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Identifying capability gaps hindering compliance with the new EU battery regulation

The case of a global automotive OEM’s aftermarket services

Master’s thesis in Quality and Operations Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2022
www.chalmers.se
Report No. E2022:030

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Abstract

The new EU battery regulation, proposed to establish guidelines on the rapidly growing battery market, creates a need for traceability. However, it is not yet clear what traceability related requirements are being put on automotive OEMs' aftermarket services and if they have the necessary capabilities to meet such requirements. Therefore, this study aims to identify what traceability related requirements that will be put on automotive OEMs' aftermarket services and identify what capability gaps, hindering the compliance with the new EU regulation, that exists in a specific automotive OEM's aftermarket services. In addition, recommendations on how the closure of identified capability gaps should be prioritized are provided. To fulfill the purpose, the study used a case study design and an abductive approach, where the main data collection method was semi-structured interviews followed by thematic analysis. Key findings suggest that traceability related EU regulation requirements put on automotive OEM's aftermarket services can be divided into the three categories; *extended producer responsibility*, *required information* and *systems*. Moreover, the three organizational capability gaps identified are *lacking responsibility clarification*, *insufficient cross-functional collaboration and data sharing* and *insufficient external collaboration and data accessing,* and the three technological capability gaps are *lacking systems able to trace on a unique level*, *lacking connected internal data sources* and *lacking ability to access remote BMS data from detached batteries*. In the closure of the identified capability gaps, three different priority levels were defined; *high*, *medium* and *low*, where the gaps *lacking responsibility clarification* and *lacking systems able to trace on a unique level* are categorized as high priority, meaning they must be closed most urgently.

Keywords: *EV battery, traceability, circular economy, EU regulation, aftermarket services, capability gaps, RBV*

Acknowledgement

We would like to thank our supervisor and examiner at Chalmers University of Technology, Árni Halldórsson, for his valuable support and input throughout the master's thesis project. By continuously bringing enthusiasm and great energy into meetings and workshops, he has contributed to the finalizing of this report. In addition, Árni Halldorsson has constantly challenged us in our work, resulting in many insights and new perspectives, which in turn has improved our projects output.

In addition, we would like to thank our supervisors and representatives at the case company for their dedication and engagement. Besides always making us feel welcomed and included, they have also facilitated our work and encouraged our continuous learning. Also, they have been very supportive by sharing and introducing us to their network, which has been crucial in the gathering of data.

Isabella Ahl and Måns Medin
Gothenburg, 2022

Table of contents

1 Introduction 1
- 1.1 Problem specification 2
- 1.2 Purpose and research questions 3

2 Literature review 4
- 2.1 Traceability 4
  - 2.1.1 Traceability systems 4
- 2.2 Circular economy 6
  - 2.2.1 Barriers and challenges in the transition towards CE 6
- 2.3 Aftermarket services 7
- 2.4 Resource-based view 8
  - 2.4.1 Resources 8
  - 2.4.2 Capabilities 9
  - 2.4.3 Justification and adoption of theoretical framework 10
- 2.5 EV batteries 11
- 2.6 Literature synthesis 12

3 Method 14
- 3.1 Research strategy 14
  - 3.1.1 Research design 14
  - 3.1.2 Research method 14
- 3.2 Data collection 15
  - 3.2.1 Structure 15
  - 3.2.2 Interview contexts 16
  - 3.2.3 Sampling 17
- 3.3 Data analysis 19
  - 3.3.1 Research question 1 19
  - 3.3.2 Research question 2 21
  - 3.3.3 Research question 3 21
- 3.4 Ethical considerations 21
  - 3.4.1 Harm to participants 21
  - 3.4.2 Informed consent 22
  - 3.4.3 Invasion of privacy 22
  - 3.4.4 Deception 22
- 3.5 Research quality 23
  - 3.5.1 Credibility 23
  - 3.5.2 Transferability 23
  - 3.5.3 Dependability 24
  - 3.5.4 Confirmability 24

4 Results and empirical analysis 25
4.1 Research question 1 25
4.1.1 Extended producer responsibility 26
4.1.2 Required information 26
4.1.3 Systems 26
4.1.4 Interaction between categories of requirements 27
4.2 Research question 2 28
4.2.1 Current state 28
4.2.2 Organizational capabilities 30
4.2.3 Human capabilities 32
4.2.4 Technological capabilities 32
5 Discussion 37
5.1 Categories of requirements 37
5.1.1 Extended producer responsibility 38
5.1.2 Required information 39
5.1.3 Systems 39
5.1.4 Legal uncertainties related to EU regulation requirements 39
5.2 Capability gaps 40
5.2.1 Organizational capabilities 40
5.2.2 Human capabilities 42
5.2.3 Technological capabilities 43
5.3 Prioritization of capability gaps 45
5.3.1 High priority level 45
5.3.2 Medium priority level 46
5.3.3 Low priority level 46
6 Conclusion 47
7 References 49
Appendix 52
Appendix I - Interview guide I

1 Introduction

Sustainability is a trend of growing importance which organizations now must address, and therefore such issues are on top of most company agendas (Frishammar & Parida, 2019). In corporate sustainability work, common guidance for many companies is the Paris Agreement where one of the overall goals is to keep global warming below 1.5 degrees Celsius (United Nations, 2015). One important aspect in achieving this goal will be the transition towards carbon dioxide neutral energy where batteries will play a key role. Particularly, batteries in electric vehicles (EV) will be important since the transport sector today corresponds to 25% of global emissions (European Commission, 2020). Consequently, the market for EVs is expected to increase by a factor of 14 between the years 2020 and 2030 (World Economic Forum, 2019). Further, this stresses the importance of an efficient and functioning market for EV batteries. Today, problems on the market are related to information failures and the complexity of battery value chains. Therefore, a new regulation concerning batteries has been proposed by the European Commission and will potentially enter into force in 2023 (Melin, et al., 2021). Furthermore, the new EU regulation will replace the current EU Batteries Directive from 2006, Directive 2006/66/EC.

Further, the objectives of the new EU regulation are to create a fair market for all batteries introduced on the European market, empower the transition towards a circular economy (CE), and ensure sustainability throughout the batteries' life cycles (European Commission, 2020). This will have implications for the automotive industry, for example, by introducing requirements on minimum levels of recycled material used in production, on the provision of performance and durability information, and collection rates targets. In other words, this will impact all phases of the EV battery life cycle, from materials sourcing and processing to second life application and recycling.

One company in the automotive industry that will be affected by the new EU regulation is this study’s case company, a Swedish original equipment manufacturer (OEM) operating on the global automotive market. The study will be conducted at the case company’s aftermarket function, including several different aftermarket services. Thus, the focus of this study will therefore be on the later phases of the EV battery life cycle and the new EU regulation requirements related to these. Specifically, the study will focus on aftermarket services from point of use (POU), which takes place once the vehicle leaves the dealer center, until end of life (EOL), which occurs when the battery needs to be replaced. To clarify, aftermarket services within these life cycle phases refers to aftermarket services at a general level rather than focusing on specific services. However, single aftermarket services such as provision of spare parts, collection of used batteries, remanufacturing and other value-added services are examples of services included in the study. Also, it should be stated that the study’s focus allows multiple battery lives, meaning that a battery can get an additional life by applying different value recovery options, such as remanufacturing, refurbishment or reuse (Lüdeke-

Freund et al., 2019) At the point where there is no possibility to provide the battery with an additional life, the recycling phase begins, which is not included in the scope of the study.

There are several examples of requirements in the new EU regulation that are relevant for aftermarket services. Such requirements are for example related to the repurposing and remanufacturing of EV batteries, the electronic exchange system (EES) with the purpose of tracking battery data, enabling multiple battery life cycles, and collection levels (Melin et al., 2021). In turn, this will impact how automotive OEMs design and deliver their aftermarket services and what capabilities will be necessary when doing so. In other words, the new EU regulation demands more circular operations and will require automotive OEMs to adapt their current operating models to meet the requirements.

Further, to achieve an efficient circulatory system, sufficient information about batteries will be a key aspect. In turn, for companies to be able to provide sufficient information about batteries, traceability will play an important role. Traceability is defined by Olsen and Borit (2013) as the "*The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle…*" (p. 148). In other words, traceability focuses on information and access to information, something that is also evident in the new EU regulation (European Commission, 2020). For example, the new EU regulation requires companies to provide information about batteries' state of health to determine the batteries' potential to be reused or repurposed (Melin et al., 2021). Thus, the new EU regulation will impact what capabilities automotive OEMs will need to possess and develop in order to meet the need for traceability.

1.1 Problem specification

As described above, the new EU regulation will have implications on how aftermarket services in the automotive industry are designed and delivered. Especially, it will have implications on what capabilities automotive OEMs will need to possess in order to be successful in meeting the need for traceability in their aftermarket services. However, there are challenges in the automotive industry associated with traceability in the later phases of the EV battery life cycle (Fransson et al., 2020) In other words, this risks becoming a problem when automotive OEMs must comply with requirements in the new EU regulation. One example of this could be that automotive OEMs may have problems with providing aftermarket related information to the EES. In addition, the challenges related to traceability in the later phases of the EV battery life cycle risk complicating aftermarket services. For example, if information about the batteries' state of health is lacking, it will be difficult to accurately determine *if* and *when* batteries need to be reused or repurposed. Similarly, insufficient information about geographical location will negatively affect the ability to collect batteries once a decision of reuse or repurposing has been made, which in turn will complicate the logistics of aftermarket services. Thus, having sufficient traceability can help automotive OEMs improve their aftermarket services while simultaneously supporting them to comply with requirements in the new EU regulation for EV batteries.

If automotive OEMs fail to comply with the requirements in the new EU regulation, it will have several implications on their competitiveness in the European market. First, automotive OEMs will face legal consequences and risk being excluded from the market. Second, automotive OEMs not complying with the new requirements risk losing market shares as a consequence of dissatisfied customers and damaged reputations due to an increased awareness of sustainability in today's society. This is likely to cause significant losses since the EV battery market is expected to grow by a factor of 14 between the years 2020 and 2030. Further, automotive OEMs who are successful in quickly adapting their operations to the new EU regulation will gain first-mover advantages compared to other automotive OEMs. In other words, complying with the new requirements will be a source of competitiveness for automotive OEMs in the European market.

Thus, there is a need for automotive OEMs to understand how the new EU regulation requirements will impact their aftermarket services. In turn, automotive OEMs will have to adapt their current operations to more circular operating models to comply with the new EU regulation. Specifically, automotive OEMs need to understand what capabilities they need to possess and develop in order to successfully transform their operations. In other words, automotive OEMs must identify potential capability gaps hindering their organization to comply with the new EU regulation. Further, traceability has been identified as a key aspect in improving the management of EV batteries throughout their life cycle. In addition, traceability will play an important role in aftermarket services, for example, when deciding if EV batteries should be reused or repurposed and, if so, knowing where, in terms of geographic location, they should be collected from. Thus, automotive OEMs must specifically understand what potential capability gaps related to traceability that's hindering them to comply with the requirements in the new EU regulation.

1.2 Purpose and research questions

The purpose of the study is to identify what requirements related to traceability that will be put on automotive OEMs' aftermarket services as a consequence of new EU regulation. Further, the study aims to identify what capability gaps that exist in a specific global automotive OEM's aftermarket services, hindering the organization to comply with previously identified requirements. Also, the study's purpose is to address how the studied global automotive OEM should prioritize the closing of identified capability gaps. Based on the purpose of the study, the following three research questions (RQs) were formulated:

1) What traceability related requirements will be put on automotive OEMs' aftermarket services as a consequence of the new EU regulation?

2) What capability gaps exist in a global automotive OEM's aftermarket services, hindering the organization to comply with identified requirements?

3) How should the closure of identified capability gaps be prioritized?

2 Literature review

The study's second chapter begins with a review of existing traceability litterature. Next, a presentation about the area of CE is given, followed by a brief introduction to aftermarket services. Following, the theory of resource-based view (RBV) is described including its key concepts of *resources* and *capabilities*. Finally, a brief description of EV batteries is presented.

2.1 Traceability

Moe (1998) defines traceability as "*...the ability to track a product batch and its history through the whole, or part, of a production chain from harvest through transport, storage, processing, distribution and sales.*" (p. 211). According to Olsen and Borit (2013), Moe's definition is the most frequently used definition derived from a scientific paper, indicating high credibility. Another commonly cited definition, is the one from ISO 9000, stating that traceability is "*...the ability to trace the history, application or location of that which is under consideration.*" (Olsen & Borit, 2013, p. 143). Further, Cambridge Dictionary (n.d) defines traceability as the ability to 1) "*...discover information about where and how a product was made.*" and 2) "*...find or follow something.*". In their study, Olsen and Borit (2013) combine several different definitions of traceability and suggest an, in their meaning, improved definition of traceability to be "*The ability to access any or all information relating to that which is under consideration, throughout its entire life cycle....*" (p. 148). While the study was conducted in the context of the food industry, where traceability is devoted a high degree of attention and plays an important role, Olsen and Borit emphasize that their new definition is also applicable in other industries.

Moe (1998) means that traceability can concern several different types of information. For example, it can be information related to products and its materials, origin, processing history, distribution and location after delivery. In addition, Moe means that traceability is related to IT and programming, and the design and implementation of such systems. Further, Olsen and Borit (2013) mean that traceability has two components, where the first component is about the recording of information and the second component is about providing access to this information. In other words, to achieve traceability, both components must be performed simultaneously. Olsen and Borit argue that while the recording of information is not too difficult to achieve, providing access to the recorded information is more complicated. Further, they mean that this is especially true for complex products with extensive supply chains. Under such circumstances, computerized traceability systems are required to keep track of information. Similarly, Moe (1998) states that *"The use of computers* (...) *enables a larger amount of data to be handled…"* (p. 213).

2.1.1 Traceability systems

The purpose of traceability systems are to systematically store and retrieve data (Olsen & Borit, 2013). In addition, Olsen and Borit argue that traceability systems must have four main characteristics. First, resources must be traceable on unit level, which academics refer to as “traceable resource units” (TRUs) (Kim et al., 1995; Moe, 1998; Olsen & Borit, 2013). For example, Moe (1998) states that “*...traceability is first of all based on the ability to identify products uniquely.*” (p. 212). However, in relation to TRU, this raises questions concerning what level traceability should be tracked on. For example, Moe means that the identification of a TRU may change downstream the supply chain, resulting in the need for a new TRU identification. This could be the case if one individual TRU is integrated with another individual TRU to create a new TRU, or the opposite where one TRU is split up into several TRUs. Further, Moe (1998) means that “*...the individual TRUs can only keep the identification of the original TRU as long as the activities occurring to the individual TRUs are identical.*” (p. 212). In addition, Wessel et al. (2021) describe that a lot of data cannot be tracked on a deeper level than batch level and therefore they mean that unique traceability is challenging today.

Second, referring back to the four main characteristics of traceability systems, each resource unit must be assigned unique identifiers or keys (Olsen & Borit, 2013). This is also supported by Franquesa et al. (2016) pointing out unique identifiers for each component as important for traceability. Third, these identifiers or keys must link to, directly or indirectly, recorded product and process properties. Fourth, access must be provided to each resource unit and its linked product and process properties. If these four characteristics are not present simultaneously, traceability systems will not be efficient. For example, not being able to identify TRUs would in practice require information to be physically labeled on each unit which for long and complex supply chains would be unfeasible.

Moe (1998) argues that information can be managed in two different ways. First, data is stored locally for each step in the supply chain, meaning that information can only be accessed by going upstream in the supply chain one step at a time. Second, data follows the product throughout the supply chain, enabling central access to upstream information without having to return to the local source. The need for central access is also discussed by Robson et al. (2007) addressing the challenge to control and manage parts’ various locations in a global supply chain. To deal with this, Robson et al. stress the need for information management where they mean that organization’s different databases must be fully connected. Similarly, Wessel et al. (2021) argue that in a traceability system, an organization must integrate all data sources. Also, Olsen and Borit emphasize the importance of sharing information both upstream and downstream in the supply chain, supporting the need for connected and integrated data sources.

For traceability systems to be efficient, it must be able to manage different types of information (Moe, 1998). For example, Olsen and Borit (2013) mean that geographical location is one important type of information in traceability systems. In addition, Olsen and Borit refer to geographical location as the ability to access position data about a given product at any given time. However, tracking geographical location alone is only one aspect and not enough for efficient traceability systems. Olsen and Borit argue that efficient traceability systems must have the ability to analytically verify a given product’s properties, for example origin, application or life history.

2.2 Circular economy

The origins of CE definition is complicated and well debated in academia (Kirchherr et al., 2017; Murray et al., 2017). The two papers, together with Geissdoeferfer et al. (2017), form three of the most cited articles within the field of CE. All of these three papers agree that the most prominent definition of CE is provided by the Ellen MacArthur Foundation as "*...an industrial economy that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy...*" (2012, p. 7). Further, Geissdoeferfer et al. (2017), Kirchherr et al., (2017) and Murray et al., (2017) provide their own definitions. First, Geissdoeferfer et al. (2017) define CE as "*...a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.*" (p. 762). Second, Kirchherr et al. (2017) provide the definition of CE as "*...an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes.*" (p. 229). Third, Murray et al. (2017) define CE as "*...an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being.*" (p. 377).

Eikelenboom and de Jong (2021) mean that it is challenging to integrate circularity in business strategy since it requires fundamental shifts in organization's core business processes. Also, the researchers describe that a company's integration of circularity includes the assignment of responsibility in the organization. Similarly, Kirchherr et al. (2017) argue that developing and implementing circularity into the business strategy implies a complete reform of the organization's ways of working. Further, Ritzén and Sandström (2017) mean that the transition towards circularity will imply a change for the whole organization including its stakeholders.

2.2.1 Barriers and challenges in the transition towards CE

In literature, several barriers and challenges related to the transition towards circularity are identified. For example Kirchherra et al. (2018) point out technological, market, regulatory and cultural barriers. Further, Eikelenboom and de Jong (2021) highlight barriers related to cultural, regulatory, technical and market aspects. In addition, Olsson et al. (2018) report cognitive, organizational and technological barriers. Also, Antikainen et al. (2018) mean that challenges related to data collection and collaboration must be addressed in order to facilitate the transition towards circular operations. Furthermore, Rizos et al. (2016) highlight lack of technological know-how as a barrier for the transition towards circularity. Similarly, Ritzén and Sandström (2017) argue that lacking knowledge is a challenge to achieve true CE. Another addressed barrier in academia is related to the lack of cross functional collaboration. For example, Angelis et al. (2018) stress the need for collaboration with stakeholders both internally and externally in the organization's supply chain. Further, Eikelenboom and de Jong (2021) mean that interactions with different stakeholders are needed to promote the transition towards circularity. Moreover, Ritzén and Sandström (2017) highlight the lack of integration between functions as a significant barrier for achieving CE. Finally, academia points out legal aspects as a barrier playing an important role in the transition towards circularity. For example, Govindan and Hasanagic (2017) mean that the lack of incentives created by governments, can hinder organizations to make necessary changes to more circular operations. Also Olsson et al. (2018) argue that uncertainty regarding how legal requirements should be interpreted is another barrier.

2.3 Aftermarket services

In academia, there are several papers contributing to the understanding of aftermarket services. For example, Benjamin et al. (2019) mean that aftermarket services include a variety of activities related to spare parts, software, field operations, end-of-life services and guaranteed up-time. Also, Ambadipudi et al (2017) describe aftermarket services as the provision of parts, repair, maintenance and digital services. In addition, Wellner et al. (2020) mean that OEMs now extend their aftermarket services offerings to include activities such as maintenance, spare parts and other value-added services. Additionally, Gatenholm et al. (2021) describe that aftermarket support is related to the phase after point-of-sales (POS) and within the in-use phase. Furthermore, while some papers do not explicitly use the term aftermarket services, they contribute to the understanding of important activities carried out on the aftermarket. For example, Tan et al. (2009) mean that automotive after-sales services includes activities such as quality assurance, repairs and maintenance, parts supply and technical advice. Also, Daugherty et al (2003) mean that the aftermarket focuses on repair services after primary sales of vehicles and that one objective is to make repair parts easily available on the aftermarket. In addition, Subramoniam et al. (2009) mean that aftermarket support is related to spare parts and services after the initial sale of a product.

Gatenholm et al. (2021) argue that aftermarket logistics differs from the conventional forward flow, shifting the focus from the phase of point of sales (POS) to the in-use phase, suggesting a link between aftermarket services and reverse logistics (RL). Further, Gatenholm et al. describe RL as "*...the flow of goods from point of use to point of origin*" (p. 1000) which they mean is related to aftermarket logistics. Similarly, Daugherty et al. (2003) address reverse logistics in the automotive aftermarket industry and describe RL by using Rogers and Tibben-Lembke's definition "*...the process of moving goods from their typical final destination for the purpose of capturing value or (for) proper disposal.*" (p. 49).

Although CE and aftermarket services are two different research areas, several papers suggest connections between the two fields. For example, Gatenholm et al. (2021) mean that Ellen MacArthur Foundation's CE framework introduces aftermarket services as a way to improve circularity. Further, Gatenholm et al. argue that applying the three aftermarket services *repair and maintenance*, *reuse and redistribution* and *refurbishment and remanufacturing*, helps to slow down the use of resources. In turn, Gatenholm et al. mean that it will prolong product lifetime and thereby promote circularity. In addition, the researchers highlight the concept of closed-loop supply chains (CLSC) which they mean link together CE, aftermarket supply chains and RL. Furthermore, Kirchherr et al. (2017) found that the 3R framework (reduce, reuse, recycle) was applied in 35-40 % of the 114 CE studies they analyzed, suggesting a link between CE and common aftermarket services.

2.4 Resource-based view

Within strategic management, there are two central views on how companies can achieve competitive advantage (Slack & Lewis, 2017). While one school, the "resource-based", focuses on internal analysis related to organizations' strengths and weaknesses, the other school, the "environmental", focuses on external analysis related to opportunities and threats. Through the 1970s and 1980s, the environmental school was dominant and the performance of organizations was viewed as a consequence of how the organizations positioned themselves on the market. For example, Barney (1991) describes that "*...Porter and his colleagues* (...) *has attempted to describe the environmental conditions that favor high levels of firm performance.*" (p. 99). In other words, this indicates a clear focus, among prominent researchers at that time, on external factors as a source of companies' success. Further, in the 1990s the "resource-based" school gained attention, as a contrast to the "environmental" school (Slack & Lewis, 2017). Contributions from Barney (1991), building on Wernerfelt's work from 1984, were central in the resource-based view (RBV) which emerged during this time. RBV focuses on the utilization of capabilities and resources, inherent in organizations' operations, to achieve competitive advantage (Slack & Lewis, 2017).

2.4.1 Resources

Wernerfelt (1984) defines resources as *"...anything which could be thought of as a strength or weakness of a given firm."* (p. 172). In addition, Barney (1991) describes resources as "*...all assets, capabilities, organizational processes, firm attributes, information, knowledge etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness...*" (p. 101). Furthermore, Grant (1991) defines resources as "*...inputs into the production process - they* [resources] *are the basic units of analysis.*" (p. 118). In other words, drawing from the three presented definitions, resources can be seen as internal inputs into organizational processes related to organizations' performance, where resources are inputs in terms of strengths or weaknesses. Hereinafter, when referring to resources, it is this description which will be referred to.

There are several different types of resources within organizations and these have been categorized in many different ways. Wernerfelt (1984) differentiate between tangible resources, such as machinery and personnel, and intangible resources, like knowledge and brand-names. Further, Barney (1991) categorizes resources into three different groups; *physical capital resources*, *human capital resources* and *organizational capital resources*. Physical capital resources refers to, for example, technology, plants, equipment, and raw materials. On the other hand, human capital resources concern employees and, for example, their training, experience, relationships and judgment. Lastly, organizational capital resources include, among others, organizational structures and processes related to reporting, planning, controlling, and coordinating. Further, Grant (1991) refers to six different categories of resources; *financial resources*, *physical resources*, *human resources*, *technological resources*, *reputation*, and *organizational resources*, which are derived from the work of Hofer and Schendel (1978). For example, human resources concern employees while organizational resources include systems and models used within companies. Further, Hofer and Schendel describe technological resources as "*...high quality products, low-cost plats, and high brand loyalty*" (p. 145).

Evidently, there are several similarities between the three different categorizations from Wernerfelt, Barney and Grant mentioned in the paragraph above. To begin with, both Barney and Grant refer to the three categories physical resources, organizational resources and human resources. Further, Wernerfelt differentiates between tangible resources and intangible resources where tangible resources are similar to physical resources and intangible resources are associated with organizational resources and human resources. Additionally, Grant also refers to financial resources, technological resources and reputation. Arguably, reputation can be seen as an intangible resource related to organizational resources and human resources. However, how financial resources and technological resources connect to Barney's and Wernerfelt's categories are not as obvious. In both categories there are components that can be classified as either tangible, and thus physical resources, or intangible, and thus organizational resources and human resources. For example, technological resources include both hardware and software which can be connected to tangible resources and intangible resources respectively. In other words, the three most prominent categories of resources are physical, organizational, and human based on the categorizations from Wernerfelt, Barney and Grant.

2.4.2 Capabilities

Grant (1991) develops the connection between organizations' resources, and their ability to achieve competitive advantage, by introducing the concept of capabilities. According to Grant, few resources are productive by themselves, but rather contribute to competitive advantage once coordinated in teams of resources. Consequently, Grant defines a capability as "*...the capacity for a team of resources to perform some task or activity.*" (p. 119). Similarly, Amit and Schoemaker (1993) defines capabilities as "*...a firm's capacity to deploy Resources, usually in combination, using organizational processes, to effect a desired end.*" (p. 35). In addition, Amit and Schoemaker mean that "*Capabilities are often developed* (...) *by combining physical, human, and technological Resources at the corporate level.*" (p. 35), reminding of the categories of resources presented above. Further, according to Grant (1991), the complexity of capabilities depends on the number of resources it relies on. In other words, some capabilities depend on a single resource while other more complex capabilities are a network of multiple interacting resources.

Aligned with above, Grant argues that "*While resources are the source of a firm's capabilities, capabilities are the main source of its competitive advantage.*"(p. 119). Further, Amit and Schoemaker (1993) mean that the strategic value of organizations' resources, and thus capabilities, depend on how difficult they are to buy, sell, imitate or substitute. Similarly, the VRIO framework, drawing on the work by Barney (1991), assesses the strategic importance of resources by examining how valuable, rare, imitable, and organized they are (Slack & Lewis, 2017). Further, Slack and Lewis emphasize that resources are dynamic and that their strategic importance can vary as a consequence of changes on the market. Therefore, it is important for organizations to continuously upgrade and develop their set of resources and capabilities to align them with changing strategic objectives in order to ensure long-term competitive advantage (Grant, 1991).

2.4.3 Justification and adoption of theoretical framework

RQ2 aims to understand what capability gaps that exist in a global automotive OEM's aftermarket services, hindering the organization to comply with identified requirements in the new EU regulation. In other words, this implies a need for a focus on the internal aspects of organizations. Therefore, using RBV as a theoretical framework in this study was assessed to be appropriate. Moreover, RBV breaks down organizations' operations into capabilities and resources and thereby helps understand how they contribute to the performance of organizations and, in turn, their competitive advantage. In the context of this study, breaking down the case company into resources and capabilities supports the understanding of whether their aftermarket services are aligned with the requirements derived from RQ1. Further, RBV is an established and tested theory and the application of it increases the study's credibility.

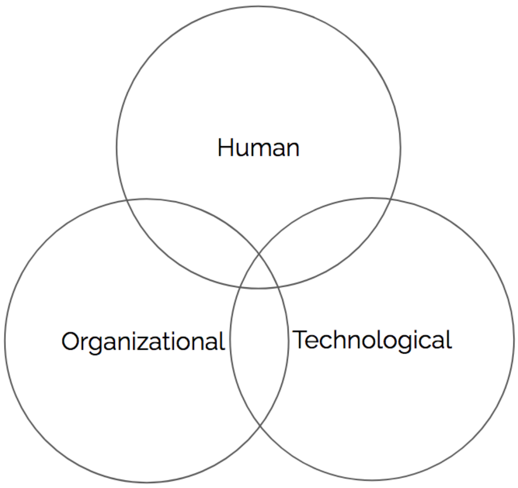
While competitive advantage, and how resources and capabilities contribute to it, plays a central role in RBV, it is not the main focus of this study. Instead, in this study, RBV is used to understand how capabilities and resources are connected. Further, the analysis of competitive advantage implies a comparison with competitors, where the VRIO framework is often applied (Slack & Lewis, 2017). However, this is not of relevance in this study since the focus is on what internal capability gaps that exist in an automotive OEM's aftermarket services, independently from their competitors. Moreover, it can be argued that complying with the new EU regulation is a competitive necessity rather than a competitive advantage, since meeting the new EU regulation requirements is a prerequisite for operating on the European EV battery market.

As argued above, the three main resource categories can be seen as physical resources, organizational resources and human resources, drawing from the work by Wernerfelt (1984), Barney (1991) and Grant (1991). While organizational resources and human resources are seen as relevant in this study, for example in terms of knowledge and organizational structures, physical resources are not likely to be of equal interest. The main reason is that this study focuses on traceability where physical resources, such as plants, equipment and raw materials, are not likely to play a crucial role. In contrast, technological resources are seen as essential in the context of this study since traceability is closely related to technology, for example hardware and software will play an important role when managing information. However, in the work by Wernerfelt, Barney and Grant, technological resources is not assigned its own category, most likely because technology was not as integrated and widespread in organizations through the 1980s and 1990s as it is nowadays. Today, technology is essential for organizations and seen as particularly relevant for this study, and therefore technological resources are devoted to their own category in this study. For example, technological resources can be seen as hardware and software (Wahl & Prause, 2013). Thus, the three main resource categories of relevance for this study are organizational resources, human resources and technological resources.

However, as RQ2 and RQ3 imply, this study focuses on capability gaps rather than resource gaps, and therefore it is of more interest to establish categories of capabilities. The main reason for this is that the study's research questions are of a more general nature rather than detail-oriented. Therefore, it is reasonable for this study to focus on capabilities rather than resources, since each capability is equal to a group of resources, aligned with the definitions from Grant (1991) and Amit and Schoemaker (1993). With that said, the same three main resource categories identified can be used to describe capability dimensions, bearing in mind a capability includes several resources. Thus, the three capability dimensions in focus in this study are organizational, human and technological, presented in Figure 1.

Figure 1

The three main capability dimensions; organizational, human and technology



2.5 EV batteries

Even though EV batteries can be several different types of batteries, the main focus is often on lithium-ion batteries. For example, Saw et al. (2016) mean that lithium-ion batteries are the most preferred battery type in the EV industry due to various benefits such as high energy density, high voltage, low self-discharge rate, long life cycle, high charging and discharging rate capability. Likewise, Chen et al. (2019) point out that lithium-ion batteries are the most researched battery type in academia. Furthermore, an EV battery has three different levels; cell, module and pack, where a pack includes several modules which in turn consists of multiple cells (Harper et al., 2019). Despite this being a standardized structure for EV batteries, the number of cells per module and modules per pack differ between battery supplier and type of battery.

One main component in EV batteries is the battery management system (BMS), discussed by several papers. For example, Yang et al. (2021) describe the BMS as being capable of data processing, analysis, modeling, state estimation, thermal management, fault diagnosis, and communication. In turn, the authors mean that such functions are important to ensure efficient, safe and reliable EV batteries, since lithium-ion batteries degrade during usage in terms of increased internal resistance and decreased capability. Similarly, Sivaraman and Sharmeela (2020) reports that the BMS monitors key battery data parameters such as voltage, temperature, power, state of charge (SOC) and state of health (SOH) to ensure safe operation. Likewise, Ali et al. (2019) mean that the BMS is an essential component in EV batteries and describe that it ensures safe operation and prolongs battery lifetime by measuring data parameters of the battery. Additionally, Lin et al. (2019) describes the BMS as "*...the brain of the battery.*" responsible for calculating SOC, SOH, state of power (SOP) and temperature.

Regarding the BMS, an important aspect discussed in literature is the accessing of BMS data. For example, Yang et al. (2021) mean that today, BMS data is mainly accessed when the battery is attached to the vehicle and mean that ideally the battery should be fully monitored in any state. Similarly, several papers discuss the importance of digital or cloud based BMSs where data can be accessed remotely and highlights numerous benefits associated with it. For example, Yang et al. report that digital batteries allow functions such as detection, prediction and optimization to be achieved, which has not been fully utilized with traditional BMSs. Likewise, Li et al. (2020) argue that digital BMS has several benefits such as monitoring, lifetime prognostics, fault detection, prediction and optimization. Also, Sivaraman and Sharmeela (2020) means that accessing BMS data remotely implies advantages like improved protection against overcharging, undercharging, overcurrent, under voltage, short circuit and temperature variations.

2.6 Literature synthesis

In other words, the study's literature review includes the areas *traceability*, *CE*, *aftermarket services*, *RBV* and *EV batteries*, as noted in Table 1. While the areas of CE and RBV are more distinct research areas, traceability, aftermarket services and EV batteries are less clear-cut. Also, while CE and EV batteries are newer areas, mainly due to today's sustainability trend, RBV, traceability and aftermarket services are more established research areas. Notably, this observation is based on an analysis of each used reference's publication year, where it can be seen that research areas judged to be newer have been published more recently.

Table 1

Compilation of how each research area contributes to answering the research questions

	Traceability	CE	Aftermarket services	RBV	EV batteries
RQ1	X	X	X		X
RQ2	X	X		X	X
RQ3					

Despite described differences, all of the areas are important in this study since each area contributes to the overall understanding needed to answer the study's research questions. First, the traceability literature is used to create an understanding of the concept needed to identify relevant requirements when conducting the analysis of RQ1. Also, this area is used to explain and support the findings in RQ2. Second, the CE area is used to create an overall understanding of the new EU regulation and the importance of its requirements, related to RQ1. In addition, it supports the analysis of capability gaps that hinder the transition towards circularity and in turn the compliance of the new EU regulation. Thereby, the area of CE does not only help answering RQ1, but also it supports the answering of RQ2. Third, the area of aftermarket services is not only used to create an understanding of the study's context, but also to support the identification of relevant requirements when analyzing the EU regulation report in RQ1. Fourth, the area of RBV provides a framework used to support the studying and defining of the case company's capabilities, needed to identify capability gaps in RQ2. Fifth, the EV battery area supports the overall understanding of the new EU regulation requirements related to RQ1. In addition, the area's contribution to the understanding of the BMS which supports the answering of RQ2. Furthermore, as noted in Table 1 that no research areas are used to directly answer RQ3 and the reason for this will be revisited later in the study.

3 Method

In this chapter, the study's research strategy, including research design and research method, is described. Next, the data collection process is presented where its structure, context and sampling are described. Following, the study's analysis of data is outlined per research question. Finally, ethical considerations and research quality are addressed.

3.1 Research strategy

The study used a qualitative research strategy due to several reasons. The phenomena studied is what capability gaps that exist in a global automotive OEM's aftermarket services, hindering them to comply with traceability related requirements in the new EU regulation. This phenomena includes several new areas where little prior research including the new EU regulation, CE and the rapidly growing EV battery market, has been done. Especially, very little to no research has been done on the interaction between these areas. In addition, research on these areas with a focus on capability gaps related to traceability on the aftermarket appears to be absent. Therefore, qualitative research is suitable in order to explore and generate understanding about the new phenomena (Bell, Bryman & Harley, 2019). In other words, the study aims to produce theories rather than test existing ones. However, to support the research process the study used existing theories and literature. Thus, an abductive research approach was used since the study alternated iteratively between theory and data. Moreover, the phenomenon includes social processes since capabilities are related to organizations ability to create value out of resources. Therefore, it is not possible to study capabilities separated from individuals' subjective experiences, and thus, a qualitative research strategy was considered suitable.

3.1.1 Research design

The study's research design was a case study performed at a global automotive OEM's aftermarket function. The case company served as an example to create an in-depth understanding of the studied phenomena (Bell et al., 2019). It should be stated the case company was not selected by the authors of this study based on predefined research questions. Instead, the case company had already defined the project in the format of a master's thesis, including general research topics, which was open for application by students. Hence, the authors of this study applied and were assigned the master's thesis project. In other words, the case and overall research topic were not chosen by the authors but instead it was assigned with the possibility to refine and specify the project based on interests and educational relevance.

3.1.2 Research method

The used research method of the study was qualitative interviews. This choice was based on the high degree of flexibility that qualitative interviews offer (Bell et al., 2019). This flexibility was of importance to ensure that the interviewees were allowed to be in charge of conversations and share a variety of information while it also allowed the interviewer to adapt questions accordingly. To obtain high flexibility, while ensuring relevant and studied topics are addressed, semi-structured interviews were used. However, informal conversations were also conducted to support the study's research, for example with relevant people during weekly meetings. Another reason why qualitative interviews were chosen was because they allowed for purposive sampling, in contrast to quantitative methods where sampling is random, described by Bell et al. It was perceived as important to be able to selectively choose interviewees based on their knowledge and experience within the organization in order to collect relevant data and answer the research questions.

3.2 Data collection

This subsection describes the structure, context and sampling of conducted interviews. Mainly, this concerns RQ2 which was where most of the study's data collection was performed.

3.2.1 Structure

As previously described, semi-structured interviews were held and prior to each interview, a PowerPoint presentation was presented to each interviewee, describing the aim of the study and key research areas. The purpose of this was to establish a general understanding of the studied areas and put it in the context of the case company's aftermarket services. To create a structure for the semi-structured interviews and ensure all areas of the research were covered (Bell et al., 2019), an interview guide was used, presented in Appendix I, which had the following layout. First, the interviewees were asked to describe their role and responsibility areas within the case company. The purpose of this was to understand the organizational context of each interviewee and in turn facilitate the data analysis of potential patterns between roles and functions. Second, introductory questions were asked to get a general understanding of the current state related to the case company's traceability work. Third, specific questions were asked where each question referred to the categories of requirements identified in RQ1. It should be stated that the interview guide only included two out of the three categories of requirements, namely required information and systems. The main reason for this being that the third category, extended producer responsibility, is seen as more of a background category to the other two, which are on a more specific level. For a more detailed explanation, see *4.1 Research question 1* in the result chapter. With that said, the purpose of asking specific questions was to identify potential capability gaps related to the three dimensions of capabilities derived from literature. However, despite the support of the three capability dimensions, flexibility in answering the questions was given the interviewees to ensure they could focus on either a specific dimension or other dimensions than the three identified dimensions, depending on their organizational context and expertise. Based on the dimension each interviewee chose to focus on, follow-up questions about the remaining dimensions were asked to ensure all dimensions were addressed.

While the questions in the introductory part were of a more general and broad character compared to the questions in the specific part, all questions were open-ended. The reason for this was to ensure that the data collected was comprehensive and nuanced (Blomkvist & Hallin, 2014). Also, open-ended questions allow interviewees to provide additional information they see fit, which is suitable for qualitative studies (Eriksson & Wiedersheim-Paul, 2008). In addition, open-ended questions do not allow yes or no answers which in turn ensure descriptive answers (Kvale et al., 2009), needed to answer the study's research questions. Furthermore, the questions in the interview guide were updated with minor changes along the way as new insights were gained. Moreover, depending on the interviewee's role, some questions could not be answered and were therefore adapted or excluded.

The informal conversations referred to above consisted of meetings, lunches, Microsoft Teams calls, chats and other spontaneous interactions. No clear structure was used, such as the interview guide, but discussions were held on topics related to the study, such as traceability, the aftermarket business, the new EU regulation and circularity. While these informal conversations are chosen not to be explicitly referred to as unstructured interviews in this study, Bell et al. (2019) describes that unstructured interviewing is very similar in character to a conversation. Drawing on Dalton's work from 1959, Bell et al. use the term "conversational interviewing" to describe a series of incomplete conversations characterized by events such as meetings, similar to how informal conversations have been used in this study. Thus, the study's informal conversations worked as a complement supporting the semi-structured interviews by creating background knowledge and overall understanding.

3.2.2 Interview contexts

All of the interviews were conducted online by using Microsoft Teams due to two main reasons. First, it was because of the ongoing COVID-19 pandemic. Second, it increased the access to relevant interviewees since the case company's aftermarket service function is global and several employees are frequently on business trips. Therefore, having the interviews online ensured equal conditions for all employees. Bell et al. (2021) mean that using online audio and video calls, such as Skype, comparable with Microsoft Teams, have a higher degree of flexibility in terms of last-minute schedule changes, compared to face-to-face interviews. This was also observed in this study, where employees at the case company were rather busy with tight schedules, making online interviews suitable. Similarly, Bell et al. highlight that it might be easier to convince employees to participate in interviews if they are conducted online compared to face-to-face, which also was a reason why an online interviewing format was chosen in this study. Further, Bell et al. point out technical barriers as a limitation to online interviews, but likely due to the quick adoption of digital communication tools within organization as a consequence of the COVID-19 pandemic and remote work, this was not perceived as a problem in this study.

The interviews were held in either English or Swedish depending on each interviewee's preference and were approximately an hour long each. Further, both of the study's authors attended every interview where one person held the interview while the other interviewer took notes. Also, all interviews except one were recorded, due to such preferences in that case. The possibility that the recording may affect how open and honest interviewees are was considered. To deal with this, each interviewee was guaranteed anonymity (Bell et al., 2019). Additionally, Patel and Davidson (2011) mean that ensuring anonymity helps interviewees feel more comfortable during interviews which was considered important in this study. In addition, Lind (2014) stresses the importance of protecting participating individuals and that they should not be negatively affected by participating in interviews. Moreover, also their integrity should be protected, helping explain the choice of anonymity. Another main reason why interviews were recorded was to enable the authors to go back to ensure notes were accurate and updated where needed. In addition, revisiting the recordings helped put certain answers in its right context. Similarly, Bell et al. (2019) mean that the recording of interviews does not only allow repeated examinations of each interviewee's answers, but also permits a more thorough analysis of empirical data, supporting the choice made in this study.

3.2.3 Sampling

The semi-structured interviews were held with 18 individuals at the case company. The decision of sample size was based on data saturation, meaning that no new interviews were conducted after reaching a point where new codes or insights could no longer be generated (Bell et al., 2019). However, Bell et al. express skepticism towards the concept of data saturation in qualitative research as they mean that the number of insights generated from a dataset is endless. While this was partly observed in this study, for example new specific details did emerge during the last interviews, but no new main themes were identified, supporting the study's choice of sample size based on data saturation. Also, Bell et al. point out that the broader the scope of a study is and the more comparison between groups in a sample that the study intends to discover, the larger the sample size must be. In the case of this study, the main focus was not to produce findings outside of the case company's organizational context nor compare different groups within the organization. Therefore, the sample size of 18 interviews were judged to be enough. Moreover, Blomkvist and Hallin (2014) mean that a sample size of approximately 10-15 interviews is appropriate for a master's thesis, suggesting this study's sample to be of an acceptable size.

The interviewees were selected from recommendations based on their expected ability to answer the questions in the interview guide. These recommendations were provided by the project's supervisors at the case company. Thus the sampling was done having the research goals in mind, suggesting a purposive sampling (Bell et al., 2019). For example, individuals working close to projects and tasks involving areas such as traceability, batteries, the new EU regulation, circularity and the aftermarket were selected. Also, since interviewees were added to the sample along the way, a sequential approach was used rather than a non-sequential approach, according to Bell et al. Further, interviewees were added to the sample based on recommendations provided during interviews, meaning a snowball sampling was used in the study, aligned with the definition from Bell et al. Furthermore, Bell et al. define purposive sampling as a non-probability sampling, something they mean is not appropriate when the objective is to generalize findings to a wider population. However, this is not the purpose of this study, being of a qualitative nature, and therefore it was not considered a problem.

Table 2

Representation of interviewees

Interviewee	Role	Department area
Interviewee 1	Employee	Aftermarket logistics and operations
Interviewee 2	Employee	Policy and Regulations
Interviewee 3	Employee	EV Development
Interviewee 4	Employee	Aftermarket logistics and operations
Interviewee 5	Employee	Aftermarket logistics and operations
Interviewee 6	Employee	EV Development
Interviewee 7	Employee	EV Development
Interviewee 8	Manager	EV Development
Interviewee 9	Employee	Aftermarket logistics and operations
Interviewee 10	Employee	Aftermarket logistics and operations
Interviewee 11	Employee	Remanufacturing
Interviewee 12	Consultant	Policy and Regulations
Interviewee 13	Employee	Aftermarket logistics and operations
Interviewee 14	Manager	Aftermarket logistics and operations
Interviewee 15	Consultant	Compliance
Interviewee 16	Consultant	Compliance
Interviewee 17	Consultant	EV Development
Interviewee 18	Manager	Aftermarket logistics and operations

The representation of the sample in the semi-structured interviews is shown in Table 2, presenting the role and department area of each interviewee. Notably, the roles include managers, employees and consultants, where the corresponding department area differs between a range of different areas. As presented in the table, the most commonly occuring role is employees and the reason for this is that employees were perceived as more accessible compared to the other two roles. Also, the table shows that the most frequently occurring department area within the sample is aftermarket logistics and operations, which could be explained by the study's focus on aftermarket services. Furthermore, a difference observed between the individuals in the sample was that the ability to answer certain questions varied due to varying background and expertise. For example, interviewees working closer to battery related tasks were generally able to provide more in-depth answers, especially from a technological perspective, compared to interviewees working with topics not primarily related to batteries. Similarly, interviewees working directly with tasks tied to traceability, had a better understanding of the topic compared to interviewees not working close to traceability. Another difference within the sample is that while many of the interviewees worked directly at the aftermarket function, where the case study was conducted, other interviewees belonged to other functions. With that said, all interviewees did either directly or indirectly work with tasks and projects related to the aftermarket market.

Despite noted differences between interviewees, it was not possible to clearly identify any patterns, based on role or department area, in the collected data. Also, it should be stated that despite the variation in detail level each interviewee answered on, all interviewees provided very similar answers, suggesting a high degree of agreement regarding the topics that were addressed in the interviews. Furthermore, a relatively homogeneous sample, in terms of interviewees being members of the same organization addressing similar topics in their daily work, may help explain the low degree of variation observed in the empirical data (Bell et al., 2019). Also, by using an interview guide when conducting the semi-structured interviews, the same questions and in the same order are being asked in all interviews. In turn, this standardization is likely to also work as a factor decreasing variation, according to Bell et al.

3.3 Data analysis

This subsection describes the study's analysis of data and is divided into the three research questions.

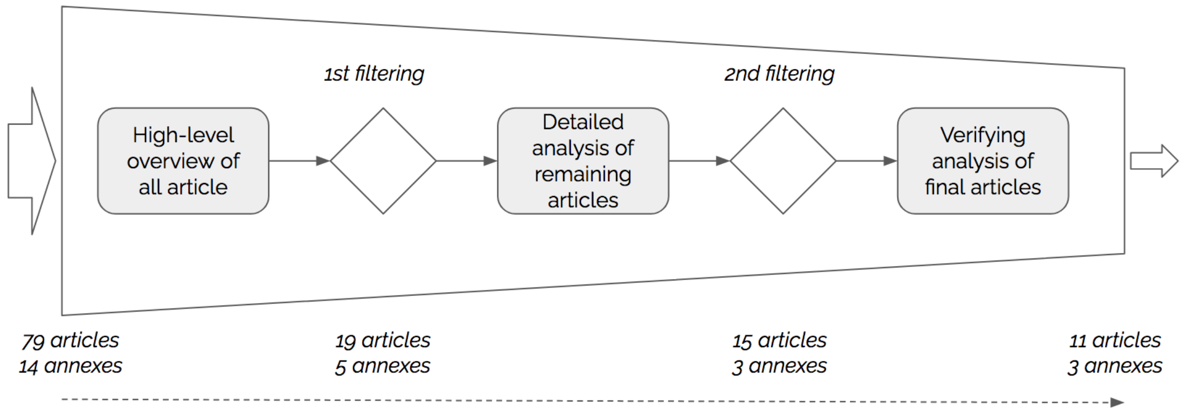
3.3.1 Research question 1

RQ1 aims to answer what requirements related to traceability that will be put on a global automotive OEM's aftermarket services as a consequence of the new EU regulation. The report published by the European Commission (2020), proposing a new regulation concerning batteries, is divided into 79 different articles and 14 annexes. Since the report is the basis for the new EU regulation, each article and annex had to be analyzed to determine its possible implications on the case company within the scope of the study. To assess the relevance of the articles and annexes, they were each examined based on three factors. First, it was of interest if the requirements in each article or annex applied to the study's scope of the EV battery life cycle, and thus, were related to aftermarket services. Second, the new EU regulation applies to different types of batteries and therefore only articles and annexes concerning EV batteries were of relevance. Third, any given article or annex were only of interest if they were assessed to be related to traceability, either directly or indirectly. Thus, an article or annex was only considered relevant if all three factors were apparent simultaneously. It should be stated that the relevance of articles and annexes, based on the filtering of the three factors, includes organizations beyond the automotive OEM industry. In fact, all organizations offering aftermarket services for EV batteries are to some extent subject to the requirements being put by the new EU regulation. However, in this study, the group of organizations being affected by the legal requirements are referred to as automotive OEMs, mainly because of the case company being such a company.

The processing of articles and annexes was based on a structured approach in three steps, illustrated in Figure 2. To start with, a high-level overview of all 79 articles and 14 annexes was conducted where the articles and annexes were skimmed to assess its relevance based on the three factors presented above. After the first filtering, 19 articles and five annexes remained to be of interest and they were then examined in detail and read thoroughly. The second filtering resulted in the removal of four articles and thus 15 articles remained relevant together with the elimination of two annexes meaning three annexes were still in the process. Lastly, to ensure that each article and annex had been evaluated correctly, with respect to the three factors presented above, a final analysis of the 15 articles and the three annexes were conducted to verify their relevance. Based on the verifying analysis, while one additional article was removed, no additional annexes were eliminated, resulting in a total of eleven articles and three annexes remaining.

Figure 2

The processing of articles



To identify categories of requirements related to traceability that will be put on automotive OEMs' aftermarket services, a thematic analysis on the eleven articles and three annexes remaining was conducted. The thematic analysis was performed on the digital platform Miro and used to structure the qualitative data collected from the articles and annexes in the new EU regulation report. In this process, each article and annex was shortly described on a digital post it-note and were then grouped into categories based on similarities in content between articles. The thematic analysis resulted in three categories of requirements. Further, how the thematic analysis has been applied in RQ1 is aligned with how Bell et al. (2019) describe that the approach is used to arrive at core themes. Also, Bell et al. mean that thematic analysis is one of the most common approaches in qualitative research, justifying the study's choice. In addition, Bell et al. point out that the thematic analysis does not have a clearly specified procedure, suggesting that the adaption of the approach in this study is acceptable.

As presented in this subsection, the analysis of the data related to RQ1 appears to be a linear process. However, in reality this was more of an iterative process where the group of relevant articles and annexes was considered to be dynamic and articles together with annexes were added or excluded along the process based on new insights. Similarly, the approach between the selection process of articles and annexes and thematic analysis was interactive where categories in the thematic analysis were updated due to status changes in the group of relevant articles and annexes.

3.3.2 Research question 2

When analyzing RQ2, a thematic analysis was performed. Based on the same arguments presented for the analysis of RQ1, a thematic analysis was assessed to be suitable also when analyzing RQ2 (Bell et al., 2019). The process of analyzing RQ2 consisted of the following steps. First, the notes and recordings of each interview were examined where key empirical data was highlighted based on whether it was assessed to help answer RQ2 or not. Second, the highlighted empirical data was then transferred to digital post-it notes on the digital platform Miro and entered per interview guide question. At this step, level 1 post-it notes were created and on each note the interviewee that contributed to the piece of empirical data was written down together with the interview question number. Third, subgroups were created per interview question and labeled with a level 2 post-it note describing the main theme for each category, similar to a title. Fourth, the focus per interview question was released and level 2 post-it notes were grouped across questions and new groups were created where the common themes within each of these groups were labeled with a level 3 post-it note. Fifth, level 3 post-it notes were grouped to create even larger groups labeled with a level 4 post-it note representing the core theme of each group. Thus, the data was analyzed on four levels where post-it notes and groups of post-it notes were coded and grouped together on each level. In other words, a level 4 group consisted of several level 3 groups where each level 3 group in turn included several level 2 groups where each level 2 group consisted of several level 1 post-it notes derived from a specific interviewee and interview question.

3.3.3 Research question 3

Once the capability gaps in RQ2 were identified, RQ3 aimed to prioritize these gaps. In order to achieve this, three different priority levels were defined; *high*, *medium* and *low*, where each level is described more in detail in subsection *5.3 Research question 3* in the discussion chapter. The description of each level worked as a guideline in the process of grouping different capability gaps into different levels. Based on the prioritization of capability gaps, recommendations were provided to the case company regarding which gaps should be addressed first.

3.4 Ethical considerations

When addressing ethical aspects in the study, the four criteria of *harm to participants*, *lack of informed consent*, *invasion of privacy* and *deception* were carefully considered to ensure any violations were avoided (Bell et al., 2019).

3.4.1 Harm to participants

Bell et al. (2019) refer to harm to participants as physical harm, stress, harm to participants' career or future employment and all of these aspects were considered in the study. For example, in order to not contribute to stress among interviewees in a busy organization with tight schedules, flexibility was given to the interviewees in terms of time scheduling and rebooking of slots. Also, all interviewees were guaranteed anonymity, both internally and externally. Internally at the case company, no individual would be able to be tied to any specific empirical data from interviews, which was ensured by keeping names, roles and functions anonymous. Externally, the anonymity was not only guaranteed for interviewees but also for the case company, meaning no details such as brand, specific products or other details were disclosed. Furthermore, prior to each interview the interviewees were asked and given the chance to approve or deny potential recording of interviews. In addition, the confidentiality of records was considered by only storing records locally at the case company's servers. Additionally, records were deleted when the study was finalized.

3.4.2 Informed consent

Informed consent is described as a key principle where participants must be provided sufficient information to make informed decisions regarding whether or not to participate (Bell et al., 2019). Prior to each interview, an email was sent to each interviewee describing the study's purpose and scope, meaning the principle of informed consent was considered. In addition, each interview began with an introductory PowerPoint, where the study was described in more detail. Also, the interviewees were informed about the structure of the interview and how long it was expected to last with the purpose of increasing transparency. However, it was challenging to find the right balance between ensuring informed consent while not providing too many details and impacting people's answers to the interview questions, something also addressed by Bell et al.

3.4.3 Invasion of privacy

Bell et al. (2019) mean that researchers must consider whether performed research implies an invasion of the interviewees' privacy. For example, interviewees may refuse to answer certain questions based on personal reasons. Since such reasons may vary per interviewee and are difficult to predict, it was important to treat each interviewee carefully, uniquely and on their own terms. By doing so, chances of noticing potential feelings of privacy invasion were increased and thereby the interviewees could be given the opportunity to withdraw their participation. Another way in which this was addressed was that if interviewees appeared to feel uncomfortable answering certain questions, for example related to that their knowledge within that field was low, the focus was shifted to allow interviewees speak about areas they felt more comfortable with.

3.4.4 Deception

Similarly to the principle of informed consent, deception was avoided by ensuring the purpose and scope of the study was carefully and thoroughly described to each interviewee. Bell et al. (2019) mean that deception occurs when research is wrongly portrayed and therefore it was important to ensure each interviewee correctly understood what the study aimed to investigate. Further, during the interviews, each interviewee was encouraged to ask questions if anything was unclear or if clarification was needed. Some interviewees requested to have meetings prior to the actual interview to create an understanding of whether or not they felt comfortable participating, something the authors accommodated. Similarly, interview questions were provided to some interviewees prior to the interviews when requested. In other words, several actions were taken in the study to ensure the absence of deception.

3.5 Research quality

Bell et al. (2019) describe that to assess the quality of qualitative research, it is important to consider trustworthiness which in turn can be divided into the four criteria; *credibility, transferability, dependability* and *confirmability*.

3.5.1 Credibility

Bell et al. (2019) refer to credibility as how believable findings are and mean that achieving a high degree of credibility is ensured by conducting research in good practice, something that was considered in the study. Also, Bell et al. highlight that credibility is established by submitting findings to study participants to ensure that researchers have correctly understood the researched context. Therefore, in this study, findings were frequently shared with supervisors at the case company. Furthermore, in the interviews several actions were taken with the aim of increasing credibility. For example, an interactive dialogue rather than a monologue was emphasized during interviews, where interviewees were encouraged to elaborate their answers and follow-up questions were asked. In addition, interviewees were challenged to elaborate their answers in relation to findings from previous interviews and new contexts. Additionally, the interviewers provided a biref summary after each answer and asked the interviewee to confirm that the interviewers had understood their answers correctly. Thus, findings were not only shared with participants of the study but were also continuously confirmed, which in turn increased the study's credibility.

3.5.2 Transferability

Transferability is described as whether or not findings can be applied in other contexts (Bell et al., 2019). Further, Bell et al. mean that the transferability of findings produced in qualitative research is relatively low since they are based on a unique social setting, in this case a case study at a global OEM's aftermarket function. However, the ability to apply findings outside the study's context differs between the three research questions. For example, RQ1 refers to traceability related requirements being put on automotive OEM's aftermarket services as a consequence of the new EU regulation. Thus, these requirements are also relevant for other organizations offering aftermarket services in the European EV battery market, including different automotive OEMs. On the other hand, the findings in RQ2 and RQ3 are capability gaps which are tied to the unique social setting of the studied case company. Therefore, findings in RQ1 are significantly more transferable to other organizations compared to findings related to RQ2 and RQ3. With that said, organizations of which the requirements in RQ1 apply to could still be interested in RQ2 and RQ3 findings to create an understanding of what types of capability gaps that may exist in similar organizations. However, organizations looking for such inputs must bear in mind that the findings are not directly transferable due to their differing social contexts.

3.5.3 Dependability

Bell et al. (2019) refer to dependability as the likelihood of research findings to apply at other times. Further, they mean that this can be ensured by keeping thorough records of the research process to enable external stakeholders to audit and review the process. In this study, this was considered by keeping close contact with supervisors, both from the case company and the University where the master’s thesis is conducted. Their external input was used to evaluate the suitability of the research process. In addition, previous research on the new EU regulation and its impact on different parts of the EV battery life cycle phases was used to compare the findings in RQ1 and ensure a high degree of dependability. Moreover, Bell et al. point out that thoroughly describing the performed work increases the transparency which was perceived as important in this study to enable others to review and evaluate the research.

3.5.4 Confirmability

The concept of confirmability is described as a study’s objectivity and to what degree researchers’ own values intrude or impact the results (Bell et al., 2019). However, Bell et al. argue that full objectivity is impossible to achieve in qualitative research. To ensure a sufficient degree of objectivity, and thus confirmability, the study has utilized external input, such as supervisors and previous research as referred to above, to minimize the influence of the authors’ own thoughts and views on the result.

4 Results and empirical analysis

In this chapter, the result for RQ1 and RQ2 is presented. The empirical data related to RQ1 includes a presentation of the three categories of requirements identified from the new EU regulation related to traceability. The result related to RQ2 derives from the semi-structured interviews and includes a presentation of the current state at the case company followed by a description based on the three capability dimensions. For RQ3, no empirical data were collected since this question is a speculative discussion based on the findings from RQ2 rather than based on empirical data per se.

4.1 Research question 1

Table 3 presents a compilation of RQ1 and the requirements related to traceability that will be put on automotive OEMs' aftermarket services as a consequence of the new EU regulation. The three identified categories of requirements, presented per column, are *extended producer responsibility*, *required information* and *systems*. For each of the three categories, a general description is provided followed by the main requirements the categories entail. Finally, the specific articles and annexes on which the categories are based are stated.

Table 3

Categories of requirements

	Extended Producer Responsibility	***Required information***	***Systems***
General description	Extended responsibility on the aftermarket associated with EOL management of batteries.	Different types of information have to follow the battery throughout its life cycle, some of it is fixed while other dynamic information has to be updated.	Systems where automotive OEMs are obligated to provide and manage information. Further obligated to provide other relevant aftermarket actors access to these systems.
Requirements for traceability	Organize collection, take back, preparation for repurposing and remanufacturing of batteries.	*Examples of static information:* - Estimated carbon footprint. - Levels of recycled material in production. *Examples of dynamic information:* - Battery durability and performance. Information required in annexes.	EES. Battery passport. QR code. BMS.
Articles & Annexes	*47, 49, 50*	*7, 8, 10, VI, VII, XIII*	*13, 14, 59, 64, 65*

4.1.1 Extended producer responsibility

Extended producer responsibility refers to automotive OEMs' EOL management of batteries and their increased responsibility in their aftermarket services associated with the later phases in the battery life cycle. According to Article 47, Article 49 and Article 50, automotive OEMs are obligated to organize the collection, take back, and preparation for repurposing or remanufacturing. Further, traceability will play an important role in determining *where*, *when* and *how* these aftermarket services should be performed. For example, in the collection and take back processes, traceability will be necessary to determine *where*, in terms of geographical location, the EV battery is located. Also, traceability will be required in these processes to understand the EV battery's state of health in order to accurately determine *when* the battery should be collected and taken back for potential value recovery treatment for an additional life. Similarly, traceability will be necessary when determining *if* and *what* value recovery treatment should be performed to each battery. For example, by utilizing information about batteries' state of health in the treatment assessment at the inspection center, automotive OEMs can ensure that correct decisions are being made in regards to the future of each battery.

4.1.2 Required information

Required information concerns information that has to follow the battery throughout its life cycle. Some of the required information is fixed and most often generated in the early phases of the battery life cycle, while other information has to be updated throughout the battery's life. In other words, required information can be divided into static information and dynamic information. According to Article 7, information about the battery's estimated carbon footprint has to follow the battery. Similarly, information related to minimum shares of recycled material levels in production must follow the battery according to Article 8. Neither the information required in Article 7 or the information required in Article 8 has to be updated in any of the life cycle phases connected to aftermarket services. However, Article 10 requires information about durability and performance and some of these variables, for example capacity and power levels, have to be updated throughout the battery life cycle. Further, Annex VI, Annex VII and Annex XIII contain additional information that needs to follow and/or be updated throughout the battery life cycle. This information concerns labeling requirements, factors to consider when determining the battery's state of health and information to be stored in the EES. Thus, traceability is strongly related to information, and therefore, traceability will be essential when keeping track of and updating the required information in the presented articles and annexes.

4.1.3 Systems

Systems refers to systems that automotive OEMs are obligated to provide information to and be able to manage. Automotive OEMs are also obligated to provide other relevant actors on the aftermarket with access to information in these systems. Further, this category can be broken down into the two main systems addressed in the EU regulation report; the ESS and the BMS. Article 64 refers to the first main system, the EES, that will be created and set up by the EU Commission. EES is a system for electronic exchange of battery information and automotive OEMs will be required to provide the system with specific battery information.

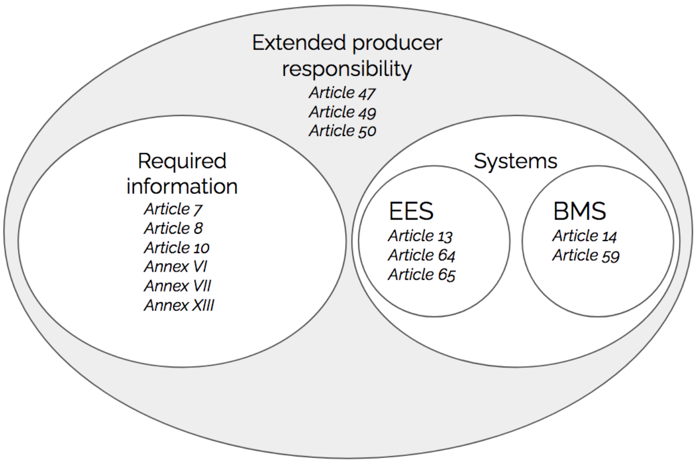
Further, Article 65 concerns the battery passport which is an electronic registration of each individual battery and will be accessed in the EES. In addition, Article 13 describes the QR code that each battery will be labeled with which will be used by different actors to access, communicate and provide information. Thus, the battery passport will hold information stored in the EES, and the QR code will be an important identifier to access this information. However, it is not clear if the QR code is required, by the EU Commission, to link directly to the passport or the EES. Furthermore, the second main system, the BMS, is a physical electronic device that stores and manages several data parameters, for example battery's state of health and expected lifetime. According to Article 14 and Article 59, automotive OEMs must ensure other relevant actors in the aftermarket network are provided access to the BMS to facilitate, for example, the repurposing or remanufacturing for second life applications.

4.1.4 Interaction between categories of requirements

The three categories presented in Figure 3 relate to each other in different ways. To begin with, the requirements in *extended producer responsibility* can be seen as the foundation on which the other categories are built upon. Consequently, this is why *extended producer responsibility* is placed behind the other two categories in Figure 3. Thus, these requirements stress the need for the requirements addressed in the two other categories; *required information* and *systems*. If automotive OEMs are to successfully perform their duties on the aftermarket, as set out in the new EU-regulation, they will have to be able to access and manage the systems where the information is stored. Further, utilizing the required information will be necessary in order for OEMs to be able to perform their aftermarket services efficiently with a high degree of traceability. In other words, the two categories *required information* and *systems* refers to information and systems related to the processes automotive OEMs are obligated to engage in on the aftermarket. Because of this, *required information* and *systems* are presented as a part of *extended producer responsibility* in Figure 3.

Figure 3

Interaction between identified categories of EU regulation requirements



4.2 Research question 2

The subsection addresses RQ2 and begins with a description of the current state at the case company, including challenges related to the new EU regulation and how the organization works with traceability today. Thereafter, the case company's organizational capabilities, human capabilities and technological capabilities are presented.

4.2.1 Current state

When being asked about the current status of the work of interpreting and adjusting the business to the new EU regulation, Interviewee 6 states that "*We are only in the initial phase of the compliance project.*". Further, Interviewee 1 means that *"Since a year back, there has been some awareness of the new regulation but no deep understanding of how the regulations will impact our business has been established."*. Interviewee 2 describes that currently, the new EU regulation is a proposal from the EU Commission and that suggestions on amendments are being submitted by the European Parliament and the European Council. Therefore, the new EU regulation is not yet approved, which in turn complicates the interpretation of how the legal requirements impact the case company's business. Another factor that complicates the work with the new EU regulation proposal is that the EU Commission, European Parliament and European Council are not aligned concerning the implementation timeline, described by Interviewee 6.

Based on the uncertainties related to the new EU regulation described above, several interviewees provide examples on when they do not fully understand implications from the legal requirements. One example is that several interviewees do not think it is fully clear what type of information they must provide to the EES and what data parameters that must be provided from the BMS. While Interviewee 9 says that "*We do not understand in detail what information that has to be entered into EES.*", Interviewee 17 shares that "*The main challenge* *is knowing what data we are required to report from the BMS.*”. Another data parameter in the new EU regulation, which the interviewees perceive as unclear, is carbon footprint. First, Interviewee 11 does not think it is clear how carbon footprint should be calculated and what life cycle phases that should be included. Second, Interviewee 7 questions whether carbon footprint should be calculated for batteries on an individual level, batch level, part number level or other level. Moreover, a central topic during interviews is the discussion of what level, referring to pack, module or cell, each battery should be traced on and the majority of interviewees do not think it is clear on what level the new EU regulation demands OEMs to trace on. For example, interviewees from the case company’s remanufacturing department are especially concerned with this question since it will highly impact their operations when performing value recovery on batteries. However, Interviewee 2, shares that “*Based on the EU Commission's definition of a battery, our interpretation is that batteries must be traced on a cell-level.”.* Also, Interviewee 3 and Interviewee 15 express a desire to trace on cell level due to business opportunities related to getting access to in-depth data.

Traceability at the case company

The ability to trace products varies between different functions in the case company. For example, several interviewees mean that traceability is well established and functioning in production, where Interviewee 7 shares that “*We are successful in capturing information about products on the production floor.*”. However, traceability is inadequate in their aftermarket operations where Interviewee 8 means that “*traceability decreases when products leave the factory and reach the market*”. Similarly, Interviewee 7 describes that “*Traceability on the service market is complex due to an increased number of external actors compared to production.*”.

While Interviewee 15 describes that *“Some data is gathered at the dealer centers when vehicles come in for service*”, the majority of the interviewees mean that the case company in general has insufficient traceability in their aftermarket services. For example, Interviewee 3 states that “*When it comes to traceability, I am not sure we are good at anything right now. We have the basics in place but nothing more.*”. Another employee, Interviewee 18, says that “*It is a shame we are lacking that far behind.*”, when being asked how the case company works with traceability today. Furthermore, Interviewee 15 states that “*We would prefer to work more with traceability than what we do today.*”. In addition, Interviewee 18 states that “*We are struggling with traceability with the few EV batteries we have on the market today.*” Moreover, Interviewee 4 and Interviewee 14 take this one step further and argue that the case company’s ability to trace is non existing for their aftermarket services. In addition, Interviewee 10, shares that “*We are not talking that much about traceability*”. Interviewee 10 continues and means there is a focus on geographical location when discussing traceability at the case company. In addition, the interviewee explains that traceability is a broad concept including several different types of information, not only geographical location. However, even though there is some focus on geographical traceability at the case company, Interviewee 9 states that “*In reality we do not even have geographical traceability in place since we do not know parts’ location when in transit.*”. The lack of geographical traceability is confirmed by both Interviewee 16 and Interviewee 18.

When discussing future traceability for batteries, the majority of the interviewees stress the importance of shifting focus geographical traceability to a broader concept of traceability including several different types of information. Further, several interviewees emphasize the need to capture information about batteries throughout their whole life cycle and implement an end-to-end perspective. For example, Interviewee 13 says that "*Even though our service market department is not the initiator of most data, we must be able to handle data from upstream actors in the supply chain.*". This is confirmed by Interviewee 3 who means that "*We must have full access to information about batteries from cradle to grave.*". In other words, the interviewees mean this would require the case company to access static information from previous life cycle phases, for example manufacturing. However, several interviewees also express the need to manage dynamic information about batteries current status. Similarly, Interviewee 7 says that "*We need to differ between static and dynamic information, where dynamic information has to be continuously updated.*". Information that has to be updated is related to the batteries current status and data parameters such as temperature, charging condition and impact, described by Interviewee 4 and Interviewee 18.

The majority of the interviewees point out several benefits with monitoring dynamic data described above. First, Interviewee 9 shares that "*Knowing this data helps us understand possible actions in different scenarios.*". Second, Interviewee 11 means that "*It would be ideal for us to know the current status of the battery since we would be able to predict when service is needed.*". In other words, working towards increased traceability is related to several business opportunities. This is described by Interviewee 15 who means that "*Business opportunities will speed up the traceability work.*". The interviewee continues and means that "*In the future data will correspond to an increased percentage of sales compared to today in a market where customers demand a higher degree of data transparency.*". In turn, Interviewee 15 argues that this stresses the importance of more data driven aftermarket services where traceability will play an important role. Further, Interviewee 4 means that the new legal requirements will serve as a driving force in improving traceability which in turn will create several business opportunities.

4.2.2 Organizational capabilities

The subsection describes the case company's organizational capabilities which are presented from both an internal perspective and an external perspective.

Internal collaboration

Nearly all of the interviewees highlight organizational aspects as one of the main challenges related to complying to the new EU regulation. For example, Interviewee 3 states that "*The EU regulation will impact all parts of our organization.*". Further, Interviewee 18 means that "*It is not clear who will do what.*". This view is shared by the majority of the interviewees who means that responsibility clarification is a central issue. For example, Interviewee 6 says that "*We must ensure we have clear responsibility definitions.*". In addition, Interviewee 16 explains that "*The whole organization must be adapted to the new EU regulation and the biggest* *challenge will be to clarify responsibility areas.*". Also, Interviewee 7 means that "*The challenge is to define which department is responsible for what and, within specific departments, who are in charge.*". Furthermore, Interviewee 4 means that "*Due to a functional organization and lacking responsibility clarification, tasks are often overlooked and missed in our service market operations.*". Further, Interviewee 15 concludes that "*In general we have the needed capabilities but responsibility must be allocated.*". Similarly, Interviewee 1 shares that "*We cannot only define what has to be done but also we must define who is responsible.*". This is confirmed by Interviewee 18 stating that "*The bottleneck is responsibility clarification, hindering us to start working on details.*".

Interviewee 13 means that "*Collaboration is negatively affected by unclear division of responsibility.".* The interviewee continues and shares that "*When information is shared, it is often sent to a lot of people making it unclear what information concerns who and if actions are expected.".* In addition, Interviewee 4 explains that "*It is often that information is not shared between functions.*". This is confirmed by Interviewee 15 meaning that "*There is a resistance within the organization to share information and that functions do not share data if they do not have to.*". Meanwhile, Interviewee 9 explains that *"Our functions have much valuable data that would be beneficial to share between departments".* Also, Interviewee 6 says that "*Different parts of our organization are poorly connected.*". Further, Interviewee 10 means that "*Previous focus on one's own department will not work for batteries, where an end-to-end mindset is needed, but instead our organization must be able to collaborate cross-functionally.*". For example, Interviewee 14 says that "*Production and aftermarket must work together to understand requirements.*". Similarly, Interviewee 9 explains that "*In the EV battery life cycle, information travels through different phases and therefore it is important that the work of defining responsibility for different processes is done together.".* Interviewee 1 elaborate on the requirements from the new EU regulation being put on the case company's aftermarket business and mean that cross-functionality is needed since the requirements impact a variety of functions and people. The interviewee continues and means that there will be significant challenges connected to this due to the size of the project related to complying with the new EU regulation.

External collaboration

In addition to internal organizational challenges, several interviewees also mention external challenges related to complying with the new EU regulation. In general, these challenges refer to the case company's collaboration and relationship with external stakeholders, often suppliers, carriers, private dealers and customers. For example, Interviewee 11 states that *"There is a challenge with getting access to suppliers' data.".* Similarly, Interviewee 15 says that *"Getting access to suppliers' data is often complicated.".* Also, Interviewee 4 explains that "*It is difficult to get access to information in private dealers' systems due to legal restrictions*". Interviewee 7 describes similar issues regarding dealers and says that "*We cannot force dealers to report data back to us.*". Further, both Interviewee 9 and Interviewee 11 mean that, to some extent, the case company's aftermarket business will depend on information from external stakeholders, especially suppliers. To deal with such challenges, Interviewee 7 describes that "*There is a need to create more transparency between different actors.*".

When discussing the relationship between the case company and external stakeholders, a central theme in the interviews is data privacy and sensitive information. For example, Interviewee 1 states that "*There is a resistance towards sharing sensitive information.*". Similarly, Interviewee 6 says that "*Some information is sensitive and we are not comfortable sharing everything with others*". Further, Interviewee 4 means that external stakeholders may not want to share sensitive information and exemplifies by describing that "*Customers might not want to share data about how they use our product, for example their geographical location.*". Moreover, Interviewee 17 shares that "*There is a lot of ongoing lobbying at an EU-level regarding what data should be disclosed or not.*". This is confirmed by Interviewee 2 and Interviewee 12 explaining that the case company, together with other stakeholders, are lobbying at an EU-level to ensure a minimum amount of sensitive data has to be disclosed.

4.2.3 Human capabilities

In general, the majority of the interviewees did not discuss human capabilities much. When being asked specifically about human capabilities, the interviewees tended to answer in general terms. For instance, when discussing challenges related to employees' competence as a result of new ways of working connected to the new EU regulation, interviewees often answer that competence would be ensured by various training. For example, Interviewee 3 says that "*As per usual, competence will be ensured by educating employees and offering competence development.*". Similarly, Interviewee 18 states that "*Competence and training must be ensured.*". Also, Interviewee 6 explains that "*We need to ensure we have the needed competence.*". Likewise, Interviewee 4 describes that "*Training is needed for both white collar workers and blue collar workers.*". Furthermore, several interviewees stress the importance of getting people onboard when adapting the organization to meet the requirements from the new EU regulation. For example, Interviewee 14 means that "*If people will be required to change their routines, it will be important for them to understand why they should do so.*". He continues and explains that it will be important for the case company to communicate the purpose of necessary changes in the organization, for example what value data employees may have to gather and report brings to their business. In agreement with Interviewee 14, Interviewee 7 states that "*If employees do not understand why they should change, it might affect their motivation.*". In addition, Interviewee 10 says that "*People must be willing to change to successfully make the transition towards batteries.*".

4.2.4 Technological capabilities

The majority of the interviewees point out the ability to trace batteries on an individual level as one of the main challenges when it comes to complying with the new EU regulation. As of today, the interviewees describe that the case company's aftermarket systems and processes are organized by part numbers. For example, Interviewee 13 means that "*Our work is based on part numbers and working with unique reference numbers will be challenging.*". This is confirmed by Interviewee 14 who says that "*Batteries will imply new ways of working connected to unique reference numbers rather than part numbers.*". Another challenge related to the transition towards unique reference numbers is creating unique keys that can follow the battery throughout its entire life cycle, according to Interviewee 7. Despite described challenges, the majority of the interviewees emphasize the importance of unique reference numbers to access required and needed information about individual batteries when describing their ideal traceability. To clarify, when discussing traceability on an individual level, the interviewees use several different terms, such as serial number, battery identification number (BIN) and traceability number, however, commonly they all refer to some type of unique reference numbers.

Interviewee 8 explains that previously, the aftermarket function at the case company has not been required to trace parts on an individual level and that it was previously considered to generate more work and costs than value. However, the case company has lately identified problems in their aftermarket services due to the lack of traceability, which is exemplified by Interviewee 4 who states that "*Goods are shipped to wrong destinations and when parts are in transit it has happened that they disappear.*". The same interviewee continues and says that "*If batteries, once volumes increase, are introduced to these operations, it will be problematic since each battery represents much value and therefore cannot be lost.*". Another factor to explain the importance of tracing batteries on an individual level is shared by Interviewee 7 who says that "*Prestanda differs between individual batteries with the same part number and therefore they must be monitored accordingly.*". Interviewee 7 continues and explains that the difference in prestanda is not as significant for other parts.

The majority of the interviewees mean that the case company's aftermarket services and systems are not designed for tracing batteries on an individual level. For example, Interviewee 14 says that "*When going from working with part numbers to unique reference numbers, new requirements will be put on our systems.*". Also, Interviewee 11 shares that "*We do not have the right systems in place.*". In addition, Interviewee 13 describes that "*Working with batteries on an individual level is complex and will require updates and development of current systems.*". The interviewee continues and explains that the case company's aftermarket systems and processes are designed for mechanical spare parts rather than electrical components such as EV batteries. Further, Interviewee 6 and Interviewee 7 mean that existing systems and processes are not designed to meet the new requirements on traceability. The interviewees continue and explain that this will create future problems with increasing battery volumes. Also, Interviewee 9 means that "*Putting a tracker on each battery will not solve the problem, but rather a complete IT infrastructure and process setup is needed to achieve full traceability on an individual level.*". Similarly, Interviewee 13 explains that "*Likely, we will have to change our core systems which make it more complicated.*".

However, while the majority of interviewees point out that systems and processes must be adapted due to the new EU regulation, several interviewees are optimistic regarding the case company's technological capability to do so. For example, Interviewee 10 shares that *"Technology is usually not the limiting factor."*. Further, Interviewee 13 stresses the importance of initiating the update of systems and processes urgently due to long lead times when implementing IT-systems changes. Similarly, Interviewee 1 says that "*Adjusting* *operations to fit the requirements in the new EU regulation takes time.*". This is supported by Interviewee 8, stating that "*The time aspect in itself is challenging.*".

Connected data sources

When discussing how the case company should be able to meet the requirements connected to the ESS in the new EU regulation, the majority of the interviewees stress the need for a central database used to feed data to the EES. For example, Interviewee 14 describes that "*We must have a central database which can feed the EES with requested data.*". Similarly, Interviewee 18 says that "*It is important to ensure all required data can be collected from one place.*". The interviewee continues and explains that "*We are developing our own IT solution which will be connected to the EES.*". Also, Interviewee 9 shares that "*To successfully feed ESS with the right information, we must connect all actors and data sources within our organization.*". In addition, Interviewee 7 explains that "*We will have to connect different data sources since today they are isolated per function.".* Likewise, Interviewee 18 says that "*We need one data lake where data is gathered from different functions' systems and IT solutions.*". This is confirmed by Interviewee 10 pointing out that "*We have good systems per se but we are missing the big picture due to lack of connection between the different systems.*". Furthermore, when discussing how the case company can successfully meet the requirements related to the battery passport located in the EES, several interviewees refer to the concept of a digital twin. For example, Interviewee 8 states that "*The digital twin is the internal solution which will feed the battery passport with requested information for each unique battery.*".

Another central topic is the QR code which the new EU regulation demands to be printed on each unique battery. For example, Interviewee 7 says that "*Relevant information will be accessed through the QR code.*". Further, Interviewee 17 means that "*The QR code will make future work easier and allows us to keep track of information related to each battery.*". Likewise, Interviewee 9 states that "*The QR code is the simple answer to the question of how to keep track of battery information.*". Furthermore, several interviewees elaborate on the link between the QR code and different data sources. For example, Interviewee 7, Interviewee 8 and Interviewee 16 describe that the QR code will be connected to the case company's internal database and the digital twin for each unique battery. However, according to several interviewees it is not clear if the new EU regulation requires the QR code to be linked to any specific system or database. For example, Interviewee 16 means that "*It is not clear if the new EU regulation requires the QR code to be directly linked to the EES or if it can be an indirect connection through our internal database.*". Related to this, Interviewee 8 believes that "*The EES will not directly be connected to the QR code, but rather to our internal database.*". Also, Interviewee 6 says that *"Discussions are going on whether the battery passport should be linked directly to the QR code or not.*".

Several employees describe that the case company has previous experience from reporting data to different authorities which will be helpful in the work of complying with the new EU regulation. For example, Interviewee 7 says that "*We see the EES as yet another reporting point among others we already have.*". The interviewee continues and exemplifies that they already report certain information to authorities in Asia. Similarly, Interviewee 8 means that

"*Uploading information to authorities is nothing new to us.*". Further, Interviewee 15 states that "*Currently we have another ongoing project where we report data to a specific agency.*". However, even though reporting information to authorities in general is not seen as challenging, Interviewee 9 notes that "*We need to develop solutions suitable for various authorities and adapt these to regional differences, not only the EU.*".

Connected batteries and utilization of BMS data

According to the interviews, several data parameters are referred to when discussing the BMS. While the main parameters are SOH and expected lifetime, others are also mentioned. This is described by Interviewee 3, meaning that *"It is more accurate to talk about SOX instead of SOH, since the BMS can provide information about various parameters.*". The interviewee continues and provides several examples of additional data parameters such as temperature, voltage, level of leakage and cells degrading. Also, the interviewee describes that what parameters a certain BMS can provide information about depends on BMS type and supplier. Another data parameter is mentioned by Interviewee 5, saying that "*We are currently discussing that we would like to have information related to batteries' state of charge.*".

When discussing EU requirements related to the BMS, a central theme mentioned in the interviews concerns how to access BMS data. When a battery is attached to a vehicle, Interviewee 15 describes that "*BMS data is accessed using telematics technology through the connected vehicle.*". When a battery is detached from a vehicle, Interviewee 7 and Interviewee 14 explain that the battery has to be manually connected, often at dealer centers, to access BMS data. Interviewee 7 continues and explains that "*No data is accessible when the battery is detached from the vehicle*.". Furthermore, Interviewee 1 says that "*The challenge is how to access BMS information remotely.*". Likewise, Interviewee 15 states that "*The main question is how to access data when the battery is detached from the vehicle.*". Therefore, the interviewees mean that ideally, batteries should be remotely connected so that real time BMS data can be accessed also when batteries are not attached to a vehicle. For example, Interviewee 16 states that "*To achieve full traceability and ensure real time accessibility, batteries must be connected.*". Similarly, Interviewee 3 says that "*In the future, we must be able to access real time BMS data also when the battery is not in a vehicle.*". In addition, Interviewee 13 describes that "*It would be beneficial if BMS data could be accessed outside of the vehicle, and this is likely to be the case in the future.*". The interviewee continues and explains that "*Today, we do not utilize all information in the BMS since it is not connected and easily accessible.*". Also, Interviewee 18 means that "*Even though some data is available today, for example through telematics technology, we do not utilize it enough.*".

The majority of the interviewees are clear on why they would like to access BMS remotely, where the main reason being the great potential in utilizing such data. For example, Interviewee 15 describes that the case company "*...has realized the potential of using data.*". In addition, Interviewee 16 means that "*We can utilize data to predict service and optimize usage.*". This is exemplified by Interviewee 18, stating that "*When batteries are not in use, time and temperature will impact SOH and expected life time, and by monitoring such variables, we can optimize our battery management.*". Similarly, Interviewee 8 says that "*There is much* *improvement potential within our organization where monitoring of data could help us work more proactively rather than reactively.*". The interviewee continues and explains that "*If traceability is improved and more information is utilized, data can be sold as a service.*". Likewise, Interviewee 1 shares that "*By utilizing data, we can offer monitoring services to prevent and predict and thereby improve uptime for our customers.*". Also, Interviewee 13 means that "*By monitoring data remotely, we can predict service and manage batteries more effectively.*".

Another issue pointed out by several interviewees when discussing the BMS is concerns related to privacy and data sharing. For example, Interviewee 15 says that *"We may not want to share BMS data in order to protect our business."*. Similarly, Interviewee 11 describes that *"Sharing BMS data may be problematic since we do not want to disclose sensitive information."*. In addition, Interviewee 6 states that "*It is challenging to ensure that only concerned parties can access relevant information in the BMS.*". Further, Interviewee 8 describes challenges related to defining what data should be available for different actors. The interviewee continues and means that protecting BMS data is important from a competitive advantage perspective.

5 Discussion

This chapter discusses each of the study's three research questions. The first subsection discusses the three categories of requirements identified in RQ1, together with a discussion about legal uncertainties related to the new EU regulation requirements. Then, RQ2 findings are discussed from the perspective of the organizational capability dimension, the human capability dimension, and the technological capability dimension. Lastly, the gaps identified in RQ2 are prioritized, and discussed, by categorizing each gap based on three different priority levels.

5.1 Categories of requirements

To verify the study's filtering of articles and annexes together with the categorization of requirements related to the new EU regulation, a comparison with two of the few other sources available performing similar analysis has been done. The first source is Melin, et al. (2021), investigating global implications of the new EU regulation and mapping out the relevance of different articles to the EV battery's different life cycle phases. The second source is Chanson (2021), on behalf of the industry association for advanced rechargeable and lithium batteries, RECHARGE, addressing the new EU regulation's impact on Battery's circular economy and presenting a classification of articles per each of the EV battery's life cycle phases. To determine the significance of this study's filtering of relevant articles and annexes, the selection was compared to what articles and annexes were addressed in the work of Chanson and Melin et al. (2021). A compilation of this comparison analysis is presented in Table 4, per the identified categories of requirements related to the new EU regulation. Furthermore, in what life cycle phase each article is addressed by Chanson (2021) and Melin et al. (2021) is also taken into consideration and is discussed per category of requirements in the subsections below.

Notably, no annexes are included in Table 3 for the following reasons. First, both Chanson (2021) and Melin et al. (2021) mainly focus on annexes rather than articles. Second, the amount of articles is significantly higher than the number of annexes, suggesting the content in the articles to have a greater impact on the legal requirements on an aggregated level, compared to annexes. Third, each annex is linked to a specific article, and therefore, that the content in the excluded annexes still is indirectly addressed in the performed comparison. In other words, even though annexes are excluded in this analysis, the overall content they address is still covered.

Table 4

Compilation of addressed articles per source

Category of requirements	Articles	Chanson (2021)	Melin et al. (2021)
Extended producer responsibility	47	X	X
	49	X	-
	50	-	-
Required information	7	X	X
	8	X	X
	10	X	X
Systems	13	X	X
	14	X	-
	59	X	X
	64	X	X
	65	X	X

Note: Articles addressed by Melin et al. and Chanson are represented with "X" and articles not addressed by the authors are represented by "-".

5.1.1 Extended producer responsibility

Based on the result, *Extended producer responsibility* refers to automotive OEMs' EOL management of batteries and their increased responsibility in the aftermarket services where traceability plays an important role. Similarly, both Melin et al. (2021) and Chanson (2021) associate the content of Article 47 with POU and EOL. Further, while Melin et al. (2021) do not include Article 49 in their analysis, the categorization from Chanson (2021) highlights Article 49 as being relevant for POU and EOL, which is aligned with this study's empirical analysis. Finally, neither of the two sources include article 50 in their analysis even though this study's result suggests this article to include requirements that will impact automotive OEMs' aftermarket services. Although the reason for excluding this article is unknown, it may be due to the fact that Article 50 concerns obligations of distributors and the two sources seem to mainly focus on obligations of manufacturers. However, the study's empirical analysis suggests there is a thin line between the definitions of manufacturers and distributors. For example, whether an automotive OEM is defined as a manufacturer or distributor when using external sourcing of batteries, can depend on if they put their own branding on the purchased batteries or not.

5.1.2 Required information

According to the result, *Required information* concerns static information that has to follow the battery throughout the battery's life cycle and dynamic information that has to be updated along the battery's different life cycle phases. Since this study is focusing on the aftermarket, it may raise questions as to why both Melin et al. (2021) and Chanson (2021) group Article 7 and Article 8 into the manufacturing phase of the EV battery life cycle. To explain this, the concept of static information may be helpful. For example, even though most data parameters referred to in Article 7 and Article 8 are gendered in earlier life cycle phases, the information will follow the battery also onto the aftermarket. Thus, the automotive OEMs' aftermarket functions must be able to manage this information. Regarding Article 10, both sources conclude the content to be of relevance for the POU, aligned with the result.

5.1.3 Systems

The result shows that *Systems* consists of requirements related to two main systems, the EES, related to the battery passport and QR code, and the BMS, from which automotive OEMs are obligated to provide and manage information. Aligned with the result, for Article 64 and Article 65, related to the EES and battery passport, both Melin et al. (2021) and Chanson (2021) refer to the life cycle phases associated with POU and EOL. Further, while Chanson groups Article 13 into POU and EOL aligned with this study's result, Melin et al. (2021) categorize this article into the manufacturing phase. To explain this difference, the concept of static information can once again be applied since Article 13 concerns the QR code which is likely to be applied onto the battery in earlier life cycle phases. However, the QR code will follow the battery into later life cycle phases, including POU and EOL, and therefore the requirements in Article 13 will also be of relevance for the aftermarket. Finally, Chanson (2021) relates the content in Article 14 and Article 59, related to the BMS, to second life application as a part of EOL. Further, while Melin et al. (2021) point out Article 59 as related to EOL, aligned with Chanson (2021), they do not mention Article 14. The reason why Melin et al. (2021) exclude this article is unknown, but according to the result, supported by Chanson (2021), it is likely to be of relevance due to the importance of the BMS.

5.1.4 Legal uncertainties related to EU regulation requirements

Based on the comparison between the study's result and external sources performing similar grouping of articles, a high degree of conformity can be noted. In turn, this supports the significance of the study's result related to RQ1. Further, a factor complicating the interpretation of the new EU regulation is the uncertainties related to several requirements and the fact that the regulation is not yet approved but is under development. Going forward, it will be important for the EU Commission to clarify the requirements to ensure OEMs are able to comply with the regulation and its requirements. This is supported by Olsson et al. (2018) meaning that uncertainty related to interpretation of legislations hinder organizations' transition towards circularity. Similarly, Govindan and Hasanagic (2017) argue that governmental incentives support organizations' adaptations of circular operations. Thus, it is reasonable to assume that if the requirements in the new EU regulation becomes more clear, it will be easier for automotive OEMs to start working on details needed to transform their operations accordingly.

5.2 Capability gaps

Table 5 presents capability gaps, per capability dimension, identified in the case company's aftermarket services related to traceability. In literature, three capability dimensions were identified; the *organizational* dimension, the *human* dimension and the *technological* dimension. However, the capability gaps identified in the study only relate to the dimensions of organizational and technological capabilities, which is why the table's middle column is left blank.

Table 5

Identified capability caps per capability dimension

Organizational	Human	Technological
- Lacking responsibility clarification - Insufficient cross-functional collaboration and data sharing - Insufficient external collaboration and data accessing		- Lacking systems able to trace on a unique level - Lacking connected internal data sources - Lacking ability to access remote BMS data from detached batteries

5.2.1 Organizational capabilities

In this subsection, capability gaps related to the organizational capability dimension are presented and discussed, namely *lacking responsibility clarification, insufficient cross-functional collaboration and data sharing,* and *insufficient external collaboration and data accessing.*

Lacking responsibility clarification

Based on the result, it is clear that the overall project of complying with the new EU regulation will affect all parts of the case company. Also, it is evident that the organization's different functions, including the aftermarket function, will have to adapt to the new legal requirements. Further, this implies changes within the organization and in turn creates new organizational challenges. There are several articles published addressing organizational challenges related to integrating circularity in organizations and the fundamental shift it implies to core business processes (Eikelenboom & de Jong, 2021; Kirchherr et al., 2017; Ritzén & Sandström, 2017). Thus, the challenges observed at the case company are not unique but, based on literature, but a general problem in organizations' transitioning towards circularity. In an aftermarket context, it can be assumed that ways of working will be highly affected by the introduction of circularity. For example, collection, repurposing and remanufacturing are processes fundamental to circularity and are highly connected to processes on the aftermarket. Thus, previously, the aftermarket has been the last stop for products but with circularity a lot of responsibility is put on organizations' aftermarket business to give batteries multiple lives. In other words, the case company's aftermarket function will most likely have to be redesigned to meet the requirements in the new EU regulation and need for circularity, which will imply significant changes within the organization.

The empirical data clearly shows that one of the main organizational challenges at the case company, related to the transition towards circular operations, is the lack of responsibility clarification. In academia, several articles discuss the assignment of responsibility as challenging when organizations transform their operations into more circular processes (Eikelenboom & de Jong, 2021; Ritzén & Sandström, 2017) since, as argued above, the transition towards circularity will require organizations to make significant changes to their operations. Consequently, it is reasonable to argue that this will create a need to clarify responsibility. However, the result clearly indicates lacking responsibility clarification at the case company which may be explained by the fact that the EU regulation project is only in its initial phase. Thus, there is a clear gap between where the case company needs to be and where they currently are when it comes to responsibility clarification. Since a lack of responsibility clarification hinders the case company from performing their organizational activities, it can be seen as a gap related to organizational capabilities (Grant, 1991). Going forward, it will be important for the case company to close this gap since responsibility clarification must be established to be able to address necessary tasks in the implementation project related to requirements in the new EU regulation. Thus, there is an organizational capability gap related to responsibility clarification and the case company must close this gap urgently.

Insufficient cross-functional collaboration and data sharing

According to the result, it is evident that currently, different functions in the organization are insufficient in sharing information between each other. Also, it is clear that the case company's different functions are poorly connected making data sharing difficult. Further, the empirical data shows that going forward, the case company must be better at collaborating internally between functions to meet the new EU requirements. Similarly, Ritzén and Sandström (2017) describe the importance of internal collaboration and the integration between functions when transitioning towards circular operations. Further, the transition towards circularity creates a need for an end-to-end perspective within organizations. In turn, this leads to a need for integrated supply chains and stresses the importance of cross-functional collaboration. For example, for the case company to be able to run their remanufacturing process efficiently, the remanufacturing organization will depend on the aftermarket function to support with necessary data. Furthermore, since the empirical data indicates a lacking ability to collaborate between functions and share data internally, it is likely to complicate the case company's strive towards increased traceability and make it difficult to comply with the new EU regulation. In other words, when it comes to cross-functional collaboration and data sharing internally, there is a clear gap between where the case company needs to be and where they currently are. In turn, this gap hinders the case company from performing their organizational activities and therefore it can be seen as a gap related to organizational capabilities (Grant, 1991). Thus, there is an organizational capability gap related to cross functional collaboration and data sharing internally which must be closed.

Insufficient external collaboration and data accessing

Based on the result, it is evident that there is improvement potential not only when it comes to internal collaboration between functions, but also for external collaboration with various stakeholders. Specifically, the empirical data suggests that there are difficulties related to accessing external stakeholders' data. Further, the result shows that going forward, the case company must improve within this area in order to comply with the new EU regulation. Similarly, several researchers highlight collaboration with external stakeholders as important to successfully make the transition towards circularity (Antikainen et al., 2018; Angelis et al., (2018); Eikelenboom & de Jong, 2021). With similar arguments as for internal collaboration, the transition towards circular operations imply an end-to-end perspective that includes stakeholders outside the own organization. For example, the case company must collaborate with suppliers to access data and report it to authorities. Further, since the result suggests a lacking ability to collaborate with external stakeholders and accessing data, it is likely to create a barrier for improved traceability and in turn make it difficult to comply with the new EU regulation. Therefore, it can be argued that there exists a gap between the case company's current ability to collaborate with external stakeholders and data accessing compared to the ability that will be needed to comply with the new EU regulation. In turn, this gap, similarly to the internal collaboration gap, hinders the case company to perform their organizational activities and therefore, it can be seen as a gap related to organizational capabilities (Grant, 1991). In other words, there is an organizational capability gap related to external collaboration and data accessing which the case company must close.

5.2.2 Human capabilities

Connected to the human dimension, the amount of empirical data is low and the data collected is on a fairly general level mainly related to training and competence development. Similarly, academia identifies lacking knowledge as a barrier for organizations' transition towards circularity (Rizos et al., 2016; Ritzén and Sandström, 2017). Due to the lack of rich data, no clear capability gap could be identified within this dimension. Moreover, this may raise questions as to why the human dimension is included in this report when it does not contribute to answering RQ2. The simple answer to the question is that the human dimension is central in capability literature and the RBV theory. Therefore, it is reasonable to assume that it should impact the case company's ability to comply with the new EU regulation. Thus, it is interesting to note the lack of rich data in this dimension. One reason for this may be that the interviewees tended to focus on capability gaps that they perceived as challenging. While the empirical data indicate that some training and competence development are needed, the interviewees did not express this to be very challenging and it could therefore be the reason why they did not focus more on the human dimension. Another reason for the absence of human capability gaps may be that case company is in the interpretation phase of the new legal requirements rather than in the implementation phase. Once the organization proceeds into the implementation phase, it is reasonable to assume that new capability gaps could be identified once the need for training and new competences become more apparent. Moreover, it should be stated that while no capability gaps were identified in the human dimension, human elements are indirectly included in the organizational dimension. For example, the organizational capability gaps referring to internal and external collaboration relates to the interaction between people, despite not focusing on the individual human per se. In other words, it could not be determined if any human capability gaps related to traceability exist within the case company's aftermarket services, but this does not mean that this dimension is not important or that it will not have an impact in the future.

5.2.3 Technological capabilities

In this subsection, technological related capability gaps are presented and discussed. The three identified capability gaps in this dimension are *lacking systems able to trace on a unique level, lacking connected internal data sources,* and *lacking ability to access remote BMS data from detached batteries.*

Lacking systems able to trace on a unique level

According to the empirical data, the case company does not have systems in place to trace batteries on a unique level in their aftermarket services. Also, the result shows that going forward, this must be established to be able to manage the logistics of batteries and in turn comply with the new EU regulation. Similarly, several academics point out that in order to have successful traceability, organizations must be able to trace products on a unique level (Franquesa et al., 2016; Kim et al., 1995; Moe, 1998; Olsen & Borit, 2013). Further, Agrawal et al. (2021) identifies uniqueness as a key traceability characteristic when implementing circularity for batteries. Furthermore, according to the findings related to RQ1, automotive OEMs must be able to trace batteries on a unique level, and thus have successful traceability, to comply with the new EU regulation. For example, a battery passport has to be registered for each individual battery containing unique information as described in Article 64 in the new EU regulation. Also, to be able to successfully perform some of the services related to the aftermarket that are pointed out in the new EU regulation, for example collection of used batteries, unique traceability will be a prerequisite. Compared to previously when the case company was not required to trace on an unique level, the requirements in the new EU regulation will therefore impact how they design and deliver their aftermarket services. For example, the case company's systems have to be redesigned to be able to manage batteries on an individual level rather than on part number level. In other words, related to the case company's systems, there is a clear gap between the current ability to trace batteries on a unique level and the ability that will be needed to comply with the new EU regulation. In turn, the case company's lack of systems able to manage batteries on a unique level hinders the case company's ability to successfully trace, and therefore this can be seen as a gap related to technological capabilities (Grant, 1991). Thus, there exists a technological capability gap related to the case company's lacking ability to trace batteries on a unique level in their aftermarket services which must be closed urgently.

Lacking connected internal data sources

The results suggest that the case company lacks connected data sources and a central internal database. Going forward, the empirical data shows that connected data sources and a central internal database would significantly facilitate the reporting of data to the EES since all the required data would be collected from one location. In academia, the relationship between connected data sources and the transition towards circularity is not distinct. However, Robson et al. (2007) and Wessel et al. (2021) report that efficient traceability systems require different data sources and databases to be fully integrated. Also, Moe (1998) and Olsen and Borit (2013) stress the importance of sharing information across the whole supply chain to enable central data access. Moreover, the case company would probably be able to report necessary data to the EES system without having fully connected data sources and an internal central database. However, there are several benefits of having this in place. First, it is reasonable to assume that it will increase the efficiency of reporting data by saving time and costs. Second, it can be seen as a long term investment since the internal database also can be utilized when reporting to other authorities than the EU. Third, the result indicates general difficulties at the case company connected to accessing data and an internal central database could therefore facilitate data accessing also in other non EU related projects. In other words, there is a gap between how data sources are connected today and how they would need to be integrated in the future in order to facilitate the reporting of data to the EES. In turn, this gap hinders the company from efficiently managing and reporting data and therefore it can be seen as a gap in their technological capabilities (Grant 1991). Thus, related to the lack of connected data sources and a central database needed to efficiently report data to the EES there is a technological capability gap that would be beneficial for the case company to close.

Lacking ability to access remote BMS data from detached batteries

According to the result, the case company has a lacking ability to access BMS data remotely when the battery is detached from the vehicle. In parallel, the empirical data shows several benefits connected to the use of BMS data, such as battery monitoring, service prediction and usage optimization, suggesting several business opportunities in terms of new service offerings. Similarly, Yang et al. (2021) support that the BMS should be fully monitored even when the battery is not attached to the vehicle. Further, several papers present various benefits related to the use of real-time connected BMSs, such as the potential for improved service prediction, optimization and monitoring of batteries (Yang et al., 2021; Li et al., 2020; Sivaraman & Sharmeela, 2020). However, it is not clear if connected BMSs are required or not in the new EU regulation. For instance, this would probably depend on whether or not the new EU regulation requires OEMs to provide relevant actors on the aftermarket with real time BMS data. If this would be the case, it would require BMSs to be connected in order for OEMs to ensure constant access to relevant data regardless of the circumstances. Thus, there is a gap between the case company's current ability to remotely access real time BMS data and the ability that the case company will need in the future to take advantage of presented benefits related to connected batteries. In turn, this gap hinders the case company from tracing and utilizing real-time BMS data and therefore it can be seen as a gap in their technological capabilities. In other words, there exists a technological capability gap related to a lacking ability to access remote BMS data from detached batteries and closing this gap would imply several business opportunities for the case company.

5.3 Prioritization of capability gaps

Based on the capability gaps identified in RQ2, hindering the case company to comply with the new EU regulations requirements identified in RQ1, it is interesting to understand how the closing of these capability gaps should be prioritized. Therefore, a prioritization of the different capability gaps have been performed which will help the case company in the allocation of limited resources. Moreover, the prioritization is of a speculative nature and based on the authors' interpretation of gathered data rather than derived from literature.

Table 6

Identified capability gaps categorized per priority level

High priority	Medium priority	Low priority
- Lacking responsibility clarification - Lacking systems able to trace on a unique level	- Lacking connected internal data sources - Lacking ability to access remote BMS data from detached batteries	- Insufficient cross-functional collaboration and data sharing - Insufficient external collaboration and data accessing

The prioritization of capability gaps is shown in Table 6 and is categorized into three different priority levels; high, medium and low. First off, the high priority level refers to the closing of capability gaps seen as prerequisites to meet the requirements in the new EU regulation and as having a high sense of urgency. Next, the low priority level relates to capability gaps that do not necessarily have to be closed in order to comply with new EU regulation, but it will facilitate this work. Finally, the medium priority level refers to the capability gaps located in between the high priority level and the low priority level.

5.3.1 High priority level

The high priority level includes the organizational capability gap *lacking responsibility clarification* and the technological capability gap *lacking systems able to trace on a unique level*. Lacking responsibility clarification is judged to be of high priority since the case company will not be able to fully perform necessary tasks in the implementation project related to the new EU regulations requirements until responsibility has been allocated. In other words, closing this gap can be seen as a first step which must be completed before other tasks and steps can be initiated. This is particularly important due to the time aspect of the project, where the new EU regulation is expected to enter into force in the near future. Also, lacking systems able to trace on a unique level is categorized as high priority since the new EU regulation clearly requires organizations to report battery information on an individual level which the case company's systems today do not allow. Thus, to be able to comply with the new EU regulation and make progress in the internal project related to it, it is recommended for the case company to prioritize urgently closing these two gaps.

5.3.2 Medium priority level

The medium priority level refers to the two technological capability gaps *lacking connected internal data sources* and *lacking ability to access remote BMS data from detached batteries*. While connected internal data sources is not a prerequisite per se, it is determined to be of medium priority since closing this gap significantly will facilitate the case company's reporting of data required in the new EU regulation. In addition, lacking ability to access remote BMS data from detached batteries is judged to be of medium priority since it is not yet clear whether or not the new EU regulation requires real-time BMS data to be reported or not. However, whether a prerequisite or not, accessing BMS data remotely implies several benefits and business opportunities for the case company. Therefore, it is recommended for the case company to close both these gaps, after closing the two capability gaps referred to in the high priority category.

5.3.3 Low priority level

The low priority level includes the two organizational capability gaps *insufficient cross-functional collaboration and data sharing* and *insufficient external collaboration and data accessing*. Both these organizational capability gaps are categorized as low priority since, while the closing of them is not necessarily required to meet the new regulation, it will facilitate the accessing, sharing, and reporting of required data and increase the efficiency of these processes. Therefore, after the closing of capability gaps categorized in the high and medium priority levels, it is recommended for the case company to close these gaps.

6 Conclusion

RQ1 aims at answering what requirements related to traceability that will be put on automotive OEMs' aftermarket services as a consequence of the new EU regulation. Findings show that such EU regulation requirements can be categorized into three categories of requirements; *extended producer responsibility*, *required information* and *systems.* First, the category of extended producer responsibility includes requirements related to EOL management of batteries and automotive OEMs' increased responsibility on the aftermarket, where traceability will be important. Second, required information refers to static information that must follow the battery throughout its life cycle and dynamic information that will have to be updated along the battery's different life cycle phases. Third, the category of systems includes requirements concerning the two main systems identified in the new EU regulation, namely the EES, related to the battery passport and QR code, and the BMS, from which automotive OEMs are obligated to provide and manage information.

RQ2 aims at answering what capability gaps that exist in a global automotive OEM's aftermarket services, hindering the organization to comply with previously identified requirements. Based on literature, the *organizational*, *human* and *technological* capability dimensions were determined as important, but capability gaps were only identified in two of them. First, the organizational capability gaps identified are *lacking responsibility clarification*, *insufficient cross-functional collaboration and data sharing* and *insufficient external collaboration and data accessing*. Second, no distinct human capability gaps are identified despite RBV theory highlighting the importance of human capabilities. Third, the technological capability gaps identified are *lacking systems able to trace on a unique level*, *lacking connected internal data sources* and *lacking ability to access remote BMS data from detached batteries*. In other words, six capability gaps were identified where three of them are categorized as organizational while the other three capability gaps are categorized as technological.

RQ3 aims at answering how the closure of the six identified capability gaps should be prioritized. To answer the question, the six capability gaps were categorized into three different priority levels, namely *high*, *medium* and *low*. The high priority level includes the organizational capability gap *lacking responsibility clarification* and the technological capability gap *lacking systems able to trace on a unique level*. The medium priority level refers to the two technological capability gaps *lacking connected internal data sources* and *lacking ability to access remote BMS data from detached batteries*. The low priority level concerns the two organizational capability gaps *insufficient cross-functional collaboration and data sharing* and *insufficient external collaboration and data accessing*. Thus, the case company should begin by closing the gaps in the high priority level, followed by the medium priority level and lastly they can focus on closing the capability gaps categorized in the low priority level.

This study contributes to the understanding of what traceability related requirements are being put on automotive OEMs' aftermarket services as a consequence of the new EU regulation. Also, on the basis of the studied case company, the study contributes to the understanding of what capability gaps that exist in a specific global automotive OEM being subject to the new requirements and how the closure of such gaps should be prioritized. RQ1, related to the relevant requirements in the new EU regulation, is of interest to practitioners within all organizations being affected by such requirements. While the findings in RQ2 and RQ3, related to capability gaps, can be of interest to the same practitioners looking for input by benchmarking themselves towards the case company, the transferability is limited due to the results' connection to a specific organizational context. Regarding the interest of findings for academia, similar arguments can be made as for practitioners. Moreover, from an academic perspective, the study contributes to a more general understanding of the interaction between the relatively new research areas CE and EV batteries, in a context of the more established research areas RBV, traceability and aftermarket services.

Furthermore, in future research it would be interesting to examine what capability gaps that exist in other automotive OEMs being affected by the same legal requirements as the case company. By comparing different automotive OEMs, the establishment of a more industry wide understanding could be created. Also, it would be interesting for future research to explore *how* identified capability gaps should be closed, focusing more on the implementation rather than on *what* capability gaps that exist, which is what this study has studied. Consequently, the recommended next step for the case company would be to initiate a project where how each gap can be closed is addressed. Specifically, the case company should focus on the two capability gaps *lacking responsibility clarification* and *lacking systems able to trace on a unique level,* which are perceived to be of high priority to close. Moreover, the study's findings suggest that data privacy is a central issue when accessing and sharing of information, working as a barrier for increased transparency and traceability. In turn, this not only hinders automotive OEMs to comply with the new EU regulation, but also jeopardizes their chances to take part of the benefits a high degree of traceability implies, as addressed in this study. Therefore, it would be interesting for future research to explore this phenomena even further to increase the understanding of how data privacy issues can be balanced with a high degree of traceability in the context of the study's research areas.

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Appendix

Appendix I - Interview guide

Role and responsibility areas

1. Could you describe your role and responsibility areas at the company?

Introductory questions

2. Could you describe how you work with traceability today?

3. Could you describe what the company is good at today related to traceability?

4. Could you describe the challenges you see with traceability today?

5. Could you describe how the company can improve its traceability?

6. Could you describe what the ideal traceability state would look like in the future?

Specific question

Required information:

7. How will you ensure that the right information follows the battery onto the aftermarket from its previous life cycle phases?

8. How will you ensure that relevant information, related to the battery, is updated on the aftermarket?

Systems:

9. How will you ensure that you are able to provide and access necessary information related to the EES?

10. How will you ensure that you have access to requested information and that it is correctly uploaded to the battery passport?

11. How will you ensure that you are able to manage the QR code?

12. How will you ensure that you have access to and can utilize data in each battery's BMS?

Concluding questions

13. Is there anything you want to add that we have not yet discussed?

14. Do you have any suggestions on people, with good insights in the areas discussed today, that you recommend we should talk to?

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