up in a kind of auction where the operators sell the products to the highest bidder. Such model would thus mean that Ericsson must place the highest bid at the auction. However, this must be done within a certain budget. This implies that the grey market is an actual competitor of Ericsson.[8]

4.5.2 Buy Back offerings by Close Customer Relationship

To become more circular and ensure that material flow back from customers to Ericsson, the key is not to buy used products from the grey market, but instead create a close relationship with the customers[3]. This will be done with the purpose of getting the first question to buy back material when a customer starts to deinstall[3]. Ericsson have previously done some good business through buy back from the grey market[4]. However, it is considered to not be the optimal way to do it[4]. To sell products with close relationship and interaction with the customers seems to be a better option than bidding against the grey market actors on an auction[8]. If an intermediary is involved Ericsson loses control of the material but still has a quality responsibility[3]. Thus, it is important to have direct contact with the customer[3]. One suggestion to ensure the material returns, is to be clear to the customer already when selling the product that when they want to deinstall, they should ask Ericsson if they are interested in a buy back[3,14]. Furthermore, it would be beneficial to have a system for how to do this and make the return to Ericsson to be the simplest option for the customer to get rid of the no longer wanted material. It is not only important to be clear that Ericsson want to get the material back but also about what it will be used for, so that the customers understand that it comes in handy and not just be scrapped[14]. Customers and companies currently have an increasing interest in that the products that are no longer needed in one place could be useful somewhere else and should not get thrown away as waste[14].

4.5.3 Buy Back with Discount System

An alternative way of selling is to have a discount system, so if Ericsson get the offer to buy back the product, the customer will get a discounted price of the new installation[8] in order to create a value of returning the products[13,14]. This type of system could especially be interesting in the business-to-business context[14]. Ericsson have studied other companies that uses this kind of system and offer a substantial discount of a new product if returning the already used one[8]. Such system seems to be even better the previous mentioned buy-back alternatives[8]. Furthermore, in the balance sheets and annual report it can be noted that these companies have basically equal revenues to a higher margin of used products compared to entire new products and it is a fairly large business for these companies that seems to work[8]. Thus, some type of discount system could a better alternative for Ericsson to offer to increase returns[8]. A discount system could also be needed to create some incentive for the customer to return the products to Ericsson, instead of selling it at a high price at the grey market[14]. This is however not uncomplicated, as Ericsson must find internal incentives, new business models and study every single profit center[8].

4.5.4 Leasing

Offering leasing as an alternative to solely selling products has been discussed at Ericsson[1] as one way of ensuring the material for refurbished products[14]. Ericsson would still own the products and have the possibility to do whatever they want with it as long as they fulfill the customer requirements[14]. A leasing model can be seen as a prerequisite for circularity and it has been noted that competitors use such models[2]. The leakage to the grey market is, as mentioned above, very problematic to Ericsson[2] and something that must be tackled[1]. With a leasing model it would be easier to take back the material needed for refurbished products and it would also minimize the risk of product leakage to the grey market[6]. The leasing model would provide Ericsson with control as they own the material, and the customer are paying a fee to use it[2]. By this model they will get the possibility to take back, change and use the material as they want which would probably give higher visibility of what products Ericsson has on the market[2]. Furthermore, if a customer wants to upgrade, it will be possible to an increased leasing fee[2]. However, to implement a leasing model would require extensive work and changes, as it is an entire new way of operating with products compared to how it is performed currently, yet it is interesting[2]. The leasing model is an entire new model for Ericsson and currently the discovered business advantage is not sufficient to implement leasing for all Ericsson's products[6]. An alternative would be to not have the leasing offer on all products, but only for the products that Ericsson actually wants to get back[6].

Leasing is a service model and considered to be more attractive than offering pure products[8]. Additionally, companies with service models are significantly higher valued at the share market[8]. A leasing model, where Ericsson should own all the products would mean a comprehensive impact of their balance sheet due to the large amount of assets, which they probably not would be able to handle[4,8]. The huge amount of tied up capital has been the critical factor to not go ahead with the solution[3].

4.5.5 Product as a Service

Product as a service is a very interesting area to investigate[11]. Ericsson has started to investigate how to sell network as a service, and thus selling the service instead of selling hardware[11], thus Ericsson would own the hardware[15]. Such model would provide Ericsson with more control of the products and the entire life cycle of a product[15]. Furthermore, the network design could be optimized from an energy and material efficiency perspective and adjusted to the needed capacity[15]. The capacity would also be increased or reduced in line with changed market needs[15]. Keeping the ownership of the products will enable easier managing of upgrades, maintenance, repair, and reuse[15]. Additionally, it will enable optimization and managing the product from an environmental perspective[11]. However, the product as a service offering would come with the same financial challenge as the leasing offering since the ownership is kept within Ericsson[8].

Currently there is an inefficiency on the market that brings overcapacity and a higher energy consumption than what is needed, which could be reduced by a service model, thus also affecting the amount of asset Ericsson must keep ownership of[8].

"The number of radios would be reduced, which reduces the energy consumption, while the capacity would be the same. The cost would be lower for the operator, the costs on a country level in Sweden would decrease somewhere between 20-40. If taking that example, Ericsson could at the same time have higher margin since they could make good money in service cost for the customer to operate the network and provide them with capacity. The cost would still be lower for the customer and give Ericsson a higher margin, resulting in more money to Ericsson"[8]

As this would keep the capacity on the right level, a lower amount of radios will be needed resulting in a reduced energy consumption as well as the cost for the operators while having higher margins of the service. To conclude, offering the product as a service could come with lower prices to the customers due to lower costs, but at a higher margin and thus bring viability in the business. However, someone must realize this and change the way of thinking in order to capture the opportunity.[8]

"There is an inefficiency on the market and in the product and someday someone will realize that and maybe take hold of it, and it could just as well be we as anyone else. It is however difficult since there are many not technical, but other obstacles standing in their way"[8]

The model would mean that Ericsson must take care of hardware and software, planning and design, installation and integration, operations and support, investment/ownership, managing the entire life cycle and lastly, sub-contractors and suppliers[15]. If implementing a business model where Ericsson owns the product and sells the function, they could close the material loop and make sure that the products are reused or recycled in the end-of-life or end-of-use[15]. Furthermore, Ericsson can ensure that the products do not end up at landfills or get recycled in an improper way[15]. This would also ensure that Ericsson gets access to critical materials through the recycling process[15]. Lastly, a product as a service model would enable optimization of energy- and material use in the network[15]. However, in some cases Ericsson are not allowed to own the hardware, some new segments are demanding private networks[15] and some customers want to own and have control of the material[8], which could hinder or complicate the implementation of a product as a service model. The implementation of a service model is thus easier in theory than in practice[8].

A new, unlicensed spectrum and spectrum sharing would open up for options for parties to share a common infrastructure, which would positively affect the material efficiency[15]. However, this model is not applicable today since the customer is the owner of the license if the frequency spectrum and thus also must own the product[15]. If instead having unlicensed spectrum it would be possible to develop models with an opportunity for customers to share the infrastructure[15]. Furthermore, even though such model has begun to be investigated, it will take a lot of time before it will be fully implemented[11].

4.6 Product Design for Circularity

Products can be designed to be more or less suitable to a circular business model. *Design for Environment* is an initiative where Ericsson are including environmental and circularity aspects into the product design. Furthermore, *Modularization* is an initiative that could enhance the circularity[5,6]. However, the current modularization work at Ericsson is not performed with an environmental focus[12].

4.6.1 Design for Environment

Ericsson has an initiative called *Design for Environment*, to investigate what can be done in the product design phase in order to reduce environmental impact in the product life cycle but at the same time fulfilling the wanted functionality, quality and performance[11, 15]. The life cycle is divided into three phases, namely production, use and end-of-life[11]. The production phase aims to design for material efficiency, the use phase aims to reach energy efficiency and the end-of-life phase aims to have efficiency in the end-of-life treatment including spare parts handling[11].

The production phase considers choice of material, to not use banned or restricted materials, i.e. material to be phased out, material declaration to know exactly what each product contains, to see how and where different materials are used and how it should be handled is a material should be banned in the future. Furthermore, product weight and material use are considered for example to see the impact of transports and lastly the product's durability, upgradability, maintenance and repairability. The use phase handles targets and roadmaps as well as measurements and power limits. The last phase, end-of-life, is about avoiding material having an impact of the recyclability, which is regulated through the banned and restricted list of materials. Furthermore, marking of the materials used in the products is a way to increase the customer ability to recycle and lastly the ease of disassembly is handled in this stage, to make it easy to disassemble by not using special tools and methods to further simplify the recycling.[15]

One of the main motives for having *Design for Environment's* input in the product design is mainly due to legal requirements. The legal requirement must be fulfilled and thus determines the lowest level. To set the lowest level, the different requirements of the markets are scanned where they will be present. EU, USA and China often have the most extensive requirements and is thus considered in the first place. EU generally have the toughest requirements and many other countries copy these requirements. Ericsson do not set different product requirements for different countries which means that the toughest requirements at any of the market where Ericsson wants to be present becomes the lowest level for all Ericsson's products in the markets. The requirements from the customers along with the life cycle assessment to understand environmental impact are also considered to be a main reason. Other reasons are to reduce the environmental impact, follow the standardization and influence from other stakeholders as for example NGOs.[11]

4.6.2 Modularization

Modularization would be very beneficial in the long term in both a strategic business point of view and in the circular point of view[5]. Even though the modularization positively affects the environment by enhancing the circularity, there is very limited focus on sustainability in that modularization project at Ericsson and no integration between the *Modularization* and *Design for Environment* teams[12]. Instead, both units report to the group function sustainability team separately, which does not anchor these two perspectives.

"I honestly have never heard of Design for Environment"[12]

The current focus of the modularization is to make the product development more efficient by not having to start from scratch with each product but instead reuse modules especially between different versions of products, but also between different products if possible[12]. However, from an environmental perspective, the modularization is a great opportunity to handle the material in a better way and to reach material efficiency[6]. What is happening now is that it is more and more product variation and the product life cycles are shortened[6]. This in combination with unpredictable demand and variations in product mix makes it difficult to determine what and how much to be stored[6]. Furthermore, this contributes to material being scrapped and material that has been produced and stored which does not come in use[6]. Modularization is vital to reuse material between different products and use the material as common denominators between the products[6].

It is currently both complicated, expensive and requires manual work to rework products. If using common modules or components in various products, it would be much easier to rework the products and less risks related to inventory of products[6]. It would thus enable more and extended reuse and possibilities to refurbish[5]. The challenge in the modularization lies in making the products less customized but at the same time fulfilling the customer requirements[5]. Thus, it can be assumed that there will be a high level of complexity and a long journey related to the modularization[5].

5 Analysis

In the analysis section the theoretical perspectives presented in the framework will be connected with the empirical findings to elaborate on different possible solutions within the investigated fields of the study, in order to enhance the circular initiative at Ericsson.

5.1 Sustainability

Sustainability is an important focus area at Ericsson and they have been awarded the 12th most sustainable organization in the world by the Wall Street Journal (Ericsson, 2021). Ericsson are however continuously focusing on sustainability and are striving to become a leading actor within this field. A transition from the traditional, linear business model into a circular business model is a way for companies to become more sustainable (Geissdoerfer et al., 2017) with a major focus on the economic and environmental aspects of the triple bottom line (Kirchherr et al., 2017). Thus, to become more sustainable, Ericsson could focus more on circularity, which is one of the focus areas within their sustainability work. Moreover, focusing on *Circular Business* could also contribute to the other two focus areas, *Engagement* and *Climate Action*. This is as the focus on *Circular Business* could increase the attention and awareness of sustainability within the company and reduced environmental impact.

5.2 Circular Economy

With the *Circular Business* initiative, Ericsson aims to transform from the currently dominating, linear consumption model into a closed, circular system. In a circular business model, resources are reused, refurbished and lastly recycled (Urbinati et al., 2017), thus avoiding resource depletion to respect the planetary boundaries (CE100, 2016). Ericsson has started its journey toward a circular model and has already reached, what de Angelis et al (2018) refers to as, the sustainable level offering reparation and recycle options.

The concept of circular economy is ambiguous, with several definitions (Kirchherr et al., 2017; Merli et al., 2018). This is also the case within Ericsson, as there is no clear corporate understanding of how to define the concept of circularity in order to make it fit into the operations at Ericsson. Thus, in order to develop a clear strategy regading circularity it is important to have a common defintion, clarifying the wanted and expected environmental effects and what possible consequences may follow (Moraga et al., 2019). Ericsson is acting proactively with the goal of becoming carbon neutral in 2030, and the *Circular Business* initiative is a key part to achieve that goal. Furthermore, becoming carbon neutral with mitigated carbon emissions is a key enabler to tackle the climat crisis of today (Ellen MacArthur Foundation and Material Economics, 2019).

Circularity for Ericsson is broadly described to enable a transition, going from a linear business model with a focus on developing, manufacturing, and delivering new products, to a more cyclic thinking. Geissdoerfer et al. (2017) define circular economy as a regenerative systems to minimize resource input and waste, emissions and energy leakage. This could be achieved by designing long-lasting products and prolong the ability to maintain, repair, reuse, remanufacture, refurbish, and recycle the products. This definition corresponds to the future long-term strategy described by Ericsson. A synthesized definition of Ericsson's *Circular Business* initiative, is to find synergies in minimized waste, scrap, and consumption, to enhance a long-term strategy with product modularity integrated in the product design, and simultaneously increase the performance of buy back, take back, reuse and refurbishment activities.

To reduce the greenhouse gas emissions throughout the supply chain, preservation of already manufactured products to reduce waste must be considered, as material consumption is a large source of carbon emissions (Ellen MacArthur Foundation and Material Economics, 2019). Considering Ericsson's sustainability work, including *Circular Business*, the possibilities to reduce waste can be achieved. It is underpinned by Ellen MacArthur Foundation and Material Economics (2019) that companies must strive to adopt to a circular business model to achieve reduced emissions. Having short lead times of the forward flow is often considered to be more crucial than the reverse flow as it aims to fulfill customer needs (Tibben-Lembke & Rogers, 2002). This implies that the lead time of the reversed flow often is less prioritized (Tibben-Lembke & Rogers, 2002). The low priority of the reverse flow has been noted at Ericsson. CE100 (2016) argues for the importance to prioritize the residual value of the returned products in the reverse logistics. Preservation of the products and higher priority of the reverse flow could thus lead to less waste and reduced emissions at Ericsson.

The *Refurbished spare part sales* was initiated in order to increase the circularity, and is currently solely managed from the global warehouse in Sweden. This entails a higher degree of unnecessary transportations in the reverse logistics, compared to if managing the refurbished spare parts from warehouses located closer to the customers. However, owing to the low customer demand, it is not possible to manage the refurbish spare parts closer to the customers due to uncertainties in time, quantity, and variants. These unnecessary and long-distance transportations to and from Sweden are a consequence of the way in which reverse logistics is currently organized within Ericsson, negatively impacting the environment with higher carbon emissions. *Refurbished spare part sales* is currently a minor ad hoc business utilizing SAR's existing flows and capacity. Development of the refurbished offerings will require scaling up these operations.

To achieve the extensive transition to become circular, de Angelis et al. (2018) argue for not only prolonging the product life cycle, but also to investigate the serviceable and durable ingoing materials. As Ericsson presents heavy carbon emissions in the annual report related to heavy metals, this is one of the areas in need of increased focus to reduce carbon emissions. To enable a reduction of carbon footprint related to metal consumption and durable materials, processes enabling reparation, reuse, recycling and refurbishment have to be considered (de Angelis el al., 2018), not only for spare parts, already initiated at Ericsson, but also for products. Furthermore, expanding the refurbished offering to include products could possibly contribute to tackle the problem of extra transportation as the demand of such offerings probably will increase. Thus, products could be managed not only from the global warehouse in Sweden, but also further down the warehouse chain, closer to the customers. The unnecessary transportations could be reduced and thus also the negative environmental impact from these resulting in a lower carbon footprint.

Furthermore, in the current business strategy Ericsson are solely providing the customers with buying opportunities, which decreases the chances of becoming circular. De Angelis et al (2018) argue that instead offering customers the possibility of accessing the products through e.g. leasing, renting or sharing products would increase the possibilities to become circular. Such business models, however, could be challenging for Ericsson and are further discussed in section *5.7 Business Models Supporting Circularity*. Such a transition would also entail increased control of the material flow (de Angelis el al., 2018), which would be beneficial for Ericsson due to the currently low control. Having control could provide companies with possibilities and incentives to increase performance in the product development process, which in turn gives opportunities to prolong the product life cycle through increased upgradability (de Angelis et al., 2018). This further supports Ericsson to do the transition.

Another challenge of becoming more circular at Ericsson is that the products already in use on the market are less energy efficient than newly developed products. The challenge lies in the tradeoff between manufacturing new, energy efficient products or introducing internal processes to provide the market with refurbished, but less energy efficient products, by introducing a circular business model at Ericsson. However, Urbinati et al. (2017) argue that the most sustainable products are the ones that already are produced. Increased circularity can be achieved through extending the product life cycle. This is through durable design, enabling reuse, remanufacturing, refurbishment, and redistribution of the products (Urbinati et al., 2017). There is a challenge for Ericsson to achieve this with the current business model, as it is characterized by low control in the reversed flow of products. Moreover, Ericsson is operating in an ever-changing market with high uncertainty and complexity in product design. According to Urbinati et al. (2017) there is a challenge to make use of end-of-life products while providing such market with high performance products. Yet, to introduce a higher degree of modularity in the product design would be a game changer in the long run for Ericsson to reach the circular business goal, further discussed in section *5.8 Sustainable Product Design to Enhance Circularity*.

To achieve a closed loop supply chain and reach a *Circular Business* goal, it is not enough to consider internal processes and development, but the entire supply chain of products must be considered (Govindan et al., 2015; Schenkel et al., 2015; Lüdeke-Freund et al., 2018). If considering both the forward and reverse supply chain, the product value during the life cycle should be maximized (Guide Jr. & Van Wassenhove, 2009). Thus, Ericsson could reach both environmental and economic sustainability by having high material efficiency and capture the opportunity of additional sales. The description of how Ericsson is trying to go from a linear thinking, considering old products as waste, instead of making a business opportunity out of them, corresponds well with Habibi et al. (2017), arguing for taking back material from the market to process it and thus utilize it as an alternative source in the production process. Ericsson is describing a goal and wanted position of becoming circular. Yet, Ericsson does not currently have either capacity, processes, or the right tools in place to enable a circular business model.

Only considering fragments instead of implementing an entirely circular business model is however not unusual as a transition from a linear to a circular business model requires long-term, cumbersome, and radical changes (Ritzén & Sandström, 2017). For Ericsson to enable value creation in a circular business model with a closed-loop supply chain, could include a use-oriented offering to decrease material use and to increase control of the material flow. To increase control of the reversed material flow, Ericsson would have to come up with processes and find a viable solution for the customers to send back the old and obsolete products, where the products otherwise end up on the grey market, competing with Ericsson.

A circular business model could further require considering a higher degree of modular product design, reducing the material consumption. However, such alteration in product design, requires considerations regarding cross-functional collaboration between several internal units. Furthermore, to support a fully circular business model, integration of business systems with different interfaces to facilitate higher efficiency in data and information sharing is preferable. Additionally, to integrate IoT solutions into the products has to be considered.

5.3 Driving Forces to Introduce Reverse Logistics

Reverse logistics is currently a commonly used practice and a key enabler in companies to close the supply chain loop and thus becoming circular (CE100, 2016). The reasons why companies implement such activities are many and can be categorized into economic benefits, legal reasons and corporate citizenship (de Brito & Dekker, 2004).

At Ericsson there are several reasons to initiate the reverse logistics of *Refurbished spare part sales* that can be related to the three categories.

5.3.1 Economic Benefits

In general, competitors could take advantage of a company's products on the secondary market if the focal company do not take that advantage themselves (Akdoğan & Coşkun, 2012). This correspond to one of the major reasons to initiate the *Refurbished spare part sales* at Ericsson as they saw a business opportunity in selling used spare parts that otherwise would have been scrapped or leaked to the grey market. Furthermore, Ericsson has noticed that competitors on the grey market make business from used Ericsson products and wanted to take that opportunity from them, by develop new business opportunities and thus reach a new customer base. The recovered products could be sold at a lower price to a less price sensitive customer segment, but with potentially higher margins and thus higher profitability.

However, most of the spare parts included in Ericsson's refurbished offering are no longer manufactured. It is thus cheaper for Ericsson to investigate the possibility to find already used products than restarting manufacturing of those spare parts to serve the customer need. Customers that inquire for spare parts are initially directed to the main flow and are only introduced to the *Refurbished spare part sales* if the parts are not available in the main flow. Thus, the demand for refurbished spare parts is currently low. The *Refurbished spare part sales* is thus neither a way to improve circularity within Ericsson nor to provide them with financial gains through additional sales, but considered to be more of a branding opportunity. This is supported by Akdoğan and Coşkun (2012) arguing for creating environmental awareness to the customers to gain competitive advantages as an economic benefit.

5.3.2 Legal Reasons

Currently, manufacturing companies to an increasing extent are held responsible for take back activities due to environmental legislation (Akdoğan & Coşkun, 2012; de Brito & Dekker, 2004). Within the EU, producers are responsible to take back and recycle material that their customer no longer need and within Ericsson the responsibility has been extended to be applied globally, even though the legislation is limited to the EU. The extended producer responsibility within Ericsson means that on customer approval, Ericsson should take back the products in the end-of-life phase for recycling. It is, however, the customers that decide if they want Ericsson to take back the material since they have the ownership. Yet, Ericsson should always offer the customers a take back and has added a clause in the customer contracts to increase the take backs. The clause implies that the customer must send back the material to Ericsson to ensure proper recycling and disposal of the products. Still, it is the customers that have the ownership of the products and thus the right to remove the clause from the contract.

Legislation is often considered to be cumbersome and to entail costly activities in the initial phase (Guide Jr. et al., 2003). A good way to overcome this and instead consider business opportunities is by working proactively with the legislations. In that way, the investments could be made over longer time periods instead of a high one-time cost when the law enter into force (Guide Jr. et al., 2003). One of Ericsson's customers has required products with a certain percentage of refurbished material. There is a possibility that other customers will come up with similar requests and that legal requirements will move in the same direction. Thus, accepting and adopting to these customer requirements could be a way to work proactively with legislation.

5.3.3 Corporate Citizenship

Due to increasing sustainability focus around the globe, companies are forced to act more responsibly and corporate citizenship has become more important (Akdoğan & Coşkun, 2012). This has further been increased by focusing on circularity and reverse logistics. The corporate citizenship concept refers not only to tackling the legal aspects, but also to societal and market requirements in terms of being environmentally and socially sustainable. This implies that the company must act responsibly and respecting the planetary boundaries (CE100, 2016). Furthermore, acting responsible give companies' greater opportunities to positively affect the company brand (Akdoğan & Coşkun, 2012).

The *Refurbished spare part sales* is one of the first initiatives to become more circular at Ericsson and to reduce the environmental impact by reusing products and components. However, the initiative is currently limited and considered to be a very niched project. Consequently, Ericsson cannot investigate the actual effects of a fully circular approach if only considering this limited operation. Furthermore, the majority of material that is currently returned to Ericsson is recycled and not reused, which counteracts the argument from de Angelis et al. (2018) about having a major focus of the inner loops as long as possible.

5.4 Reasons for customer returns

De Brito and Dekker (2004) mention five types of customer returns. Since Ericsson operates in a Business to Business context, the Business to Consumer returns is not considered in this case. Currently at Ericsson, warranty returns in form of claims and service returns are the returns handled by the service contracts within SAR. Furthermore, due to the EU-legislation of producer responsibility Ericsson has started to take back of the end-of-life products for proper recycling as these cannot longer be used. Ericsson are currently good at recycling the material that is returned, however not that good at reuse and should thus focus of increasing the end-of-use returns which are currently very limited. Buy back of end-of-use products could both improve the circularity and limit the leakage to the grey market by increasing the reuse or returned products.

5.5 Reverse Logistics Activities and Challenges

Reverse logistics is much more than performing forward logistics in the opposite direction, bringing various challenges in order to be successful (Sangwan, 2017). Currently, for *Refurbished spare part sales*, the reverse logistics is handled by the internal unit SAR. SAR have established, continuously updated and improved processes in place to manage the reverse logistics. *Refurbished spare part sales* is currently managed as a small side project as a first step in the process of becoming more circular. This is possible since *Refurbished spare part sales* only handles small volumes by using their current capacity and resources. However, if expanding the initiative up to product level, i.e. to refurbish entire products, the processes will have to be developed and cannot be performed as a side project anymore.

Another challenge related to the reverse supply chain is that the reverse flow is generally not as extensively tracked as the forward flow (Tibben-Lembke & Rogers, 2002). For Ericsson it is hard to know when or if the customer is reaching the end-of-use or end-of-life phase of the products and to offer them to take back or buy back the products. To cope with this challenge Ericsson have to increase insight of when the products reach the end-of-use or -life phase, for example by incorporating RFID in the products, thus enabling tracking and tracing of the products through IoT, further analyzed in section *5.10 IoT integration of ERP and products*.

5.5.1 Collection of Used Products

All activities needed to perform collection of used products, i.e. purchase, transport and storge, are referred to as the collection activity (Fleischmann et al., 2000). The current collection activity at Ericsson is performed when a product or component is broken at a customer with a service contract, then SAR should send a replacement product and collect the broken or faulty component. The same process is used by the *Refurbished spare part sales*.

Generally, it is hard for companies to predict when the returns will be initiated as well as what volumes to expect. These uncertainties make it hard to forecast the returns (Tibben-Lembke & Rogers, 2002; Defee et al., 2009). Furthermore, the forecasting process is problematic since returns generally are initiated by the customers (Tibben-Lembke & Rogers, 2002; Srivastava, 2013). The forecasting process at Ericsson is even harder to predict, as the reverse logistics handles broken products from the customers, and it is very hard to predict a product failure.

Furthermore, it is difficult to achieve economies of scale in the return flow (Defee et al., 2009) due to that the products are flowing from many origins to one or a few destinations (Tibben-Lembke & Rogers, 2002). At Ericsson, and within the *Refurbished spare part sales,* this is a major challenge since that flow handles minor volumes. However, SAR has solutions like milk-runs and pick-up points to reach economies of scale. Furthermore, as the returns to *Refurbished spare part sales* are combined with the returns within SAR, these are not as low as if they would have been treated separately.

Further, it is often difficult to transport the return products, mainly due to that the products are not packed in the original standard packaging or not properly packed and protected for transport (Tibben-Lembke & Rogers, 2002; Defee et al., 2009). This makes the handling of the return products harder during the transport and can possibly cause damages to the products. This could be due to that customers just want to get rid of the products, not caring about the residual value in them. Thus, Ericsson must get the customers to understand the value of the products and facilitate an easy return process to convince them to return products.

Ericsson are currently experiencing a product leakage to the grey market resulting in not having the ability to take advantage of that business opportunity. To cope with this challenge, Ericsson must change their business model or introduce internal processes to buy back the material when customers no longer need them. One way to do this is to create incentives for the customers to sell the product back (Goltsos et al., 2019). The incentives could be that customers returning material to Ericsson get rewarded by for example a discounted price on their next buy. Another way to incentivizing returns is to create convenience by making the return to Ericsson the easiest way to get rid of the products. To facilitate an easy return for the customer, Ericsson could together with the new product also send what is required for the customer to send the old product back, i.e. a carton and return slip. This will not just make it less cumbersome for the customer, but also for Ericsson to receive the returned product in a standardized package and thus also facilitate for better conditions during transport, with less damages of the returned products. Thus, the challenge of products not being properly packed and protected for transportation (Tibben-Lembke & Rogers, 2002; Defee et al., 2009) could be overcome. As the customer still will need the products to overlap in time, the time between the pick-ups or milk-runs can be used for repackaging, and the returned product can be shipped during the next round.

Goltsos et al. (2019) describe designing the collection activity as a challenging task due to uncertainties both in when and if products will be returned and how many that will returned. To design and operate an efficient collection process, Ericsson has to handle the uncertainties in some way, either by estimating the quantity and timing of the returns which is the way it is currently performed, or to more extensively track and trace the products both during use and returns to get real time information, further discussed in section *5.10 IoT Integration of ERP and Products.* By extensively tracking products and overcoming challenges regarding uncertainty, the collection activity could be designed to make returns simple. However, in order to track products owned by the customers, Ericsson must interact with their customers regarding returns and deliveries, yet, there could be legal restrictions in what, and how much Ericsson are allowed to track. The tracking and tracing could however be simplified if Ericsson keeps the ownership of the products, elaborated on in the section *5.7 Business Models Supporting Circularity.*

Pre-sorting of the goods to grade the product quality and then dividing it into different remanufacturing options to make that process as efficient as possible (Goltsos et al., 2019) is closely related to the next phase, inspection and separation. It is however, also related to the collection activity as pre-sorting can be helpful in eliminating collection and transportation of goods that cannot be recycled or reused, back to Ericsson, and instead sending it directly to proper disposal.

5.5.2 Inspection and Separation

The inspection activity includes a challenging trade-off regarding how much time, effort and material the company have to put into the recovery process in comparison to the value of the product that should be recovered (Defee et al., 2009). Therefore, Ericsson must set up clear processes and instructions of what products, and in which condition and quality it is worth to recover and reuse products rather than recycle.

Furthermore, Blackburn et al. (2004) describe that the inspection activity should be performed based on whether a company should adopt a responsive or efficient reverse supply chain. The nature of the reverse supply chain is further indicating if the company should perform the inspection centralized or decentralized. For innovative products, characterized by short life cycles and high time sensitivity a responsive reverse supply chain with decentralized inspection is preferred, while for functional products which do not get old and obsolete quickly and thus are not very time sensitive, an efficient reverse supply chain with centralized inspection is more suitable to gain economies of scale (Blackburn et al., 2004).

The products offered by Ericsson, and the entire ICT industry, are characterized by long life cycles, which indicate that an efficient reverse supply chain could be developed. However, changing customer demands characterized by higher speed and better technology, have resulted in products get outdated faster, and are thus shortening the life cycles of the products, which suggests a responsive reverse supply chain. Yet, the life cycles are currently not short enough to consider a responsive reverse supply chain as more suitable. It will however be important for Ericsson to see the shifts and changes and adapt the reverse supply chain strategy according to changing behaviors and customer demand.

5.5.3 Reprocessing and Disposal

The aim of the circular economy is to recapture value from used, returned products and to avoid disposal (Fleischmann et al., 2000), closely related to reprocessing of products. In the inspection activity the quality of the products should be determined and accordingly be separated into different recovery processes. Due to varying quality of the used products, not all products returned to Ericsson have to go through the same reprocessing steps to be recovered and sold again. Thus, Ericsson must have proper inspection and separation of the returned products to minimize extra transportation and recovery processes. Ericsson will also have to take the related cost and negative environmental impact into consideration when improving these processes. To reduce improper disposal (Fleischmann et al., 2000), Ericsson are offering all customers a product take back in the end-of-life of products in order to properly recycle the material to not end-up as landfill.

5.5.4 Redistribution

The redistribution activity aims to get the refurbished products out on a potential market (Fleischmann et al., 2000). The redistribution activity is similar to the forward flow in a traditional distribution network. In order to determine the value of the product there have to be a market and demand for the recovered products to understand how different customers perceive the value of recovered products in various ways, thus affecting their willingness to pay (CE100, 2016). Additionally, the recovered products can be offered to a lower price, thus opening up for a new potential market by reaching a customer segment of more price sensitive customers. However, in order to properly set a price for the refurbished products, Ericsson must collect and understand data of customer demand for such products. The pricing may according to Tibben-Lembke and Rogers (2002) be further challenged by varying quality of products, the cost of recovery as well as uncertainties in supply.

The current secondary market for *Refurbished spare part sales* is the same as the primary market. However, Ericsson could possibly reach a customer segment that currently could neither afford a full-service contract nor buy new spare parts. Yet, the current *Refurbished spare part sales* offer is very niched and subject to low volumes, making it hard to reach a broad target group and increase the demand. Furthermore, it may be difficult to understand the actual effects of transforming the entire organization to become circular by only considering the currently limited and niched offering.

If expanding the refurbished offering to offer refurbished products and not just spares there is a potential new secondary market. Since the grey market is existing, there seems to be a market for refurbished products. Additionally, Ericsson has made an initial study to investigate the potential of selling refurbished products, with preliminary results showing that there is a market. The trial of refurbished products started due to a customer requirement of including a certain amount of refurbished material in the products. The refurbished products will probably be just a small project in the trial phase, however a better way to assess the effects than the refurbished spare parts. This is due to the potentially higher demand of refurbished products. Furthermore, the trial of refurbished products at Ericsson could enable data collection to analyze the customer demand and value of recovered products. If using and understanding the recovery and remarketing data, the planning of remarketing products can be performed properly, recovered products can quickly be returned to the market and the customer behavior could be positively affected (CE100, 2016).

Ericsson fear, there is a risk of cannibalization of the main flow of new products. According to Defee et al. (2009) it is important that the new channel do not cannibalize on the existing offering. However, according to TU Deft: Online Course (2017) companies must change their way of thinking about reuse and repurposing of products to not see it as cannibalization, but an additional type of sales. Thus, it will initially important to balance the refurbished products sales with the main flow of new products. Ericsson's current way of looking at cannibalization jeopardizes the principles behind the pursuit of circularity and thus, Ericsson gradually must rethink and redirect the entire organization to adopt a completely circular business model.

5.6 The Reverse Logistics Maturity Model

Since Ericsson offers highly complex products, with high residual value, but with relatively low return volumes, the *Archetype 3- Advanced Industrial Parts* is identified as the most suitable archetype (CE100, 2016). This is further underpinned by ICT products being an example of products associated with this archetype (CE100, 2016).
In order to improve the reverse logistics and increase the maturity level, it is important to have a holistic perspective (CE100, 2016), not only focusing on the transports, as often is considered to be the major part of the logistics. It is not the returns to Ericsson that are environmentally friendly, but that the returned products are recovered and redistributed, instead of producing as many new products. The environmental benefits will occur only when there is a circular flow. Furthermore, the returned products will not be useful for Ericsson if not remarketed and making business of them. However, it will be impossible to increase the circularity if products are not returned, and thus, the reverse logistics is a key enabler (CE100, 2016).

5.6.1 Current Maturity Levels and Improvements of the Reverse Logistics

The current reverse logistics maturity level will be analyzed by using the matrix presented in *table 3* in *2.4.3 Maturity Levels*, from CE100 (2016). Each component with connected decision dimensions will be assessed. Furthermore, improvement areas to reach the next level of maturity will be identified for each component and decision dimension.

Front end

In the *Front end* component and in the *Strategic* dimension, SAR is considered to be on the *Quantitatively managed* level as there is a well-defined reversed logistics strategy in place with clear processes which substantially is driven by profit generation. In order to reach the *Optimized* level, SAR will have to be integrated with the operations and business system of Ericsson to a greater extent, thus making data and information sharing possible. Yet, it would also require working cross-functionally, to enhance the circularity and alignment of business goals. However, *Refurbished spare part sales*, which currently utilizes SAR's resources and capacity as an ad hoc activity, is clearly on the *Initial* level in the model. There is currently limited customer demand of refurbished spare parts with low prioritization of the flow internally. In order to make *Refurbished spare part sales* work, Ericsson relies on SAR's processes To start the journey towards increased maturity of the *Front end* component in the reversed logistics, Ericsson has to understand the importance of the cross-functional benefits that would come if integrating the business systems between these units. The current maturity level in the *Front end* component can be seen in *table 8.*

Table 8: Current maturity level in the Front end component.

		Initial	Managed	Defined	Quantitatively managed	Optimized
Front end	Strategic	Standalone RL with business goals limited to cost minimization	Basic strategy in place to manage RL	RL strategy aligned with supply chain strategy, defined RL process in place.	RL is integrated with supply chain strategy driven by profit generation	RL is integrated as cross-functional process within different business units. RL is driven by profit generation and is aligned with business goals
	Tactical	RL network is not well defined and is managed reactively	RL network is planned and established	RL network is standardized. Return agreements or contracts in place for proactive collection	RL network and flows are planned through collaboration agreements with stakeholders to define performance requirements	RL network and flow is optimized through defined performance objectives in collaboration with logistics provider
	Performance	Items are collected with no record of lead time, return rate and volume	Items are collected and traditional measurements are available (lead time, return rate and volume)	The RL time and flow are measured. Also, items qualities are measured	Item's traceability metric is well defined and used, coordinated in shared system across value chain to monitor and assess return agreements	The RL process is monitored and responsively updated, with real time exchange of value chain information on returned items between logistics provider and company

Further, as SAR has standardized and optimized processes in place and good collaboration with the logistics providers, SAR is categorized to be on the level of *Optimized* in the *Tactical* dimension, whereas *Refurbished spare part sales* due to the reactive ad hoc process still is on the *Initial* level. For Ericsson to further mature on the *Tactical* level, the supply network would first have to become planned and established on the *Managed* level. This would lead to the possibilities to establish standardized processes with proactive collection in the *Defined* level. Again, to reach the *Defined* level, Ericsson must utilize SAR's knowledge in order to increase the maturity.

Furthermore, in the *Performance* dimension, SAR is considered to be on the *Optimized* level characterized by real time feed of information from the logistics provider with monitoring in place. However, *Refurbished spare part sales* is considered to be somewhere between the levels of *Initial* and *Managed,* since there are an estimated time frame of 2-60 days, yet there are still no standard measurements in place due to the limited demand from the customers. If Ericsson will enable an increased demand and thus higher volumes, the ability to measure data both in quality and time will be enabled and thus traceability options. This would permit Ericsson to reach a level of *Quantitatively managed*. For Ericsson to reach the *Optimized* level would require monitoring with real time information feed throughout the supply chain.

Engine

The internal unit SAR possesses full control of the reversed flow in which Ericsson, and in particular *Refurbished spare part sales,* has limited insight. Thus, the *Engine* component is based on the processes within SAR. However, in the *Strategic* dimension, SAR is categorized to be on the *Quantitatively managed* level due to the well-functioning processes in place, which due to the viability of recovery options in economic and technical aspects, results in an increased viability in the environmental recovery options. However, the strategy is not fully aligned with innovative product design covering product recovery already in the design phase, thus, not reaching the *Optimized* level. These aspects are instead considered by the *Design for Environment* unit internally at Ericsson, yet, is not fully aligned with SAR. The current maturity level in the *Engine* component can be seen in *table 9.*

Table 9: Current maturity level in the Engine component.

		Initial	Managed	Defined	Quantitatively managed	Optimized
Engine	Strategic	Asset's recovery program in operation but not directly aligned with strategy	Recovery strategy in place based on economic and technical viability of recovery options	Recovery strategy is aligned qualitatively with RL strategy and business strategy	Recovery strategy stated and quantitatively driven based on economic, technical, and environmental viability of recovery options	Fully aligned recovery strategy in place, including innovative product design which considers product recovery
	Tactical	Inventory control for returned products is unstable	Returned products inventory control is planned and visible to management	Returned products inventory with standardized processes and ability to forecast returns amount	Returned products inventory process performance is established and prediction of returns condition is available through monitoring assets on the use stage	Returned products inventory process is continuously improved based on quantitative understanding of the process and can respond to change in product mix, volume, equipment, sourcing, planning
	Performance	Returned material data not or only partly in place (quantitative and qualitative)	Process in place to measure returned material data	Returned material data is measured for pre-sorting and evaluating recovery options	Returned material data is assessed and used for controlling recovery processes	Returned material data is used for product design and recovery processes

However, regarding the *Tactical* and *Performance* dimension, SAR has already reached the *Optimized* level. In the *Tactical* dimension, the processes regarding inventory of returned products are standardized and continuously improved based on quantitative understanding of the processes. Thus, the processes can be changed and improved responding to changes in product mix, volume, equipment, sourcing and planning. In the *Performance* dimension, SAR has processes in place to measure and assess data related to the returned material. This data is not only used within SAR to control the recovery process, but also fed back into the product design unit to improve the next version of the product, thus avoid doing the same mistakes once again. The returned material data could for example be return percentages and recovery data from the screening or testing centers.

The *Refurbished spare part sales* are currently only relying on the processes performed within SAR and their existing resources and capacity. However, if expanding the refurbish initiative, Ericsson must decide if keeping the flow within SAR with its standardized and optimized processes by expanding the current resources and capacity or if there is a need to create a separate unit handling theses flows. If creating a new unit, this should learn from the well-established, already existing processes within SAR in order to be successful and reach a higher maturity level already from start.

Back end

SAR is a service organization, replacing faulty units at the customer with a replacement unit. Thus, there is currently no existing secondary market for this with new customers, but just a loop between SAR and the existing customers.

Regarding the *Refurbished spare part sales* there is a secondary market, however containing same customers as in the primary market. Thus, *Refurbished spare part sales* has some knowledge about the secondary market. Yet, the knowledge is limited due to the low demand and prioritization of the refurbished products in this flow. The *Refurbished spare part sales* is thus considered to have reached the *Initial* level of the Reverse Logistics Maturity Model in the *Strategic* dimension. The current maturity level in the *Back end* component can be seen in *table 10*.

Table 10: Current maturity level in the Back end component.

		Initial	Managed	Defined	Quantitatively managed	Optimized
Back end	Strategic	Knowledge about secondary markets for recovered assets is not in place	Knowledge on secondary markets is available and understood	Knowledge about demand markets for recovered assets is used during return processes	Knowledge (e.g., demand forecasting) about secondary markets for recovered assets is integrated in management decisions for reverse flows	Recovered asset demand and product development are integrated to identify new products, markets and business models
	Tactical	Remarketing planning and pricing are not well established	Remarketing planning and pricing are performed with limited transparency on demand	Remarketing planning and pricing are performed and controlled through standardized processes with transparency on demand	Remarketing and recovery data is used to measure and control the remarketing process and predict variation	Recovered products are returned to market swiftly through proper remarketing planning and influencing customer behavior
	Performance	Market data is not in place to assess recovered products' potential for secondary markets	Recovered products' market share data is available	Recovered products' market share data is used for remarketing analysis	Recovered products' market share data is used to expand market segmentation. Products value decline rate is monitored and controlled along product and technology life cycle	Market analysis is underpinned by full transparency on recovered products' market share and secondary markets

In the *Tactical* dimension, the *Refurbished spare part sales* is considered to have remarketing planning and pricing in place, however with limited regard to customer demand, thus reaching the *Managed* level. This is probably due to the low demand for these products. Furthermore, the pricing of the products is set to a standardized price from the refurbished organization, as a certain percentage of the cost of the product, independent of demand. Yet, that is a recommended price, and the actual price is set by the sales units located closer to the customer. However, as the recommended price is set without any regard to the demand, the *Defined* level is not reached.

In the *Performance* dimension, the *Refurbished spare part sales* is considered to be on the *Initial* level since the market data is not in place to assess the potential of recovered products in the secondary market. This is due to low volumes and demand of these products and since the secondary is the same as the primary market.

The *Back end* component of the model will be extremely important if deciding to scale up the refurbishment to product level. Scaling up would open up for a new customer segment and thus a secondary market that currently is not exploited by Ericsson. The potential market for refurbished spare parts and products has been investigated, with the preliminary result that it seems to be a market. The knowledge and understanding about the secondary market are critical in order to be successful and reach the higher levels of reverse logistics maturity when or if expanding the refurbishment up to product level.

5.7 Business Models Supporting Circularity

Ericsson is currently selling physical, tangible assets, in combination with service contracts offered by SAR. Thus, Ericsson is considered to have what da Costa Fernandes et al. (2020) refers to as a product-oriented product-service system, as they are offering solutions where products and services are integrated to fulfill customer requirements and thus generating more value compared to offering a pure product. The services offered to the customers of Ericsson are of a basic nature, including transportation and providing spare parts, which indicates a focus on transaction-based services (Chesbrough et al., 2013). However, Ericsson is providing the customers with replacement units when a part is broken, that is a type of spare part management. Furthermore, these services are provided in service contracts which indicates a focus on a what Chesbrough et al. (2013) refer to as relationship-based service. Yet, Ericsson do not offer maintenance service as monitoring and preventive maintenance, which are considered to be of importance when providing relationship-based services (Chesbrough et al., 2013).

In contrast to product-oriented companies, use-oriented companies focus on creating value out of intangible assets, while keeping the ownership of the product (da Costa et al., 2020).

Da Costa Fernandes et al. (2020) describe both the product and use-oriented product-service systems as means to adopt a circular business approach. However, the use-oriented product-service systems are supporting the circular business approach to a larger extent (European Environment Agency, 2017). Moreover, the more integration it is between the product and the service, the larger and more complex is the challenge of redesigning the company's offerings (Kaddoura et al., 2019). Due to the more complex challenge and larger change required to transform into a use-oriented product service-system, companies usually start with transforming into a product-oriented product service system, which is also the case for Ericsson.

At Ericsson the change of the business model is a large trade-off between keeping a product-oriented model with the risk of product leakage to the grey market or move towards a use-oriented model to gain control of the material. If keeping a product-oriented model the leakage to the grey market could be reduced in various ways, but not eliminated, as the customers possess ownership of the material and thus decide whether Ericsson could buy the material back, or not. However, the European Environment Agency (2017) argues that an introduction of a product-oriented not model would imply any major organizational changes. Moving towards a use-oriented model, would provide greater support for circularity (European Environment Agency, 2017) through greater possibilities to track and trace, and control of the material flow (TU Delft: Online Course, 2017). This would support Ericsson's *Circular Business* initiative more extensively. Yet, Kaddoura et al. (2019) argues that such transition requires a major organizational change. Furthermore, moving towards a use-oriented model would mean that the company must with the negative financial challenge implied from such transition.

If Ericsson wants to limit the leakage to the grey market, buying back material from the grey market is not a viable alternative, even though it is a business model that may support a circular approach by getting material back to refurbish and remarket. Such model would probably be more costly than buying back material directly from the customers.

Instead, two product-oriented models that could limit the leakage to the grey market are either to provide the customers with buy back offerings and get the customers to return the products by interacting with them, or to develop buy back offerings including discounts for the next purchase. Both these two business models rely on making the buy back to be the most simple and beneficial way for the customer to get rid of products they no longer need. However, there is still a risk of product leakage to the grey market, yet to a limited extent.

In addition, leasing and product as a service are two use-oriented business models that could support the circular economy at Ericsson and simultaneously preventing the problem of product leakage to the grey market. According to TU Delft: Online Course (2017) manufacturers are provided more control of the products if selling services rather than products, thus keeping the ownership of products, and are further provided with the possibility to track usage and location of the products. With the capability to track the usage and product location, Ericsson would be able to forecast when a product or a certain component needs to be replaced. Furthermore, the tracking is beneficial in collecting data reading the products that can directly give feed-back to the product design. *Table 11* gives a summary of the different business models.

Table 11: Summary of different business models.

	Buy back from grey market	Buy back with close customer relationship	Buy back with discount system	Leasing offering	Product as a service
Ownership	Customer	Customer	Customer	Ericsson	Ericsson
Product-service system	Product-oriented	Product-oriented	Product-oriented	Use-oriented	Use-oriented
Risk of leakage	Products has already leaked to grey market	Relatively high	Average	Low	Low
Control of material flow	Low control when product reaches the customer	Ability to track	Moderate control	Ability to track and trace	Ability to track and trace
Organizational change	Almost no change, already today buy back from grey market	Moderate change to develop stronger relationships and facilitate easy return process	Moderate change to find internal incentives and facilitate easy return process	Huge change in the entire organization, an entirely new business model	Huge change in the entire organization, an entirely new business model
Impact for the customer	No impact, many customers already today sell used products to grey market	Incentivcized to return products to Ericsson instead of selling to grey market with easier return process	Incentivized to return products to Ericsson instead of selling to grey market with easier return process	Get access of ”their own product” instead of ownership	Get access to shared products instead of ownership
Financial challenge	Risk of paying a higher price than if directly buy back from the customer	Investing in relationship, and increased buy back of material	Providing customer with dicsount, however by getting products in return	Pre-finance and high number of tied up capital, find and utilizing financing companies	Pre-finance and high number of tied up capital, find and utilizing financing companies

A use-oriented business model could further significantly increase the circularity since keeping the ownership at the manufacturing company creates incentives for the producer to design for longevity, durability, easy recovery and recyclability as well as to minimize the total cost of ownership (European Environment Agency, 2017). This would be beneficial for Ericsson, as the design of the products could be optimized in order to prolong their life cycles. The customers would consequently also gain value from a use-oriented model, since they only would pay for the actual use, and would receive better service from the producer who wants the products to last longer (Philips Lighting Holding B.V., 2017).

Ericsson has identified a risk of cannibalization of new products if improving the circularity and offering refurbished products. TU Delft: Online Course (2017) presents that to enable a transition to a use-oriented business model, companies should not consider the reused and recovered products to cannibalize on the new product sales, but instead see it as an additional type of sales. In other words, Ericsson must change their way of thinking about such products and business. Additionally, the increased circularity would probably enable Ericsson to develop a new customer segment featured by customers that cannot afford or require the latest technology. To further overcome the risk of cannibalization the refurbished products may not be offered to all customers, but to a customer base that otherwise would not buy any products.

However, transforming from a company selling products to instead offer services could be both challenging and problematic. A major challenge in both the leasing and product as a service offerings, is related to the financing of such solutions. Ericsson expresses that owning all the products would heavily affect the tied-up capital and thus the balance sheet, where the financing mechanisms currently used in the traditional, linear business models are not adapted to the use-oriented models (European Environment Agency, 2017). Currently, when Ericsson is selling a product, the customer pays all at once. If instead developing a use-oriented model, the customer would pay for the actual use which thus implies that Ericsson would have to pre finance the product chain.

Ericsson must find alternative ways to overcome the financial challenge if deciding to move towards a use-oriented model. One way would be to find investment companies to share the risk, but also the returns with. The financing challenge is especially large if offering leasing of the products since all customers would access “their own” products. However, adopting a product as a service model could possibly reduce or eliminate the current inefficiencies in the market by letting the customers get access to, and share, common networks. Thus, the number of products in the market could be decreased, as well as the tied-up capital compared to a leasing offer. Further, the customers could be offered lower prices due to lower internal costs at Ericsson, possibly at a higher margin.

Da Costa Fernandes et al. (2020) mention that another challenge when moving towards a use-oriented product-service is that customers get access to the product instead of owning. That challenge will probably not be as large as if Ericsson decides to offer leasing to the customers, since the customer still get access to “their own” products although Ericsson possess the ownership. The risk of resistance from Ericsson’s customers will probably be higher due to sharing of the products with others, possibly and probably their competitors. However, Ellen MacArthur (2020) describes that customers today neither expect, nor always want the ownership of the product, but rather the access. Yet, some of Ericsson’s customers must own the products due to legislation in specific countries which could be problematic with this type of model. To overcome that challenge, Ericsson could provide that particular customer segment with some type of buying opportunities to limit the leakage to the grey market as much as possible. The segmentation should however not be limited to those who have or not have legislation regarding ownership of products, but also include, for example, customer willingness to get access rather than ownership.

Further, the transition affects the entire supply chain (TU Delft: Online Course, 2017) and Ericsson has to build, develop and adapt the infrastructure and their processes to organize maintenance and repair of products. Furthermore, a process for collecting products when they are no longer needed at the customer must be developed. However, it can be assumed that the reverse logistics and collection of goods will be easier to manage and adapt if Ericsson owns the products and can decide when, what and how to replace.

Lastly, Ellen MacArthur Foundation (2017) states that there is an unfamiliarity in the use-oriented business models, in that it is a relatively new concept, that there is a preconception of it being a more expensive alternative and that it creates inconvenience through lack of ownership. This in addition to the challenges mentioned above creates skepticisms and resistance in many companies, also on Ericsson.

5.8 Sustainable Product Design to Enhance Circularity

The initiative within Ericsson called *Design for Environment* was initiated to design products with less environmental damage (Moreno et al., 2016). This design initiative is supporting the circular business approach by designing products that could be easily disassembled, reused, and recycled. Furthermore, this initiative focuses on designing products that are durable and that enables repairability, maintenance and upgradability to keep the products in the inner loop described by de Angelis et al. (2018) for as long as possible and to, as a last step, enable recycling.

Currently, most products are neither adapted, nor ready for the circular business approach, but follow a traditional, linear consumption model (Moreno et al., 2016). However, *Design for Environment* at Ericsson is a start to adapt to a circular model, and thus a way to tackle the climate crisis. In the initiative, the entire life cycle is considered to reduce the environmental impact in all stages, while simultaneously fulfilling the quality, functionality, and performance requirements of the customers as well as the legal requirements. Thus, the choice of material is based on a banned and restricted list, to use as environmentally friendly materials as possible, not using illegal materials, or materials with a risk of being restricted in the future. Ericsson are further designing products to become more energy efficient and to adapt their size and weight to reduce transportations.

Another way to incorporate the sustainability perspective in the product design is modularization (European Environment Agency, 2017). At Ericsson, the sustainability focus of the *Modularization* initiative is currently low and is instead focusing on the business perspective. Adopting a modular product design could enable and simplify both repair, remanufacturing and extend the life cycle of products. Currently at Ericsson, there is a large variety of customized products and the product life cycle is getting shorter and shorter. According to the European Environment Agency (2017), complex and customized product are likely to counteract with a focus on circularity due to more complicated processes regarding repair, reuse and recycling. Thus, it would be beneficial for Ericsson to go further with the *Modularization* initiative and to customize the products at the latest possible stage, as emphasized by European Environment Agency (2017). Variations in demand and highly customized products complicates to forecasting process and dimensioning of the size of inventory (Hsuan Mikkola & Skjøtt-Larsen, 2004), which often lead to scrapping of material even before use. The *Modularization* team at Ericsson could thus benefit from investigating the possibilities to not only reuse modules between different versions, but also between different products.

Modularization could provide Ericsson with a great environmental opportunity by increasing the material efficiency and by reducing waste and scrap as suggested by the European Environment Agency (2017). However, the teams of *Modularization* and *Design for Environment* at Ericsson do not collaborate, although they partly address the same area and tackle the same challenges. If making the two teams collaborate, and thus extending the environmental focus in the modularization efforts, the circularity could be enhanced, which is further discussed in section *5.9 Cross-Functional Teams.* Modularization could further be helpful to overcoming the challenges regarding refurbished products closer to end-of-support by making it easier to change, replace, and update parts in order to make the product more up-to date and more energy efficient in line with what is recommended by the European Environment Agency (2017). Additionally, since some customers are upgrading their products a modularized solution would enable Ericsson to just change a certain or a few modules, and still provide the customer with the new technology.

5.9 Cross-Functional Teams

Cross-functional teams have been seen to increase performance (Turkulainen & Ketokivi, 2011) and efficiency of organizations when utilized to the right proportions to the context (Henke et al., 1993). Due to the size of Ericsson's organization with many business units and several separate teams, bureaucracy to some extent is unavoidable. In addition, Ericsson is operating in an ever-changing market with high uncertainty and high complexity in product structure, which implies a need for a high degree of cross-functionality between separate teams with an organizational design perspective. As

Ericsson is actively working to increase the circularity, cross-functionality could be a key enabler to enhance the transition. The internal initiative of *Design for Environment*, which aims to decrease the environmental impact in the product design without negatively affecting the functionality, quality, or performance, is currently reporting and working towards the corporate sustainability team. The same goes for the team working with *Modularization* of the products, which also reports to the same sustainability team. Thus, the competence, knowledge and information sharing is not reported further and is not shared between the two teams to be included in the product design.

Crossing the traditional hierarchical structure of authority is argued by Henke et al. (1993), to not only enhance the development lead time through direct communication and knowledge sharing, but the ability to increase the performance of the products would increase. It is further argued that the competitive position on the market also could be enhanced by cross-functionality (Hong et al., 2004). Such cross-functional collaboration between the teams of *Design for Environment* and *Modularization* at Ericsson would strengthen the positive effects of cross-functionality in product design with less scrap at Ericsson. SAR could further provide valuable information about what different components in the returned products that currently are scrapped to reach increased material circularity, e.g. glued material, which currently is impossible to recycle. To enable SAR to be included in such collaboration, integration of Ericsson's and SAR's business systems would be required, further discussed in section *5.10 IoT Integration of ERP and Products*. To combine different perspectives and competences across functions, increases the chances of synergies and can be an enabler to manage fluctuations in demand (Turkulainen & Ketokivi, 2011). Such collaboration could also facilitate for higher design and volume flexibility, as smaller adjustments will be easier to perform if having a common understanding and interpretation of the market and internal operations (Turkulainen & Ketokivi, 2011). The performance in the product design phase within Ericsson would become more efficient and would be of great importance when or if introducing a higher degree of modularity.

The development lead time could further be reduced if working multi-functional together with operations and marketing where the input from these units could lead to early detection of defects and enhance the speed or even eliminate steps in the design iterations, which in turn can generate shorter time to market (Turkulainen & Ketokivi, 2011). As group function sustainability currently is the unit having the contact with these two functions of different homogenous environments with different team cultures, and also have the accurate information from both sides, the most beneficial way to merge such functions would initially be to act as a bridge argued by Proehl (1996). When having established a relationship and a common goal of moving forward, the risk of having the feeling of performing the wrong activities and thus not create value to the business will be reduced (Proehl, 1996). Additionally, this could also be because both *Design for Environment* and the *Modularization* teams have other responsibilities and tasks outside such initiative. This could result in the sense of having too much to do, which in turn can lead to lost competence due to drop-offs, described by Proehl (1996). When a cross-functional integration is established, the teams and the organization can start to work as a unit without frictions and could result in lower manufacturing costs and higher product innovativeness (Turkulainen & Ketokivi, 2011). This would be a key enabler for Ericsson and could contribute to reach a higher degree of circularity in the early product design phase, instead of sub-optimizing performance in each unit or division. If not considering integration of valuable knowledge and information sharing described by Hong et al. (2004), the manufacturing costs can in the long term become more extensive. This is as issues or defects related to e.g. market requirement, i.e. conformance quality of circular requirements can occur at a later stage, and requires costly late adjustments in product design (Turkulainen & Ketokivi, 2011). To include such aspects in a collaboration between *Design for Environment* and the *Modularization* team, would enhance the circular perspective in the product design phase. Additionally, through this cross-functionality at Ericsson, the different functions and units can achieve corporate information sharing and interpretation without friction which could enhance Ericsson's business to move forward and thus become more circular.

5.10 IoT integration of ERP and products

Ericsson has identified two main issues that makes it complicated to become more sustainable through circularity and reverse logistics affecting the long-term business strategy. Firstly, the incomplete insight into SAR's processes, handling the customer returns, and secondly, the product leakage to the grey market where Ericsson wants to gain control. IoT could enable solutions to resolve these issues, as the integration possibilities are broad. To integrate Ericsson's and SAR's ERP systems, SAP and Mercury (M5), through IoT as a cloud based solution, would facilitate the data to be transferred and be supported from both sides, i.e. enable both interfaces to handle the same information (Tavana et al., 2020), even though both systems separately are speaking two different languages. For example, such cloud based IoT solution could receive data or information in encapsulated form from Mercury (M5), which in turn can get transferred into SAP in real-time. The data could for example regard stock outs in inventory, when reorder or replenishment of material is needed, or when orders and deliveries are performed. This integration between Ericsson and SAR would generate higher efficiency and flexibility in data sharing and integration as suggested by Chen et al. (2014) and opportunities of a higher degree of automation with increased performance of the total management to a relatively low implementation cost as suggested by Tavana et al. (2020).

In order to utilize IoT as a tool for the purpose of increased insight, it is important to investigate and analyze what kind of data that is required to be shared, as well as perform preparations in the ERP systems facilitate for the integration (Tavana et al., 2020). This is due to the seemingly unlimited data that could be provided through IoT, which can improve the management performance and insight if managed with the right proportion to the context. Though, Tavana et al. (2020) state that several business systems, including SAP have the capability to be integrated with IoT, but there is no support in the literature for the integration of Mercury (M5). If deciding to move forward with a solution of integrating the business systems with IoT, Ericsson would need to investigate if Mercure (M5) is integrable with IoT, or if there are any possibilities of adjustments in Mercury (M5) to enable an integration. If such integration would be possible, it could facilitate for a higher degree of insight and interplay between SAP and Mercury (M5), which would enhance data and information sharing and thus the *Circular Business* goal. To instead develop a separate tool only for an integration between two different interfaces could increase the implementation time to a higher cost, as the IoT solution is scalable (Tavana et al., 2020). To utilize IoT could further increase the circularity and could enable Ericsson to integrate other business systems with their business system SAP. This could further lower the implementation cost since Ericsson otherwise would need to design and implement tools for every integration throughout the network.

Regarding the issue of leakage to the grey market, an integration of IoT into products could be beneficial to increase circularity in the reversed material flow and to support a use-oriented business strategy. By keeping ownership of the products and utilizing the possibilities to integrate technology increased control is enabled. To integrate an embedded sensor or device into Ericsson's products connected to the IoT cloud-based solution, less human interaction would be needed. Such solution would result in higher flexibility and efficiency in material flow and inventory management (Tavana et al., 2020). The ability to track (Wortmann & Flüchter, 2015) and trace (Tavana et al., 2020) products during transportation in real time, would also be facilitated for all actors involved, i.e. Ericsson, SAR and the customers. These devices would further enable all actors to get real time notification if any deviations and defects during use or transportation occur, which could resolve several problems and time-consuming activities for Ericsson and SAR. Some products are sensitive and must not be exposed for extreme environments, by using sensors such data could be detected both in use and transportation, which according to Tavana et al. (2020) could enable lower uncertainties in quality and condition of returned products.

The device can further, through real-time notifications, provide information from site such as deviations in product behavior, usage and wear, which could reduce the time of reparation and activities connected to solve issues related to product usage (Tavana et al., 2020). The risk of stolen products would also be reduced if utilizing this technology as deviations directly are reported (Tavana et al., 2020). This further implies for increased material control to increase the circularity. Due to the integration capabilities, this technology is further proved to work efficiently when dealing with intermediaries (Tavana et al., 2020). As Ericsson sell their products through intermediaries an IoT integration in the products would fit into their business approach.

6 Conclusions and Recommendations

This chapter presents the conclusions as well as recommendations for Ericsson and suggestions for further research, aiming to point at actions needed to improve reverse logistics in order to reach a higher level of circularity. The higher level of circularity should decrease the environmental impact without negatively affecting the business.

6.1 Answers to the research questions

Ericsson is aiming to become more sustainable through adopting a circular business approach. A business opportunity was identified in selling refurbished spare parts instead of letting the unauthorized actors on the grey market take advantage of and profit from Ericsson's material. Thus, *Refurbished spare part sales was initiated* as one of the first steps to become circular. Yet, Ericsson is still at an early stage in their *Circular Business* initiative and must increase the reverse logistics maturity in order to move forward.

Refurbished spare part sales is currently responding to certain customers' demand and work as an ad hoc process. Furthermore, SAR's capacity is fully utilized despite representing a small share of the refurbished business. This means that SAR have not established any additional capacity to handle *Refurbished spare part sales,* instead this initiative is managed as a side project of SAR's ordinary work of providing hardware services. SAR has well-established processes to handle the reverse logistics and recovery of already used products, and the processes are to a large extent measurable, controlled and continuously updated. Although SAR is an internal unit within Ericsson, the two units use different business systems. This results in lacking information and data sharing between the units, and that Ericsson has limited insight into SAR's processes. To further improve the reverse logistics and enhance the circularity, Ericsson must integrate their current business systems with SAR's, to enable information and data sharing. Such integration could be facilitated by IoT as a cloud-based solution. This would enable translation of the data in real-time, which in turn would bring increased insight for Ericsson, and in particular the *Refurbished spare part sales* initiative, into SAR's operations. The integration would further enhance cross-functionality between these units. Furthermore, a combination of integrated business systems and increased cross-functionality would enhance knowledge sharing between these units and a circular business approach. The integration would require economic investments which at first sight would mean a negative impact on the business. Yet, in line with the *Circular Business* initiative, such investment would in the long-term rather result in positive outcomes for the business. Apart from facilitating integration between business systems, IoT can also be integrated into the products through RFID technology. This would enable tracking and tracing and making it possible to receive notifications of deviations during use and in transportation. Such solution would facilitate increased control of material flow and prevent product leakage to the grey market.

Regarding the recovery of used products, SAR could further develop its strategy by aligning the recovery options with innovative products designs to include recovery aspects already in the product design phase. As the internal unit *Design for environment* is responsible for taking these aspects into consideration when designing products, the development would benefit from involving SAR. Such integration would enable knowledge and information sharing as well as strengthening the already existing feedback loop. Furthermore, the recovery process could be simplified by increased modularization, since this permits customization at the latest possible stage and repair, maintenance and upgradability for Ericsson's diverse product offerings to be performed in a similar way. This would mean that the products could be kept in the inner loop for a longer period of time. However, as the current modularization work within Ericsson mainly is performed from a business perspective, not taking sustainability aspects into consideration, the *Modularization* initiative would be enhanced by working cross-functionally with the *Design for environment team*. The collaboration would support the circular business initiative without requiring an economic investment.

Furthermore, to enable remarketing of the refurbished offering, Ericsson must develop a new potential market. SAR has no secondary market for their products as these loops between SAR, providing customers with replacement units, and the customers, sending faulty units back. Thus, SAR do not possess any knowledge about the potential market for the refurbished offering. Moreover, the customers demanding refurbished spare parts is the same as the customers of the main flow. Thus, the knowledge about a potential new secondary market of the refurbished offering is currently limited.

However, based on the existence of the grey market it seems to be a market for already used products that Ericsson could benefit and profit from. Furthermore, due to one proactive customer's request of having a certain percentage of refurbished material in their products, Ericsson initiated an investigation of the potential for such market. The preliminary results indicate there is an existing business opportunity for Ericsson to delve into. However, it is important to gain knowledge and understand such a market, and to utilize the knowledge during the return processes. The knowledge must also be integrated in management decisions, and used to identify new products, markets, and business models to scale up the circularity and improve the reverse logistics. To develop and gain knowledge about a potential secondary market would require an initial investment. However, it could generate additional sales in the long term.

As the *Refurbished spare part sales* offering is managed from the global warehouse in Sweden due to low customer demand and high uncertainties for these products, long-distance transportations are needed, which results in higher carbon emissions. To enable an increased demand for the refurbished offering, Ericsson could expand this offering to not only include spare parts, but also entire products. Stimulating the demand would lower the variety and uncertainties and thus enable Ericsson to manage the offering from local warehouses with local presences. This would result in eliminating unnecessary transportation and minimizing the related carbon footprint. However, by expanding the offering, the overall reverse transportation would increase. Yet, these transportations are necessary to support the circularity with its environmental benefits. Furthermore, if reaching scalability in the initiative, Ericsson will be able to reduce the carbon emissions from these transportations by for example route optimization and increased fill rate. A local presence could further lead to higher customer awareness of the offering which in turn might stimulate the demand. To not expand the refurbished offering could jeopardize the *Refurbished spare part sales* and thus the *Circular Business* initiative. This is due to the risk of not reaching a high enough demand, and thus no economic viability in the offering. Furthermore, as the *Refurbished spare part sales* is utilizing SAR's existing processes and capacity, an expansion of the refurbished offering would force Ericsson to decide if keeping the reverse logistics of the refurbished offering through SAR or to create a new unit to handle the refurbished flow. Due to SAR's well-established processes and a possible integration of the business systems, keeping the reverse logistics within SAR would be the most natural choice in the initial phase. However, as the refurbished initiative is further scaled up, the reversed logistics cannot be managed as a side project within SAR but must be allocated own resources and capacity.

A use-oriented business model would provide Ericsson with the best possible support to enable circularity. Ownership enables prolonging the product life cycle and keeping the products in the inner loop for as long as possible. Keeping the ownership of products would further provide Ericsson with greater control and capabilities to track and trace during use and transportation. It would further give the opportunity to decide on what level to track and trace the products and thus, prevent product leakage to the grey market. Tracking and tracing would further facilitate gathering of data which may contribute to route optimization and to increase the fill rate of the reverse transportations.

The positive environmental effects that can be achieved through a circular approach and by an increased reverse logistics maturity level, are highly related to preservation of the already manufactured products to increase the material efficiency and reduce scrap and waste. Additionally, products designed for circularity will be developed aiming to prolong the product life cycle and reduce the energy consumption. Furthermore, by adopting a more circular approach, Ericsson will be able to increase the reuse of material, to only at the latest step recycle material i.e. reducing improper disposal and scrapping. Moreover, preservation of products and increased reuse of material will mitigate resource scarcity and contribute to respecting the planetary boundaries. As Ericsson's products contain heavy metals, preservation and reuse of these products could reduce the related carbon emissions. If expanding the refurbishment up to product level, the ability to reduce carbon emission related to heavy metals would be possible.

To conclude, increasing the maturity level implies a transition including comprehensive organizational changes requiring both time, effort, and initial investments. However, not investing in the suggested improvement areas could result in fewer business opportunities in the future. Only looking at fragments of the *Circular business* approach does not lead to increasing the maturity level of the reversed logistics, nor the circularity. It is therefore a necessity to look at the circular challenge from a holistic perspective, and thus to include circularity in the business model for Ericsson to become more sustainable.

6.2 Recommendations for Ericsson

It is important to emphasize that the goal of the *Circular Business* initiative is not circularity itself but becoming more sustainable. Thus, it is important to have a common definition of circularity within the company, broken down with common goals aiming to reach the overall sustainability target of being carbon neutral in 2030. The definition should be tailor made for Ericsson as there is no definition suitable for all companies. A key enabler to focus on in the *Circular Business* initiative is reverse logistics, and to adopt a holistic perspective to find what areas that are going to be affected by the transition. Thus, to reach increased circularity, Ericsson will have to start with scaling-up and enhancing the circularity in the reverse logistics through a combined business model containing buying options and use-oriented offerings towards the refurbished product market. This entails increased material control and decreased material consumption throughout the supply chain. However, to achieve this, internal support of integration and cross-functionality is required, which in the long-term enhances a modular product design with decreased carbon footprint.

Due to the low demand of the niched offering of *Refurbished spare part sales*, Ericsson is recommended to go further with the initiated trial of refurbished products to see the actual effects of circularity when reaching a broader target group. In combination with expanding refurbishment up to product level, Ericsson is recommended to have local presence of the refurbishment offer. This is to generate increased awareness from a potential market, which in turn can lead to increased demand from the market. When having established an increased demand, the possibility to set a price based on demand, instead of a certain percentage of the price of a new product, will be possible. Having local presence would also result in a lower carbon footprint from transportation, since the distance of transportation would decrease. Moreover, Ericsson must gradually rethink and redirect the organization to adopt a circular business model as the current way of looking at cannibalization regarding refurbishment, jeopardizes the principles behind the pursuit of circularity.

The expansion will force Ericsson to take a decision regarding keeping the reverse flow within SAR or setting up a new flow to handle the refurbished products. However, due to SAR's well-established processes and a possible integration of the ERP systems to enable information sharing between SAR and Ericsson, the recommendation is to keep the reverse logistics within SAR in the initial phase of the expansion. Yet, as the trial phase is over, and the refurbished initiative is scaled up, the reversed must be allocated its own resources and capacity.

It is further recommended to integrate Ericsson's and SAR's ERP systems. To look in to means of performing this integration with a cloud based IoT solution is recommended, due to lower implementation cost and scalability options throughout the organization. Such solution would also facilitate information and knowledge sharing, which is a vital component in order to adopt a fully circular business approach. As an extension of the ERP integration, it is further recommended to look into the possibilities of integrating IoT into the products through RFID. This is to facilitate tracking and tracing as well as real-time information through notifications of deviations during transportation and use for all stakeholders involved. This solution could further support a use-oriented business model and prevent leakage to the grey market.

Regarding business models supporting circularity, offering products as a service is considered to be the most advanced and promising approach for a circular business at Ericsson. This type of business model permits increased control of material and returns, ability to track and trace, minimizing the leakage to the grey market and reduce inefficiencies in customer use of products. Thus, the recommendation for Ericsson is to move towards such use-oriented product service system. However, redesigning the current offering towards offering products as a service requires large organizational changes not only within Ericsson but also by their customers. Furthermore, the business relationships will be affected by such change and must be reconsidered. Thus, Ericsson is recommended to gradually make the transition. One way to approach this challenge is to develop a set of business models matching different offerings, which could result in a broader customer base together with a gradual transition towards more advanced and sustainable operations. However, to minimize the current competition with the grey market, Ericsson is recommended to not engage in business with actors on the grey market. A first step for the segmentation could be to divide customers in groups of those who must own, want to own, and want to get access without getting the ownership of the products. In the segments where the ownership is transferred to the customers, Ericsson is recommended to create incentives and rewards to provide the customers with an easy return process. By performing a customer segmentation, Ericsson can develop approaches that fit with the different demands of the customers in the best possible way and at the same time prepare the customers for the alternative offering that will be developed. Furthermore, by gradually performing this transition, Ericsson will have time to find solutions of how to overcome the financial challenge incurred by keeping the ownership of products.

Regarding sustainable product design enhancing circularity, Ericsson is recommended to go further with both the *Design for environment* and the *Modularization* initiatives to keep products in the inner loop of repair, maintenance, and upgradability for as long as possible. Moreover, Ericsson is recommended to increase the environmental focus within the *Modularization* initiative to design products with less environmental impact and to reach higher material efficiency and thus reduce waste with increased design and volume flexibility. Furthermore, the *Modularization* initiative is supporting the circular business approach by providing Ericsson with the possibility to customize products at the latest possible stage, thus overcoming the risk of products becoming old and obsolete in inventory.

Furthermore, to enhance a circular business approach with decreased material consumption and thus lower environmental impact, cross-functional teams are recommended. Cross-functionality between the teams of *Design for Environment* and *Modularization* is recommended. These two teams can in such collaboration find synergies to create a more environmental conscious, and thus sustainable product designs. This is to enable a higher degree of reuse and refurbishment in the outer loop of the products and to lower the manufacturing costs in the long term. Additionally, SAR can through the integration of the ERP systems and with the competence of the employees provide valuable information into this cross-functional team. SAR possesses knowledge and data about scrapped material and inaccuracies of returned products due to insufficient assembly and product design. This can enhance the sustainable development of long-lasting product designs and thus increased reusability, recyclability, refurbishment, and maintenance options.

6.3 Recommendation for further research at Ericsson

This master's thesis has been an explorative study since the transition towards a circular business approach still is at an early stage within Ericsson. Thus, many interesting areas for further research has been identified and will be presented below.

The first area suggested for further research is how the expansion of refurbished offering to include products, and not just spare parts, will affect the reverse logistics with its related processes.

Regarding the IoT integration, it is unknown if the business system Mercury (M5) could be integrated with IoT, just as SAP could be. Thus, further research of the possibility to integrate Mercury (M5) or if it could be adapted in any way to be able to integrate, through IoT is suggested. Furthermore, other application areas of IoT integration in the focal company should be investigated. Such solution would enable a corporate solution, instead of developing separate integration tools for every integration that is needed.

Another interesting area related to moving towards a use-oriented product-service system is how to implement and realize a product as a service offering. Such movement will entail huge changes and challenges throughout the organization related to the mindset within the organization and the business models for both the focal company and the customers. Thus, further research of how to overcome these challenges and adapt to the changes is suggested. Additionally, the customer attitudes against getting access and not ownership of the products should be investigated, and thus also how to perform customer segmentation related to this. Therefore, Ericsson is recommended to further investigate how business relationships with their customers will be affected by such change.

In this master's thesis, the product design teams of *Design for environment* and *Modularization* have been recommended to work more cross-functional to incorporate new aspects in the product design. Furthermore, to reduce scrap, cross-functionality has been recommended to share information from the reverse flow to product design. Further research could thus investigate if there are other functions that need involvement and work more cross-functional to enhance the circular initiative.

Lastly, the reverse transportation and especially the environmental impact from these, has been identified as an important area to investigate when transforming into a circular business. Thus, this should be investigated proactively to prepare for a possible scale up of refurbishment. Yet, to measure the related carbon footprint will only be appropriate when having reached scalability and having established processes to manage the return flow. This is to see the actual effects and how to possibly improve and optimize transportation.

References

Akdoğan & Coşkun. (2012). Drivers of Reverse Logistics Activities: An Empirical Investigation. *Social and Behavioral Sciences*, 1640-1649.

Barkemeyer, R., Holt, D., Preuss, L., & Tsang, S. (2011). What Happened to the 'Development' in Sustainable Development? Business Guidelines Two Decades After Brundtland. *Sustainable Development, 22*(1), 15-32. doi: https://doi.org/10.1002/sd.521

Blackburn, J. D., Guide Jr., V. D., Souza, G. C., & Van Wassenhove, L. N. (2004). Reverse Supply Chains for Commercial Returns. *California Management Review*, 6-22.

Boström, Jönsson, Lockie, Mol, & Oosterveer. (2015). Sustainable and responsible supply chain governance: challenges and opportunities. 1-7. doi:https://doi.org/10.1016/j.jclepro.2014.11.050

Bryman, A. (2008). *Samhällsvetenskapliga metoder.* Liber.

CE100. (2016). *Waste not, want not: Capturing the value of the circular economy through reverse logistics.* Ellen MacArthur Foundation .

Chen, S.-L., Chen, Y.-Y., & Hsu, C. (2014). A New Approach to Integrate Internet-of-Things and Software-as-a-Service Model for Logistic Systems: A Case Study. *Sensors*, 6144-6164. doi:https://doi.org/10.3390/s140406144

Chesbrough, H., Di Minin, A., & Piccaluga, A. (2013). Business model innovation paths. In L. Cinquini, A. Di Minin, & R. Varaldo, *New Business Models and Value Creation: A Service Science Perspective* (Vol. 8, pp. 45-62). Milano: Springer-Verlag Italia. doi:10.1007/978-88-470-2838-8_3,

da Costa Fernandes, S., Pigosso, D. C., McAloone, T. C., & Rozenfeld, H. (2020). Towards product-service system oriented to circular economy: A systematic review of value proposition design approaches. *Journal of Cleaner Production, 257*, 1-16. doi:https://doi.org/10.1016/j.jclepro.2020.120507

de Angelis, R., Howard, M., & Miemczyk. (2018). Supply chain management and the circular economy: towards the circular supply chain. *Production Planning & Control*, 425-437. doi:https://doi.org/10.1080/09537287.2018.1449244

de Brito, M. P., & Dekker, R. (2004). A Framework for Reverse Logistics. In M. F. R. Dekker, *Reverse Logistics: Quantitative Models for Closed-Loop Supply Chains* (pp. 3-28). Springer Science & Busienss Media.

Defee, C. C., Esper, T., & Mollenkopf, D. (2009). Leveraging closed-loop orientation and leadership for environmental sustainability. *Supply Chain Management: An International Journal, 14*(2), 87-98. doi:https://doi.org/10.1108/13598540910941957

Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research. *Journal of Business Research, 55*(7), 553-560. doi:https://doi.org/10.1016/S0148-2963(00)00195-8

Durach, C. F., Kembro, J., & Wieland, A. (2017). A NEW PARADIGM FOR SYSTEMATIC LITERATURE. *Journal of Supply Chain Management, 53*(4), 67-85. doi:https://doi.org/10.1111/jscm.12145

Elkington, J. (1998). Partnerships from cannibals with forks: The triple bottom line of 21st-century business. *Environmental quality management, 8*(1), 37-51. doi:https://doi.org/10.1002/tqem.3310080106

Ellen MacArthur Foundation. (2015). *Towards a Circular Economy: Business Rationale for an Accelerated Transition.* Ellen MacArthur Foundation.

Ellen MacArthur Foundation. (2016). *Empowering Repair.* Ellen MacArthur Foundation.

Ellen MacArthur Foundation. (2020). *What can I do within my business?* Ellen MacArthur Foundation.

Ellen MacArthur Foundation and Material Economics. (2019). *Completing the Picture: How the Circular Economy Tackles Climate Change.* Ellen MacArthur Foundation.

Ellen MacAurthur Foundation. (2017). *Circular economy options in office furnishing: Rype Office.* Ellen MacAurthur Foundation.

Ericsson. (2021, January 28). *About us: Sustainability and corporate responsability*. Retrieved from Global awards and recognition: https://www.ericsson.com/en/about-us/sustainability-and-corporate-responsibility/sustainability-metrics/awards

European Commision. (2020). *EUR-lex: EUR-Lex - 52020PC0080 - EN*. Retrieved from Eur-lex Europa: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588581905912&uri=CELEX:52020PC0080

European Environment Agency. (2017). *Circular by design: products in the circular economy.* Copenhagen: EEA. Retrieved from https://circulareconomy.europa.eu/platform/sites/default/files/circular_by_design_-_products_in_the_circular_economy.pdf

Fleischmann, M., Krikke, H. R., Dekker, R., & Flapper, S. D. (2000). A characterisation of logistics networks for product recovery. *Omega, 28*(6), 653-666.

Geissdoerfer, M., Savaget, P., Bockena, N. M., & Hultnik, E. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757-768. doi:https://doi.org/10.1016/j.jclepro.2016.12.048

Geldermans, R. J. (2016). Design for Change and Circularity – Accommodating Circular Material & Product Flows in Construction. *Energy Procedia, 96*, 301-311. doi:https://doi.org/10.1016/j.egypro.2016.09.153

Gerring, J. (2004). What Is a Case Study and What Is It Good for? *American Political Science Review, 98*(2), 341-354. doi:https://doi.org/10.1017/S0003055404001182

Goltsos, T. E., Ponte, B., Wang, S., Liu, Y., Naim, M. M., & Syntetos, A. A. (2019). The boomerang returns? Accounting for the impact of uncertainties on the dynamics of remanufacturing systems. *International Journal of Production Research, 57*(23), 7361-7394. doi:https://doi.org/10.1080/00207543.2018.1510191

Govindan, K., Soleimani, H., & Kannan, D. (2015). Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future. *European Journal of Operational Research, 240*(3), 603-626. doi:https://doi.org/10.1016/j.ejor.2014.07.012

Guide Jr, V. D., Harrison, T. P., & Van Wassenhove, L. N. (2003). The Challenge of Closed-Loop Supply Chains. *Interfaces, 33*(6), 3-6. doi:https://doi.org/10.1287/inte.33.6.3.25182

Guide Jr., V. D., & Van Wassenhove, L. N. (2009). The Evolution of Closed-Loop Supply Chain Research. *Operations Research, 57*(1), 10-18. doi:https://doi.org/10.1287/opre.1080.0628

Habibi , K. M., Battaïa, O., Cung, V.-D., & Dolgui , A. (2017). Collection-disassembly problem in reverse supply chain. *Int. J. Production Economics*, *183*, 334–344. doi:http://dx.doi.org/10.1016/j.ijpe.2016.06.025

Henke, J. W., Krachenberg, R., & Lyons, T. F. (1993). Cross-Functional Teams: Good Concept, Poor Implementation! *Elsevier Science Publishing Co., Inc.*, 216-229.

Holmqvist, T. K., & Persson, M. L. (2003). Analysis and Improvement of Product Modularization Methods: Their Ability to Deal with Complex Products. *Systems engineering*, *6*(3), 195-209. doi: https://doi.org/10.1002/sys.10046

Hong, P., Doll, W. J., Nahm, A. Y., & Li, X. (2004). Knowledge sharing in integrated product development. *European Journal of Innovation Management*, 102-112. doi:DOI 10.1108/14601060410534393

Horton, P., & Horton, B. P. (2019). Re-defining Sustainability: Living in Harmony with Life on Earth. *One Earth, 1*(1), 86-94. doi:https://doi.org/10.1016/j.oneear.2019.08.019

Hsuan Mikkola, J., & Skjøtt-Larsen, T. (2004). Supply-chain integration: implications for mass customization, modularization and postponement strategies. *Production Planning & Control*, *15*(4), 352-361. doi:https://doi.org/10.1080/0953728042000238845

ITU. (2021, 04 30). *Internet of Things Global Standard Initiative*. Retrieved from ITU Commited to connecting the world: https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx

Justesen, L., & Mik-Meyer, N. (2013). *Kvalitativa metoder: Från vetenskapsteori till praktik.* Studentliteratur.

Kaddoura, M., Kambanou, M. L., Tillman, A.-M., & Sakao, T. (2019). Is Prolonging the Lifetime of Passive Durable Products a Low-Hanging Fruit of a Circular Economy? A multiple case study. *Sustainability, 11*(18), 4819. doi: https://doi.org/10.3390/su11184819

Kannan, D., Diabat, A., Alrefaei, M., & Yong, G. (2012). A carbon footprint based reverse logistics network design model. *Resources, Conservation and Recycling*, *67*, 75-79. doi:10.1016/j.resconrec.2012.03.005

Karlsson, T., & Torfgård, L. (2020). *Circularity in ICT Supply Chain Management: Assessing material efficiency in inventory management for circularity at Ericsson.* Diva.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221-232. doi:https://doi.org/10.1016/j.resconrec.2017.09.005

Linnenluecke, K. M., Marrone, M., & Singh, A. K. (2020). Conducting systematic literature. *Australian Journal of Management*, *45*(2), 175-194. doi:https://doi.org/10.1177/0312896219877678

Lüdeke-Freund, F., Glod, S., & Bocken, N. M. (2018). A Review and Typology of <circular Economy Business Model Patters. *Journal of Industrial Ecology*, *23*(1), 36-61. doi:https://doi.org/10.1111/jiec.12763

Malmgren, K., & Mötsch Larsson, K. (2020). *Reverse Logistics in the Transition Towards Circular Economy-A Case Study of Customer Returns at IKEA.* Chalmers University of Technology.

Mariadoss, B. J., Tansuhaj, P. S., & Mouri, N. (2015). Marketing Capabilities and innovation-based strategies for environmental sustainability: An exploratory investigation of B2B firms. *Industrial Marketing Management*, 1305-1318. doi:https://doi.org/10.1016/j.indmarman.2011.10.006

Mastrogiacomo, L., Barravecchia, F., & Franceschini, F. (2018). Definition of a conceptual scale of servitization: Proposal and. *CIRP Journal of Manufacturing Science and Technology, 29*, 141-156. doi:https://doi.org/10.1016/j.cirpj.2018.11.003

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production, 178*, 703-722. doi:https://doi.org/10.1016/j.jclepro.2017.12.112

Mora, C., Spirandelli, D., Franklin, E. C., Lynham, J., Kantar, M. B., Miles, W., . . . Hunter, C. L. (2018). Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emission. *Nature Climate Change*, *8*, 1062–1071. doi:https://doi.org/10.1038/s41558-018-0315-6

Moraga, G., Huysveld, S., Mathieux, F., Blengini, G. A., Alaerts, L., Van Acker, K., & Dewulf, J. (2019). Circular economy indicators: What do they measure? *Resources, Conservation and Recycling, 146*, 52-461. doi:https://doi.org/10.1016/j.resconrec.2019.03.045

Moreno, M., De los Rios, C. Z., & Charnley, F. (2016). A Conceptual Framework for Circular Design. *Sustainability, 8*(9), 937. doi:https://doi.org/10.3390/su8090937

Philips Lighting Holding B.V. (2017). *Minimise your environmental footprint and create instant savings.* Philips Lighting Holding B.V. Retrieved from https://images.philips.com/is/content/PhilipsConsumer/PDFDownloads/United%20Kingdom/ODLI20171031_001-PDF-en_GB-7036_Circular_Lighting_Digi_WTO_01.pdf

Porter, M. E., & Heppelmann, J. E. (2014). How Smart, Connected Products Are Transforming Competition. *Harvard Business Review*, 1-23.

Proehl, R. A. (1996). Enhancing the effectiveness of cross-functional. *Leadership & Organization Development Journal*, 3-10. doi:https://doi.org/10.1108/01437739610127450

Quarshi, A. M., Salmi, A., & Leuschner, R. (2016). Sustainability andcorporatesocialresponsibilityinsupply. *Journal of Purchasing & Supply Management, 22*(2), 82-97. doi:https://doi.org/10.1016/j.pursup.2015.11.001

Ritzén, S., & Sandström, G. Ö. (2017). Barriers to the Circular Economy – integration of perspectives and domains. *Procedia CIRP, 64*, 7-12. doi:https://doi.org/10.1016/j.procir.2017.03.005

Rodrigue, J., Slack, B., & Comtois, C. (2001). The paradoxes of green logistics. *In World Conference on Transport Research (WCTR).* Seoul.

Sahyouni, K., Savaskan, R. C., & Daskin, M. S. (2007). A facility location model for bidirectional flows. *Transportation Science, 41*(4), 484-499. doi:https://doi.org/10.1287/trsc.1070.0215

Sangwan, K. S. (2017). Key activities, decision variables and performance indicators of reverse. *Procedia CIRP, 61*, 257-262. doi:10.1016/j.procir.2016.11.185

Schenkel, M., Caniëls, M. C., Krikke, H., & van der Laan, E. (2015). Understanding value creation in closed loop supply chains – Past findings and future directions. *Journal of Manufacturing Systems, 37*(3), 729-745. doi:https://doi.org/10.1016/j.jmsy.2015.04.009

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333-339. doi:https://doi.org/10.1016/j.jbusres.2019.07.039

Srivastava, S. K. (2013). Issues and Challenges in Reverse Logistics. In S. M. Gupta, *Reverse Supplyu Chains: Issues and Analysis* (pp. 61-80). CRC Press.

Sun, Q. (2016). Research on the influencing factors of reverse logistics carbon. *Springer-Verlag Berlin Heidelberg*, 22790–22798.

Sundin, E., Östlin, J., Rönnbäck, A. Ö., Lindahl, M., & Sandström, G. Ö. (2008). Remanufacturing of Products used in Product Service System Offerings. In M. M., U. K., & K. F., *Manufacturing Systems and Technologies for the New Frontier* (pp. 537-542). London: Springer. doi:https://doi.org/10.1007/978-1-84800-267-8_110

Tavana, M., Hajipour, V., & Oveisi, S. (2020). IoT-based enterprise resource planning: Challenges, open issues, applications, architecture, and future research directions. *Internet of Things*, 1-27. doi:https://doi.org/10.1016/j.iot.2020.100262

Thierry, M., Salomon, M., Van Nunen, J., & Van Wassenhove, L. (1995). Strategic issues in product recovery management. *California management review, 37*(2), 35-114. doi:https://doi.org/10.2307/41165792

Thornhill, A., Saunders, M., & Lewis, P. (2009). *Research methods for business students.* London: Prentice Hall:.

Tibben-Lembke, R. S., & Rogers, D. S. (2002). Differences between forward and reverse logistics in a retail environment. *Supply Chain Management: An International Journal, 7*(5), 271-282. doi:https://doi.org/10.1108/13598540210447719

TU Delft: Online Course. (2017). *Circular Economy: An Introduction*. Retrieved from DelftX CircularX: https://courses.edx.org/courses/course-v1:Delftx+CircularX+1T2017/course

Turkulainen, V., & Ketokivi, M. (2011). Cross-functional integration: what are the real benefits? *International Journal of Operations & Production Management*, 447-467. doi:DOI 10.1108/01443571211223095

Urbinati, A., Chiaroni, D., & Chiesa, V. (2017). Towards a New Taxonomy of Circular Economy Business Models. *Journal of Cleaner Production, 168*, 487-498. doi:https://doi.org/10.1016/j.jclepro.2017.09.047

Waqas, M., Dong, Q.-l., Ahmad, N., & Zhu, Y. (2018). Critical Barriers to Implementation of Reverse. *Sustainability, 10*(11), 1-25. doi:https://doi.org/10.3390/su10114202

Vereecken, W., Van Heddeghem, W., Colle, D., Pickavet, M., & Demeester, P. (2010). Overall ICT Footprint and Green Communication Technologies. *Proceedings of the 4th International Symposium on Communications, Control and Signal Processing (ISCCSP 2010)*. doi:https://doi.org/10.1109/ISCCSP.2010.5463327

Wortmann, F., & Flüchter, K. (2015). Internet of Things: Technology and Value Added. *Springer Fachmedien Wiesbaden*, 221-224. doi:10.1007/s12599-015-0383-3

Yin, R. K. (2011). *Applications of Case Study Research.* sage.

Appendix A – Interview template - Internal Ericsson employees

1. Brief presentation about ourselves and our work at Ericsson
2. Brief presentation of the interviewee and his/her role at Ericsson

Specific questions regarding circularity at Ericsson

1. What is the definition of circularity within Ericsson?
2. What is the aim of the circular initiative?
3. How do Ericsson work with circularity?
4. What challenges are related to the initiation of a circular business model?
5. How do Ericsson work to further expand and develop the circular initiative?

Specific questions regarding the refurbishment program

1. What is your relation to *Refurbished spare part sales*?
2. What is the main purpose of *Refurbished spare part sales*?
3. What was the driving forces to initiate the *Refurbish spare part sales*?
4. What are the challenges related to the reverse flow of refurbished spare parts?
5. What products are returned to highest extent?
6. What is the reason for customer returns?
7. Can you describe the current reverse logistics process of *Refurbished spare part sales*?
8. Have you considered a new reverse logistics strategy if the refurbishment program expands?
9. What are the potential challenges and opportunities with expanding the refurbished offering to product level?

Specific questions regarding business models

1. How could the business model be designed to support circularity and limit leakage to grey market?
2. Do you have a process in place to assess if it is worth to buy back material from the customers?

3. Currently, businesses are moving towards offering services instead of pure products, is that something Ericsson has considered to some extent?

Specific questions regarding Design for Environment

1. How do Ericsson currently work with adopting the environmental aspects in the product design?
2. How do Ericsson currently work with adopting a circular approach in the product design?
3. How are reusability, repairability, maintenance, upgradability and recyclability incorporated into product design at Ericsson?
   a) Why are these incorporated?
   b) How are those followed up and controlled?
4. Are any modularization aspects incorporated in the product for environment work?
5. How will future work related to circularity in product design be performed?

Specific questions regarding Modularization

1. Why was the *Modularization* initiative implemented at Ericsson?
2. Why is it important to focus on modularization?
3. Is the current product portfolio standardized or customized?
4. What is the status of the modularization work?
5. Are any environmental aspects incorporated in the modularization?
6. How will future work related to modularization be performed?

Specific questions regarding the Reverse Logistics Maturity Model

Front end

Strategic

1. Is the Revered Logistic strategy stand alone with business goals limited to cost minimization?
2. Do you have a Basic strategy in place to manage RL?
3. Is the reverse logistics strategy aligned with supply chain strategy, defined RL process in place?

4. Is the reverse logistics integrated with supply chain strategy driven by profit generation?
5. Is the reverse logistics integrated as cross-functional process within different business units, driven by profit generation and aligned with business goals?

Tactical

1. Is the Reverse logistics network is not well defined and is managed reactively?
2. Is the Reverse logistics network planned and established?
3. Is the reverse logistics network standardized and return agreements or contracts in place for proactive collection?
4. Is the reverse logistics network and flows planned through collaboration agreements with stakeholders to define performance requirements?
5. Is the reverse logistics network and flow optimized through defined performance objectives in collaboration with logistics provider?

Performance

1. Are the items collected with no record of lead time, return rate and volume?
2. Are there traditional measures, e.g. lead time, return rate and volume available?
3. Are the reverse logistics time and flow as well as items quality measured?
4. Are Item's traceability metric well defined and used, coordinated in shared system across value chain to monitor and assess return agreements?
5. Is the reverse logistics process monitored and responsively updated, with real time exchange of value chain information on returned items between logistics provider and company?

Engine

Strategic

1. Do you have an asset recovery program in operation, and if so, is it direct aligned with the strategy?
2. Do you have a recovery strategy in place based on economic and technical viability of recovery options?

3. Is the recovery strategy aligned qualitatively with reverse logistics strategy and business strategy?
4. Is the recovery strategy stated and quantitatively driven based on economic, technical, and environmental viability of recovery options?
5. Do you have a fully aligned recovery strategy in place, including innovative product design which considers product recovery?

Tactical

1. Is the inventory control for returned products stable?
2. Is the returned products inventory control is planned and visible to management?
3. Is the returned products inventory performed with standardized processes and ability to forecast returns amount?
4. Is the returned products inventory process performance established and prediction of returns condition available through monitoring assets on the use stage?
5. Is the returned products inventory process continuously improved based on quantitative understanding of the process and can respond to change in product mix, volume, equipment, sourcing, planning?

Performance

1. Do you have returned material data, quantitative and qualitative, partly or fully in place?
2. Do you have a Process in place to measure returned material data?
3. Do you measure returned material data for pre-sorting and evaluating recovery options?
4. Is returned material data assessed and used for controlling recovery processes?
5. Is returned material data used for product design and recovery processes?

Back end

Strategic

1. Do you have knowledge about the secondary markets of recovered assets in place?

2. Is the knowledge on secondary markets available and understood?
3. Is the knowledge about demand markets for recovered assets used during return processes?
4. Is the knowledge, e.g. demand and forecasting, about secondary markets for recovered assets integrated in management decisions for reverse flows?
5. Are recovered asset demand and product development integrated to identify new products, markets and business models?

Tactical

1. Are the remarketing planning and pricing well established?
2. Are the remarketing planning and pricing performed with limited transparency on demand?
3. Are remarketing planning and pricing are performed and controlled through standardized processes with transparency on demand?
4. Are remarketing and recovery data used to measure and control the remarketing process and predict variation?
5. Are Recovered products returned to market swiftly through proper remarketing planning and influencing customer behavior?

Performance

1. Do you have market data in place to assess the potential of recovered products on secondary markets?
2. Is data of the recovered products' market share available?
3. Is the data of recovered products' market share used for remarketing analysis?
4. Is the data of recovered products' market share used to expand market segmentation and products value decline rate monitored and controlled along product and technology life cycle?
5. Is the market analysis underpinned by full transparency on recovered products' market share and of the secondary markets?

Appendix B – Interview template - External experts

1. Brief presentation about ourselves and our Master Thesis
2. Brief presentation of the interviewee and his/her role

Specific questions regarding circularity and environmental impact

1. What environmental benefits and consequences are related to becoming more circular?
2. In what ways can a company ensure that material is returned when the customers no longer need it?
3. Which are the most important aspects of an initiation of a circularity initiative?
4. Which are the most important aspects of an expansion of a circularity initiative?
5. Can you describe the role of the reverse logistics in the circular economy?
6. Can you describe the role of the circular business model in companies?

Specific questions regarding scale up of circularity and business models supporting circularity

1. Which are the major benefits of becoming more circular from a company perspective?
2. Which are the major driving forces in becoming more circular from a company perspective?
3. Which are the most common challenges when initiating and implementing a circular business model?
4. In what ways can a company ensure that material is returned when the customers no longer need it?
5. What is customers' perception of recycled products in relation to new ones?
6. How could companies encourage their customers to send back used products to be recovered and sold again?
    a. Incentives?
    b. Effort?
7. What are the customers' attitudes towards accessing products rather than owning them?

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