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How to increase the awareness of the logistics perspective in the product development process

A study executed at a Swedish Manufacturing Company with regards to behavioural and organisational factors

Master's thesis in Supply Chain Management

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How to increase the awareness of the logistics perspective in the product development process:
A case study at executed at a Swedish Manufacturing Company with regards to behavioural and organisational factors

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Master's Thesis 2021: E2021:075

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Abstract

The globalisation has created an increasing need for companies to consider logistics due to the significant impact it has on total costs. Additionally, the market is continuously developing with new technologies and customer demands with e.g. shorter product life cycles, which creates the need to have a well-developed product development process. More functions, including logistics, have to be involved in order to satisfy all stakeholder demands concerning the product. Hence, cross-collaboration is important in order to understand other company functions' needs as well as to reach the best result.

This master thesis focusses on how to increase the awareness of the logistics perspective in the product development process at a Swedish Manufacturing Company. The thesis begins with a literature study in order to gain knowledge about the subject to be investigated. This is followed by a case study presenting the company, how the work is executed today, and opportunities for development. Thereafter a benchmark of IKEA of Sweden is presented. The benchmark was done in order to analyse a product development process on a company that has a strong position from a logistics perspective. Lastly, the thesis ends with conclusions and recommendations for the Swedish Manufacturing Company.

Findings regarding how to increase the logistics awareness in the product development process are divided into organisational and behavioural factors. This division is due to that there are many factors affecting the willingness to integrate the logistics awareness in the product development process. The main findings are that collaboration needs to be increased across the boundaries within the company, especially in the early part of the product development process. This will increase the interaction and accordingly increase the knowledge about other functions within the company and their perspectives.

Keywords: Product development process, Design for Logistics, Cross-collaboration, Logistics Awareness

Acknowledgement

This thesis was conducted during the spring of 2021 on the master programme Supply Chain Management at Chalmers University of Technology. The research was executed on one of the world's leading manufacturers, which is referred to in this report as Manufacturing Sweden.

The study concerned a very interesting topic which provided a lot of interesting findings as well as knowledge. The topic of the study was found to be aligned with our education at Chalmers University of Technology, hence knowledge acquired during our studies could be applied. We would like to express our gratitude to this Swedish Manufacturing Company for the opportunity to write this master thesis. In addition, we want to thank the interviewees for their cooperation and participation. A special thanks to the department of Logistics and foremostly our supervisor Victoria for all support during this spring.

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Lundmark, Emilia

Söderberg, Anne

Vocabulary

BASS	Business Area Sourcing Specialist
CAD	Computer Aided Design
CG	Concept Gate
CSG	Concept Study Gate
CPM	Chief Project Manager
DE	Design Engineer
DFL	Design for Logistics
DFLe	Design for Logistics engineer
DFX	Design for X
DG	Development Gate
DVP PH	DVP Project Handbook
ETL	Engineering Task Leader
FDG	Final Development Gate
FeG	Feasibility Gate
GA	Geometrical Architect
GAM	Geometrical Architect Meeting
LE	Logistics Engineer
LOG	Logistics
Log PM	Logistics Project Manager
LRM	Logistics Range Manager
MSM	Manufacturing Strategy Manager
NPD	New Product Development
OP	Operations
OP PM	Operations Project Manager
PAM	Project Assurance Manager
PC	Project Controller
PCI	Product Change Initiation
PD	Packaging Development
PDD	Product Design Developer
PDe	Product Design
PDE	Product Design Engineer
PDT	Project Development Team
PE	Packaging Engineers
PLS	Project Leaders
PM	Project Manager
PMT	Project Management Team
PPL	Product Planning
PUR	Purchasing
RFID	Radio Frequency Identification
RG	Release Gate
RPT	Range Planning Team
TECH	Technology
TLM	Total Logistics Management
TPE	Technical Preparation Engineer

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1. Introduction

This chapter gives a background to the subject of the master thesis as well as why it is conducted. Thereafter, the aim of the study is defined.

1.1 Background

The market is today defined by high competitiveness, which forces companies to constantly seek for improvements (Takita & Leite, 2018). In addition, the product's life cycles gradually become shorter, and competitor's product becomes more similar regarding both technology and price (ibid). Hence, other aspects become more important to differentiate against competitors such as storage, distribution and transport, in other words logistics. Logistics is a process that takes place from the transport of goods from their origin, through the company functions, until the delivery to the end-customer. The purpose is to plan, coordinate, organise and implement the bridging between the company functions, and at the same time, satisfy the customer demands (Femerling & Gleissner, 2013). The logistics process has become more complex due to globalisation, as well as the increasing demand of the customer regarding sustainability, quality, price, cost-efficiency, flexibility and speed in delivery (Heragu, et. al., 2019). Accordingly, logistics has become one of the most important functions of firms and has a significant impact on total costs (Chiu & Kremer, 2011). Globalisation has become especially important from the perspective of inbound logistics, which is explained as the transportation, storage and receiving of goods to a business (Enarsson, 2013).

Several aspects affect the inbound logistics, and one important factor is the design of the product (Cagliyan, 2018). This is because of the strong connection the design of the product has with e.g. assembly, packaging, transportation, product quality and sustainability (Klevås, 2006; Christopher, 2011). The design of the product is settled during the product development process, and due to the fast development of technologies it has become important to have a well-developed process (Hsu & Yang, 2019). In addition, 70-80% of the total product cost is set in the design phase, and the rest, 20-30%, is set in the operational system (Klevås, 2006; Chiu & Kremer, 2011). Therefore, the earlier the logistics perspective is integrated in the product development process, the larger impact it has on total product costs. Bielecki and Galínska (2017) argue that in order to achieve a logistically efficient product, the properties of the product need to be considered early in the product development process. A logistically efficient product is defined as *"a product that is characterised by a set of properties that enable an effective and efficient internal and external flow of the product, and the related information to it*" (Bielecki & Galínska, 2017:102). However, the product development process is complex due to the fact that it involves several stakeholders that also want to influence the design of the product. Hence, the flow would be simplified with investments in cross-collaboration, inter-firm relationship management, joint decision making and inter-organisational process development (Mellat-Parast & Spillan, 2013). It means to join forces and work towards a common goal, which is considered necessary due to the many functions that exist within organisations (Bryson, Crosby & Stone, 2006).

Consequently, the product development is a complex process. However, if logistics is considered in the product development process it can be beneficial and accordingly contribute to a logistically efficient product. The Swedish Manufacturing Company (henceforth referred to as Manufacturing Sweden) wanted to explore this subject further. Therefore, this master thesis will investigate how to increase the awareness of the logistics perspective in the product development process. The awareness of the logistics perspective is defined in this report as having knowledge about logistics and its impact.

1.2 Aim

Logistics is strongly dependent on product design, hence integrating the awareness of the logistics perspective in the product development process has multiple advantages. Therefore, this master thesis aims to investigate how the logistics awareness should be integrated in the product development process.

2. Analytical framework

The analytical framework will begin with an investigation of how a product development process is executed, to gain a broader knowledge about the subject. Then, the logistics management process and cross-collaboration will be examined to find important factors. Thereafter, an investigation of methods on how to integrate the logistics awareness in order to create a problem analysis will be performed.

2.1 The Product Development Process

New product development is important in order for companies to create a sustainable business that continuously evolves and is competitive on the market (Hsu & Yang, 2019). The fast development of new technologies and product functions are shortening the product life cycles, which has created a need for companies to have well-developed New Product Development (NPD). According to Hsu and Yang (2019), the NPD consists of four major stages, optimal specification, optimal prototype, optimal production and optimal marketing. These are divided into seven procedures, which are product position, specification design, configuration design, manufacturing design, function test, trial production and mass production (Figure 1).

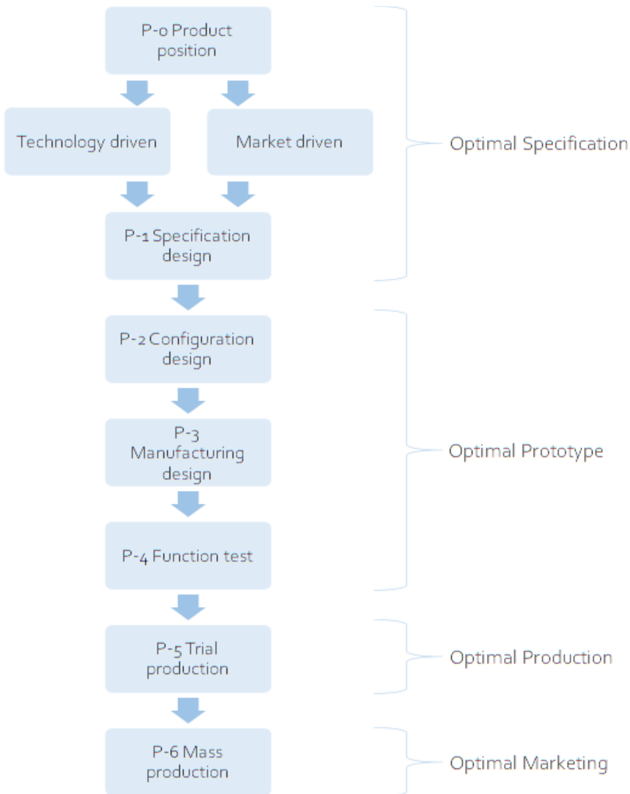

Figure 1. The optimised NPD process (HSU & Yang, 2019)

Procedure 0-1 are included in optimal specification stage, procedure 2-4 in optimal prototype, 5 in production quality and 6 in optimal marketing. In the optimal specification stage, the work should be focused on targeting the product positioning, creating a feasibility analysis of technology, price and market, as well as product design strategy. The output should be a feasibility analysis, preliminary specification and a first draft of a prototype. Hereafter the development should, according to Hsu and Yang (2019), either be market-driven or technology-driven. Market-driven development process is more focused on existing technology, while technology-driven is more focused on developing new products from the start (Hsu & Yang, 2019). In procedure 1, the design parameter trade-off should be executed in order to know what requirements should be balanced, as well as a market competition analysis in order to know what customers find attractive. A new draft of a prototype should be developed with the new data collected. In procedure 2 the product detailing will be executed, and the detailed design should be completed. Samples should also be made as well as more detailed prototypes. The operable prototype should be created in procedure 3 and therefore the design of the mould needs to be finished. Procedure 4 should contain both functional and reliability testing of the prototype to later on culminate into a functional prototype. Thereafter in procedure 5, a mass production test of the prototype should be executed. This is done to achieve technical confirmation of the process and tools as well as process and equipment validation. This should later on also culminate to a new prototype. In the last procedure, the prototype in procedure 5 should be mass produced, and also match the company's marketing strategy.

2.2 The Logistics Management Process

According to Christopher (2011:2) supply chain management seeks *"to achieve linkage and co-ordination between the processes of other entities in the pipeline, i.e. suppliers and customers, and the organisation itself*". Logistics management is however all about planning, coordinating, organising and implementing both information and material flow between the company functions (Femerling & Gleissner, 2013). This report will be more focused on logistics management, since it is more connected to the subject investigated.

To achieve desired levels of delivered quality and service at lowest possible cost, the logistics management must be managed well according to Christopher (2011). The logistics management is the link between the marketplace and supply base and spans the whole organisation from raw material to final product (ibid.), which is visualised in Figure 2.

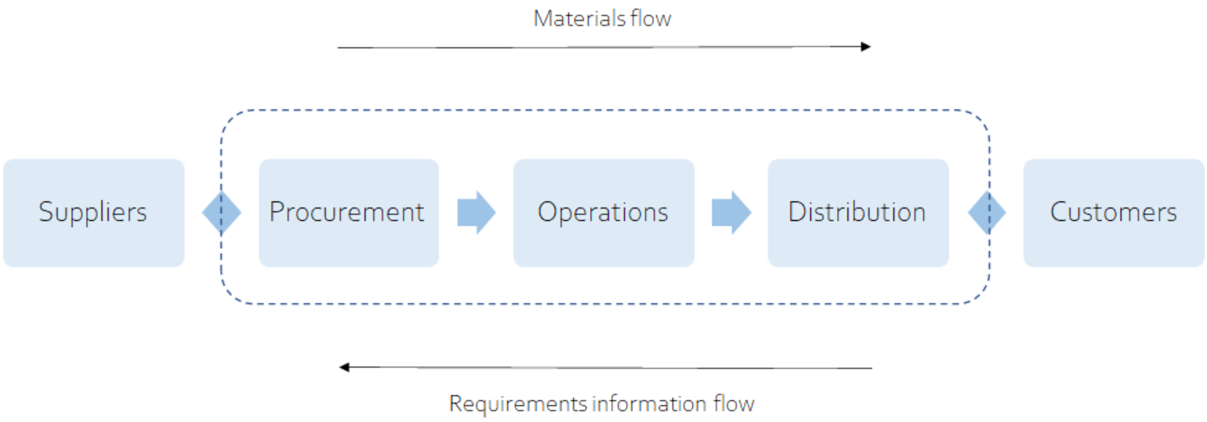

Figure 2. Logistics management process (Christopher, 2011)

The material- and information flows are extended through the whole organisation which is important in order to satisfy the customers' demands and accordingly remain a competitive position on the market (Christopher, 2011). Today the customer demands are many, where some of them are e.g. higher service, lower costs, quality or short time to market (Heragu, et. al., 2019). Accordingly, the information has to flow through the whole company in an easy way to create transparency. Hence, the customer demands will be visualised early in the processes and consequently all company functions will work toward the same organisational goals. However, manufacturing companies have been vulnerable to the increasing demands of the customers, which resulted in investments in new methods such as Lean Supply Chain, Agile Supply Chain, Flexible Supply Chain and Resilient Supply Chain (Bielecki & Galínska, 2017). These investments were made because it is important for companies to be flexible and responsive (Christopher, 2011). Therefore, logistics management should be a planning concept that seeks to create a holistic framework and a one-plan mentality for all functions within the company (ibid.).

2.3 Cross Collaboration in New Product Development

As mentioned, it is important for companies to be innovative and to have a well-developed New Product Development (NPD), in order to stay competitive in the market (Bix & Witt, 2020; Acar, Knippenberg & Tarakci, 2019). However, companies are dispersed globally which hinders collaboration between company functions. The knowledge transfer across company functions is according to Luo, Slotegraaf and Pan (2006) critical to obtain outcomes such as new product success, organisational learning and overall firm performance. It is however not easy to transfer knowledge across company functions, it is rather difficult and complicated (ibid.). Even if the process is well organised to share knowledge, employees could still guard and selectively share information. This often occurs due to the internal competition of the organisations scarce resources but can also be an effect of inter-functional rivalry or arduous relationships (ibid.). Nevertheless, it is important for employees to understand that all company functions work towards the same organisational goal, even though individual goals and strategic priorities exist. To facilitate the sharing of knowledge across company functions, cross-functional integration could be implemented, which is defined according to Song and Parry (1994:4) as *"the level of unity of effort across functional areas in developing and launching a new product"*. It is however not easy due to the many constraints that need to be considered, at the same time as the product complexity increases with new technology etc. (Bix & Witt, 2020). Constraints are here referred to as either limitations of resources, or conditions that reduce the solution set for a certain problem such as a requirement. Nevertheless, constraints do not have to affect NPD negatively, it can also enhance creativity and innovativeness (ibid.).

Bix and Witt (2020) investigated how constraints affect NPD in measuring cross-functional integration, which can facilitate the sharing of knowledge across company boundaries. To proceed, "cross-functional coopetition" was used, which is defined as *"joint occurrence of cooperation and competition between actors on an individual, microeconomic and macroeconomic level"* (Bix & Witt, 2020:30). Luo, Slotegraaf and Pan (2006) argues that "cross-functional coopetition" encompasses three areas: cooperative intensity, cooperative ability and competition. The first is described as the intensity of interactions company functions have between the boundaries (ibid.). Cooperative ability encompasses the ability to comprehend the work of other functions, as well as translating the knowledge shared to value for its own company function. Competition describes the rivalry of tangible and intangible resources between the functions within the organisation (ibid.).

The research of Bix and Witt (2020) later on developed into a framework that should be easy to implement compared to the already existing ones that are more complex (Bitt & Witt, 2020). The framework emerged in 11 themes that were aggregated into four dimensions, in order to see which themes affected what. Themes 1-4 impact cooperative intensity, 5-7 impact cooperative ability, 8-10 impact competition and 11 increases the design effort (Figure 3). These dimensions show which constraints that would enhance the "coopetitive" behaviour in each specific area. Thereafter a framework was developed that could enhance the cross-functional integration in new product development (Bix & Witt, 2020). The framework should be easy to implement in a corporate environment and is visualised in Figure 3.

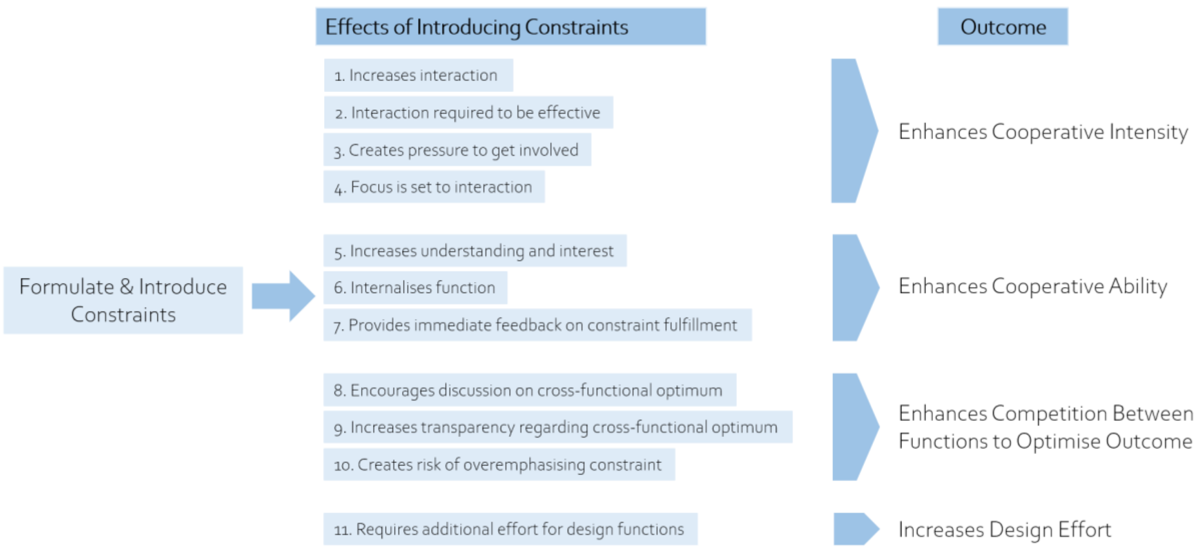

Figure 3. How to introduce constraints in new product development (Bitt & Witt, 2020)

The research showed that constraints most often enhanced innovativeness and creativity, while it sometimes also was seen as a burden which could affect the creativity negatively. Conclusively, the research implied that integrating new constraints mostly presented positive impacts on innovativeness and creativity. However, the design effort needs to increase either way which therefore could affect time to market negatively.

2.4 Integration of Logistics Awareness

Organisations are composed of many functions that have individual goals and strategic thinking, which often diminishes the holistic thinking of the organisation in general. Therefore, problems often lie in how to connect the functions in order to focus on the main organisational goal instead. Cross-collaboration is therefore vital in order to succeed with a holistic view and transparency in the company. Accordingly, this chapter will bring up concepts on how to increase the logistics awareness in the product development process.

2.4.1 Total Logistics Management

Bielecki and Galínska (2017) created a concept called Total Logistics Management (TLM) to combine other methods developed during recent years such as Lean Supply Chain, Agile Supply Chain, Flexible Supply Chain and Resilient Supply Chain. TLM is defined as *"the realisation of all organisation operations and processes in order to obtain an effective and efficient goods and information flow"*(Bielecki & Galínska, 2017:101). TLM is divided into two dimensions. One of them concerns the physical flow of goods and information starting from the raw materials, through manufacturing, to the end customer, to reverse logistics. The other concerns the development of products and services from the logistics perspective. These dimensions are complementary to the already existing knowledge, and therefore constitutes a more mature stage in the logistics development within the organisation. Bielecki and Galínska (2017) argue that it is hard to create a logistically efficient product, even though it is important. This is because of the difficultness to satisfy the earlier mentioned customer's demands, while the logistically efficient product is more adapted to flow and inventory streamlining rather than the customers' demands (Bielecki, 2018). Therefore, the product conditions should follow some assumptions when considering the logistics perspective (Bielecki, 2018:177):

- *the concept of the product shall refer to both final product and all features assigned to it which directly or indirectly impact the issues of logistics – a widened structure of a logistic product,*
- *a product should be viewed from a dynamic perspective, i.e. involving both the product as such, related to the design and design process and the process of product improvement, which modifies the design in terms of logistic streamline,*
- *each of the conditions need to be analysed from the perspective of the customer, the manufacturer and common benefits,*

- *each of the conditions shall be analysed in respect of optimising one of the 7Rs.*

The 7R's mentioned is the principle based on delivering the right product, in the right condition and quantity, to the right place, at the right time, with the right price and to the right customer. Considering all this, Bielecki (2018) argues that bearing the logistics in mind during the design phase of the product may remarkably simplify further transport processes. The design for external customers has always been obvious, since the customers are the ones that companies usually target when developing products. However, when the product design is based on the internal demands, the enterprise has, according to Bielecki and Galínska (2017) a great maturity and well-developed organisational culture.

The TLM concept is based on 6 principles which are modified in order to clarify the message, and are stated below (Bielecki & Galínska, 2017:102).

1. *Logistics quality guarantees full customer satisfaction and continuous logistics quality improvements. Supply chain optimisation should also become a routine*
2. *The pursuit of logistics partnership should be based on professionalism and trust*
3. *The concept assures safety and security for people, goods and information flows*
4. *Creating an integrated information flow through the logistics chain that is quickly accessible*
5. *Sustainable logistics development ensures that an organisation's impact on its environment is appropriate*
6. *Total Product Management based on product logistic efficiency is the foundation to secure effective and efficient goods and information flow*

Principle 2 constitutes the need for professionalism and trust between the external suppliers within the supply chain. The focus of the report is more internally within the organisation and therefore principle 2 is outside the scope of this report. The remaining principles will be described further.

Logistics quality should be according to Bielecki and Galínska (2017) connected to the 7R's principle or the three basic elements of logistics and supply chain management, which are product, processes and relations. Referring to the product element, in its initial phase of product design, no boundaries should be imposed on the designer in order to enhance the innovativeness (Bielecki & Galínska, 2017). Thereafter, the concept developed should be looked upon in four other perspectives, marketing, manufacturing, quality and logistics. All perspectives should have common ground, but if applying TLM, the logistics perspective should be superior (ibid.). A product that is superior in all these perspectives, does however not exist, because of the difficultness for all perspectives to be superior at the same time. The need for the perspectives to have common ground, does however highlight the importance of cross-collaboration between the company functions within the organisation (ibid.). Accordingly, both internal and external customer satisfaction can be achieved by continuous collaboration and logistic quality improvement.

The third and fourth principle of TLM is based on the implementation of technologies for secure material processes and information (ibid.). The authors do however argue that it is not the actual implementation of technologies, it concerns the retrieval of information in "one-click". In the supply chain this could be exemplified with Radio Frequency Identification (RFID), bar codes or automation in general. However, in the internal logistics process it could be exemplified with retrieving value-added information within the company in an efficient way (ibid.). Therefore, an integrated information flow should be implemented in order to retrieve information quickly. This could therefore be described as information retrieved in "one click".

The fifth principle is based on the sustainable approach logistics should have that guarantees the right supply chain, as well as the right impact on the environment. This means that the companies have huge challenges concerning the environment and sustainable development from a logistics perspective. According to (Bielecki & Galínska, 2017:104) sustainable development is defined as "*integrated governance where social, ecological, institutional and political aspects become superior for politics and management*". Therefore, the organisations should bear the environmental aspects in mind since there are many aspects that should be considered.

The last principle that is relevant for this report is the one that concerns the logistically efficient product. It is defined, according to Szymonik and Bielecki (2015:41) as "*a material object of market exchange possessing specific properties and features which allow for the effective and efficient internal transfer of the product and related information through, supply, manufacturing and distribution phases, and externally enable to integrate effectively and efficiently processes of storage, transport, packaging, inventory management and handling orders within the concept of Total Logistics Management".* This definition clarifies the importance of the product design's connection to the logistics perspective (Bielecki &

Galínska, 2017). The principle could be performed in two ways, either conceptual- or adjustment strategy (ibid.). The conceptual strategy is executed when the product has high adaptability in the supply chain, which means that the product itself and the processes connected to it, can be precisely planned at the design stage. Therefore, this strategy has a high flexibility in how the product should be designed, as well as how the processes should be executed early in the product development process. Whereas, the adjustment strategy has a low product design adaptability, and features are hard to modify due to legal, economic or market reasons. Because of this, there is not as much flexibility in how to execute the processes, nor the flexibility in the design of the product (Bielecki & Galínska, 2017).

Conclusively, Bielecki and Galínska (2017) argue that the product analysis and logistics strategy choice are crucial starting points when implementing TLM. The conceptual strategy is better due to the higher potential it has through a logistics perspective compared to the adjustment strategy. However, it is still acceptable to choose the adjustment strategy according to Bielecki and Galínska (2017), but in this case it is important to have continuous logistical improvements and TLM principles should be implemented. Therefore, Bielecki and Galínska (2017) argue that the TLM concept should be a realisation of all organisation operations and processes in order to obtain an effective and efficient goods and information flow.

2.4.2 Design for X

Product development is a complex process where many functions are involved (Heragu, et. al., 2019). The design of the product is an important function in the product development process, which has significant effects on the assembly of the product, transportation, product quality, reliability, sustainability, etc. (Cagliyan, 2018). Consequently, there are many aspects to consider and a methodology that handles the trade-offs between the requirements to facilitate and improve the development of the product design is Design for X (DFX) (Cagliyan, 2018). The purpose of DFX is to identify the most appropriate product design early in the product development process by taking design requirements, constraints and challenges from different aspects into consideration (Cagliyan, 2018). The methodology takes 11 different design approaches into account which are e.g. design for manufacturing, design for assembly, design for quality, design for sustainability, design for cost and design for logistics (Figure 4). By dividing the different design aspects and focusing on a limited number of elements at time, it is easier to examine the design of the product and distinguish best practice (Eastman, 2012).

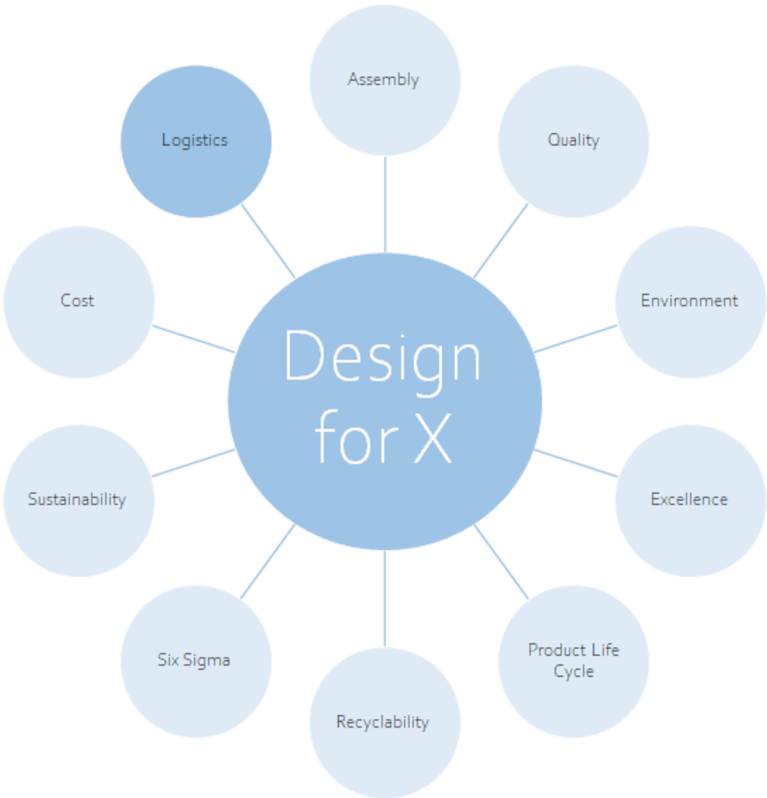

Figure 4. Design for X´s standpoints/views (Cagliyan, 2018)

Design for Logistics

Design for Logistics is the methodology approach that takes the logistics aspects into consideration during the product development process (Cagliyan, 2018). The importance of logistics has grown significantly, and if the logistics' perspective is considered in the product development process, it can be beneficial (ibid).

Design for logistics concerns the logistics aspects that affect and are affected by the product design which are cost, quality, change of volume, delivery, usability and physical design requirements (Cagliyan, 2018). These are in turn divided into four design components for logistics; manufacturing, packaging, transportability and engineering, that all have different features affecting design for logistics (Figure 5).

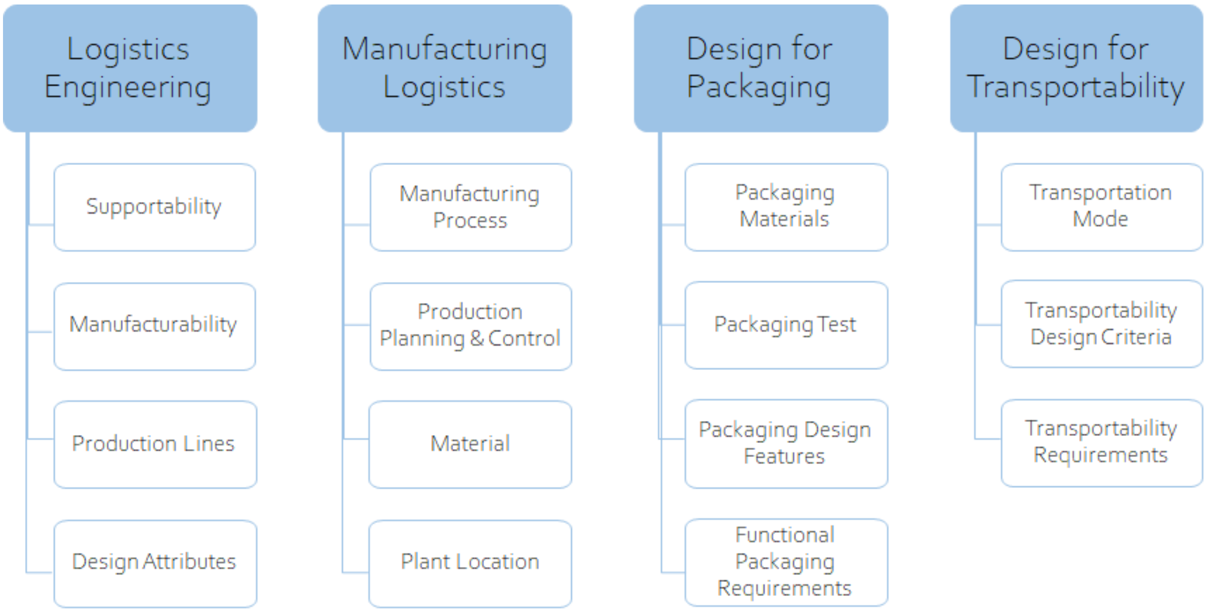

Figure 5. The four design components of Design for logistics (Cagliyan, 2018)

Logistics Engineering is the part of logistics that refers to the supportability of the product or system throughout its life cycle, e.g. maintenance (Cagliyan, 2018). Logistics engineering is affected by the design process and puts requirements on the design of the final product that should be complied (Gnanasekaran, et. al., 2003). Therefore, logistics should be an integrated part of the design process together with manufacturability, cost, size and weight, reliability, safety and performance (ibid). Further, Gnanasekaran, et. al. (2003) argues that collaboration between design and logistics is beneficial and can be achieved by periodic visits, continuous communication and well-developed specifications of the design (Dowlatshahi, 1999). Logistics engineering concerns the product or system throughout its life cycle and therefore, also includes environmental aspects such as disposal and energy savings (Cagliyan, 2018). Design features associated with Logistics engineering are; Design for supportability, Design for manufacturability, Design for product lines and Design attributes.

Manufacturing logistics refers to how the product design affects the processes and activities in the production of the product (Cagliyan, 2018). The characteristics of the manufacturing processes and activities have a huge impact on the logistics and vice versa (Gnanasekaran, et. al., 2003). Consequently, the manufacturing processes set constraints and creates opportunities for the logistics system, which contribute to design for logistics. The design features of Design for Manufacturing are Manufacturing processes, Production planning control, Material and Plant location.

Design for Packaging handles the physical appearance of a product which in turn has a big impact on the supply chain, both from a marketing- and cost perspective (Cagliyan, 2018). The design of the packaging affects functions throughout the whole supply chain, e.g. transportation and storage, which entails multiple requirements. Products are often packed together in different load carriers during the distribution, hence the product design is influenced by the design of the load carrier and a small adjustment can have a significant impact (Cagliyan, 2018). The design of the packaging also impacts the customer's perception of the product and functions as a protecting coverage. Including logistics requirements for packaging early in the product development process can increase the efficiency of the systems performance and overall production and lower operational costs, e.g. warehousing, transportation and material handling. Design features that are associated with Design for Packaging are; Packaging material, Packaging testing, Packaging design and features and Functional packaging requirements.

Design for Transportability includes the most important element, transportation, that usually stands for the majority of the logistics cost in businesses (Cagliyan, 2018). The efficiency of transportation is highly dependent on the design of the product, e.g. size of shipment, number of carriers and transit time, are all variables that will be affected by the product's design. Consequently, design for transportability can contribute to economies of scale, price reductions of goods and services as well as to achieve competitive advantage. Design features associated with design for transportability are; Transportation mode, Design criteria and Transportability issues.

2.5 Problem Analysis

The difficulties in cross-collaboration have been expressed in the Total Logistics Management (TLM) concept, Design for Logistics concept as well as the Cross Collaboration in New Product Development concept. This could explain why logistics is not as integrated as it should be in the product development process. The TLM concept brings up the need to implement a holistic one-plan mentality through the whole company from a logistics perspective. Bielecki and Galínska (2017) argue that the logistics demands should be superior when designing a product, since it is difficult to create a product being superior in all areas at the same time. This is also brought up by the concept of Design for Logistics, since it is easier to focus on one part at a time when designing the product. Accordingly, the Design for Logistics concept brings up the importance of logistics and the need to collaborate with the design function, which also is brought up by the Cross Collaboration in New Product Development concept. The importance of human behavioural factors when changing the processes are brought up, as well as how to facilitate the sharing of knowledge across boundaries. Conclusively, there are many factors that can hinder, but also enable the will or possibility to integrate the logistics awareness earlier in the product development process. This could be factors such as not having knowledge about the subject, or because of the already many functions needed to be considered in the product development process. It is however important to integrate the logistics demands early in the product development process in order to facilitate the logistics' process as well as to decrease costs. This is because, as mentioned, around 80% of total product costs are set early in the product development process (Klevås, 2006). Further, a framework is developed in order to guide the following study. The framework is presented below in Figure 6.

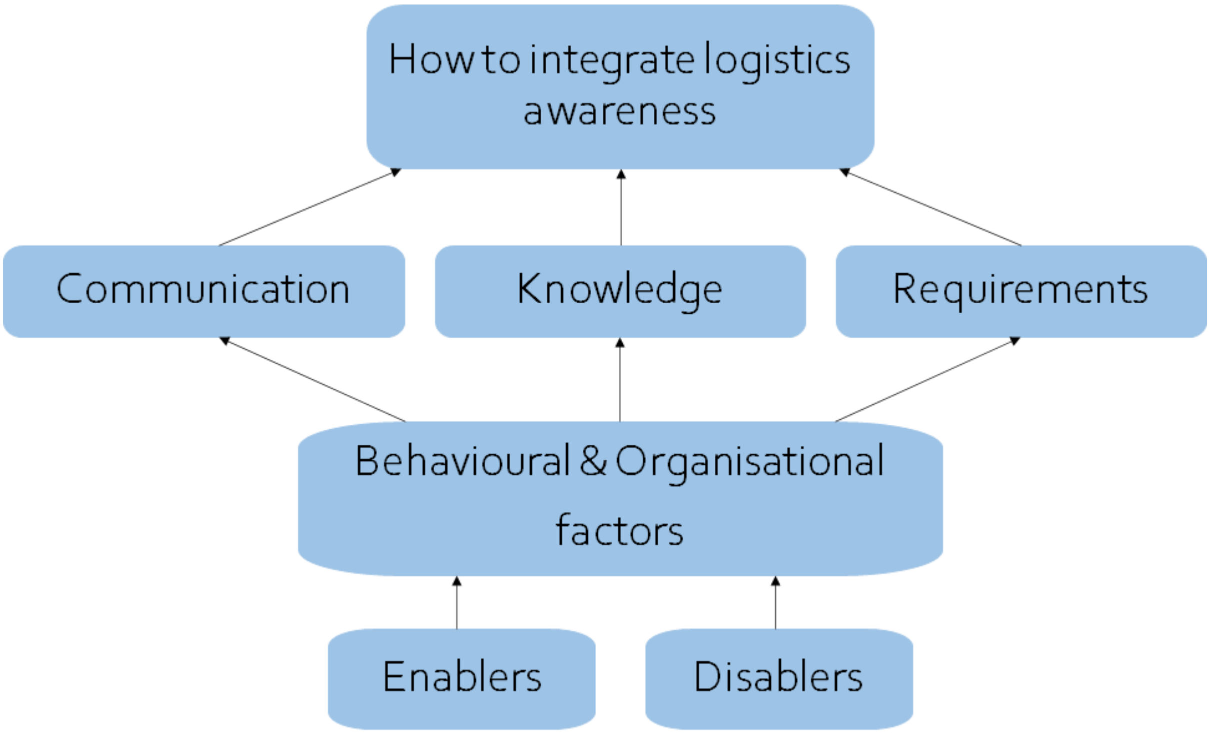

Figure 6. Developed theoretical framework

During the literature study it was noticed that several factors affect the integration of logistics awareness in the product development process. The main areas that were found having an effect were, as shown in Figure 6, communication, knowledge and requirements. Communication was found to have an effect since Bix and Witt (2020) argued that increased interaction is vital in order to facilitate the sharing of knowledge across boundaries. Bielecki and Galínska (2017) also argued that the communication should be transparent through the whole company since the knowledge transfer can be facilitated. According to Bix and Witt (2020), knowledge was also an important factor to consider in the New Product Development (NPD). It plays a huge part in the sharing of each function's knowledge across the company in order to develop organisational performance (Bix & Witt, 2020). Lastly, requirements also have an effect on the integration of logistics awareness. The Design for Logistics- and TLM concepts mention the positive effect the logistics demands have, if it would be considered earlier in the product development process. Bielecki and Galínska (2017) even argue that the logistics demands should be superior compared to others if the TLM concept would be implemented. This is however not possible, since the cross-collaboration across functions is important in order to work towards the same organisational goals.

The three factors are divided into organisational and behavioural factors, since both individual attitudes and organisational challenges may occur. Individual attitudes occur due to different backgrounds and experiences, while organisational challenges occur due to difficulties in change of processes or integration of requirements (Bix & Witt, 2020; Cagliyan, 2018). The factors will further be divided into enablers and disablers in order to facilitate further studies on Manufacturing Sweden and IKEA of Sweden (henceforth referred to IKEA).

2.6 Specification of issue under investigation

The framework developed will be used in further studies on Manufacturing Sweden and IKEA. The study on Manufacturing Sweden will be focused on finding enablers and disablers that affect the integration of logistics awareness. Accordingly, the study on IKEA will focus on gathering data from a company with a strong position through a logistics perspective. Therefore, the research questions are based on the developed framework and will be used as a basis in further investigation of the two companies.

- Which enablers and disablers for logistics awareness in the product development process are presented at Manufacturing Sweden?
- How can logistics awareness be integrated in Manufacturing Sweden's product development process with regards to the behavioural and organisational factors?

3. Swedish Manufacturing Company

In this chapter Manufacturing Sweden' organisation will be explained as well as the industry they operate in. The focus will be on the divisions of Operations and Technology of Manufacturing Sweden. Information is collected from Manufacturing Sweden's official website and internal platform.

3.1 The Swedish Manufacturing Company

Manufacturing Sweden is an established company with a leading position within the business the company operates in (Manufacturing Sweden, 2021). The company also offers complete solutions for financing and service, but the core business focus on, production, distribution and sales. Based on Manufacturing Sweden's revenue, it is the second largest manufacturer in the world.

Manufacturing Sweden operates globally but its markets share in the segment exceeds to 25% in Europe, 22,2 in Brazil, 18,9% in Japan and 16,3% in North America. The company has a global presence with sales of products and services in 190 geographical markets, with main share on sales in Europe, North America and Asia (Figure 7). Production sites are located in many countries as well as several development centres and a large number of logistics- and parts distribution centres.

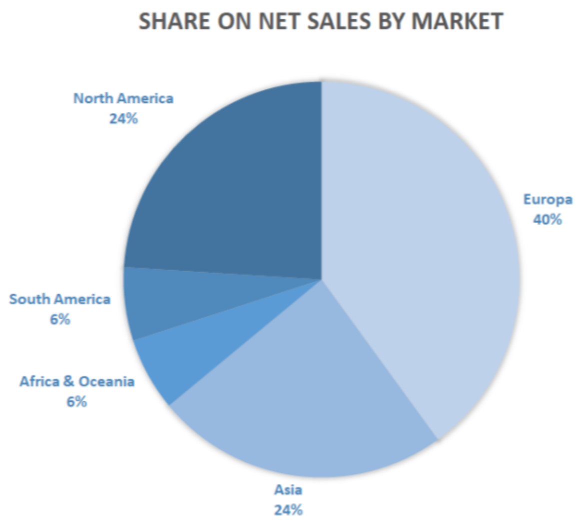

Figure 7. Share on net sales by market

3.2 Company Structure

Manufacturing Sweden's headquarter is located in Sweden, where this master thesis was conducted. The organisation operates in several business areas including three divisions (Figure 8), Technology (TECH), Operations (OP) and Purchasing (PUR)(Manufacturing Sweden, 2021). The focus of the report is TECH and OP, which will be described further.

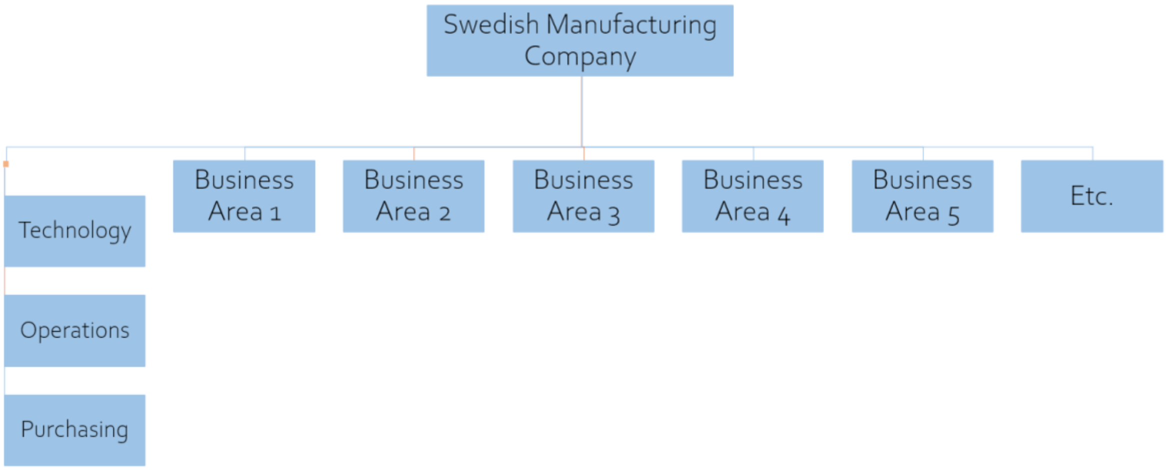

Figure 8. Layout of Manufacturing Sweden's organisation

Technology (TECH) is Manufacturing Sweden's global development organisation of products (Internal platform, 2021). The responsibilities are to provide technology research, product design, development, project execution to the final product and to support the products in the aftermarket.

Operations (OP) is Manufacturing Sweden's global operational organisation, responsible of all global manufacturing for the portfolio (Internal platform, 2021). In addition, OP is responsible for the aftermarket logistics services for all divisions.

4. Methodology

In this chapter the methodology underlying this study is presented. The study started off with a literature study searching for relevant theory regarding the subject and proceeded with a case study on Manufacturing Sweden. Thereafter, a benchmark on IKEA was performed to gain knowledge on best practice within a product development process from a logistics perspective. Conclusively, the validity and reliability of the results of the study are discussed.

4.1 Research approach

The report is based on a case study of the company Manufacturing Sweden in combination with a benchmark of IKEA, a global home furniture company. The master thesis is conducted on behalf of the logistics department Logistics (LOG) at Operations (OP). The aim of the study is to investigate how logistics awareness can be increased in the product development process.

Several methods can be used to perform a study and the suitability of the method depends on the aim (Bryman & Bell, 2015). Hence, the choice of method is essential in order to approach the problem in the best possible way. A frequently used method in business research to gain deeper knowledge about a specific topic, is a case study (Dubois & Gadde, 2002). In this report a case study was used to gain deeper knowledge about the product development process at Manufacturing Sweden. The study provided information about how the company currently works, key actor roles concerning the design in the product development process and how the design of the product is settled. Current processes and collaborations between functions were thereafter analysed to identify behavioural and organisational factors that affect the integration of logistics awareness in the product development process. In the collection of data there are two main strategies: Qualitative and Quantitative (Bryman & Bell, 2015). A Qualitative approach is based on observations, interviews and focus groups and collected data is expressed in text, pictures and graphs (Yilmaz, 2013). Hence, a qualitative approach gives a deep knowledge about the topic and therefore was the chosen strategy for collecting data in both the case study and benchmark.

In this report the theoretical framework and empirical data has been combined, and the research approach was an abductive approach (Bryman & Bell, 2015). The abductive approach was used in this report, which is an iterative approach where theoretical and empirical data are matched back and forth from the beginning (Dubois & Gadde, 2002). This was done in order to adapt the analytical framework with the findings to accordingly meet the purpose of the report, which will be explained further in the following section.

4.2 Research process

To fulfil the purpose of the report in how to increase the awareness of the logistics perspective in the product development process, and to answer the research questions, the master thesis was conducted accordingly (Figure 9).

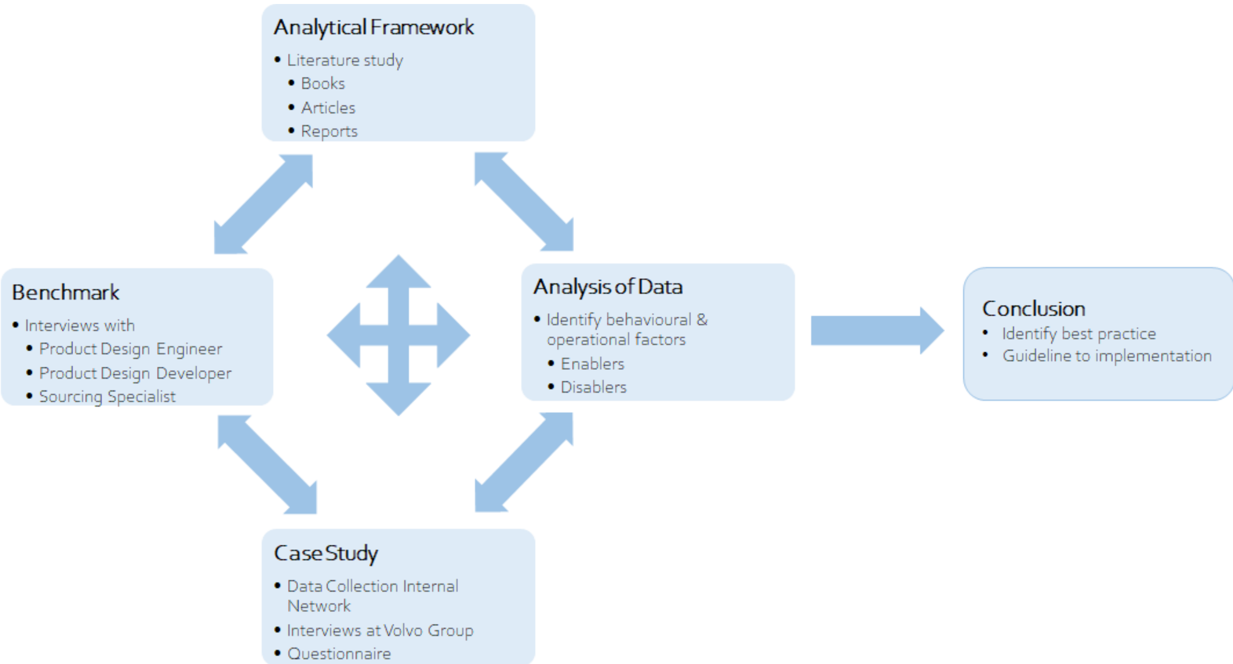

Figure 9. Visualisation of research process

A literature study was conducted to gain knowledge about the subject and to develop an analytical framework. In parallel with creating the analytical framework, a case study was executed to collect information of Manufacturing Sweden’s product development process and an overview of the current state. Data about the process was gathered through Manufacturing Sweden’s internal platform, questionnaires, and interviews at Manufacturing Sweden with representatives that are involved in the product development process. The analytical framework was developed by confronting the findings at Manufacturing Sweden with collected data from the literature study, hence the scope of the research was narrowed down and defined. In addition, a Benchmark of IKEAs' product development process was conducted to identify examples of best practice on how logistics awareness can be integrated successfully in the product development process. The questions of the benchmark were developed based on the analysis of the case study and analytical framework. The analytical framework, case study and benchmark were analysed back and forth during the report. This, to create suitable theoretical models according to the findings in the empirical study. The case study and benchmark were also in turn analysed back and forth together with the analytical framework, to collect information of interest for the scope. Consequently, the analytical framework, case study and benchmark were repeatedly developed and adapted during the research to identify behavioural and organisational factors, as well as enablers and disablers to integrate the logistics awareness in the product development process. Finally, a conclusion of how the logistics awareness can be integrated in the product development process with regards to the behavioural and organisational factors was made.

4.3 Literature study

A literature study was conducted to gather data of the report's scope. Hence, the purpose of the literature study was to increase the knowledge about the product development process and methods of how to integrate the logistics awareness. The data was gathered from articles, reports and books from the library of Chalmers University of Technology and the Public library. To obtain relevant information for the literature study, the search will be based on the following words; *Logistics Design, Design for Logistics (DFL), Logistic Management, Logistics awareness, Total Logistics Management (TLM), Product development process, Cross-collaboration, etc.*

Literature of the product development process was collected to gain a broader understanding of how products are developed. In addition, the logistics management process will be investigated in order to analyse important factors included. Thereafter, methods on how to implement the logistics awareness were collected, to understand how the purpose of the report could be achieved. Several methods were investigated and narrowed down to a few that were found relevant to the study. The literature study was executed in parallel with the case study, hence the information collected was analysed and the literature study was adjusted and complemented according to findings at the company. Thereafter literature regarding cross-collaboration was investigated. This was done since the difficulties in cross-collaboration that occurred when developing products, was often discussed in retrieved literature. Cross-collaboration between functions in an organisation concerns communication, sharing of information and knowledge between functions, and consequently considered important in the study. The literature study was used as a base when developing the problem analysis and in turn the research questions in the report. In addition, the problem analysis was partly used to develop the questions for the interviewees conducted at Manufacturing Sweden and IKEA, in order to answer the research questions.

4.4 Data Collection

The data was collected from two different sources of information, primary data and secondary data (Bryman & Bell, 2015). Primary data is defined as data collected only for the purpose of the research and secondary data is defined as data collected for other purposes. The empirical data was collected through primary data from interviews at both Manufacturing Sweden and IKEA as well as Manufacturing Sweden’s internal platform. The analytical framework was created through secondary data such as books and articles.

4.4.1 Case Study

The data collection began at Manufacturing Sweden with an analysis of the internal documentation regarding how the product development process is executed. Each gate, process and the connections in between were analysed thoroughly. This led to continued investigations in the company’s hierarchy in order to gain knowledge of who to interview regarding what, as well as who is reporting to whom. The methodology used to collect data is called snowball sampling, which means that the original interviewees information helps to find new participants, which in turn leads to further participants in the study. The approach of the snowball sampling will be explained further below.

Interviews is a frequently used method to gather data and there are three different ways to design the interview: structured, semi-structured and unstructured (Denscombe, 1998). To create an understanding of logistics involvement in the current product development process interviews were held at the department Logistics (LOG) within Operations (OP). First an interview with a Business Process Developer, our supervisor at Manufacturing Sweden, was conducted to get an overview of the current product development process, such as who is involved and where. Interviews with our supervisor were continuously held, in order to get the support needed during the process. The information retrieved from our supervisor was in turn used to contact additional interviewees from logistics that are involved early in the product development process. Interviews were then conducted in the order that the interviewees are involved in the product development process, starting with Logistics Range Manger (LRM) then the Design for Logistics engineers (DFLe) and third Technical Preparation Engineer (TPE) (Table 1). The interviewees at the OP department, Logistics, were interviewed again later on in the research to ask more in-depth questions when the knowledge about the topic had increased. To gain knowledge about how the design is settled early in the product development process interviews were held with representatives from Technology (TECH). Through investigations, help from our supervisor at Manufacturing Sweden and the conducted interviews we identified key roles of interest to talk to which were i.e., Geometrical Architects (GA), Design Engineers (DE) and Engineering Task Leader (ETL) (Table 1**)**. Interviews were held respectively with each of them to identify possible opportunities to increase the logistics awareness in the early stage of the product development process.

The interview techniques that have been used both internally and externally were semi-structured interviews, which means pre-prepared questions and complementary questions. This method was chosen since the interaction increases between the interviewee and interviewer, since it gives the interviewer opportunity to deviate from the prepared questions and add questions of relevance that appear during the conversation. Hence, the flexibility increases, and the information exchange is improved. All interviews were executed on Microsoft Teams and was recorded after approval by the respondent, in order to collect as much data as possible. The initial questions used in the case study are presented in Appendix A where the interviews lasted for one hour. To strengthen information gathered from the interviews at TECH a complementary questionnaire was created based on statements of the collected data (Appendix B). The questionnaire was distributed to DEs in order to get a broader perspective of the current situation.

The organisation's way of working was under development during the research. The classical project structure with specific roles were exchanged for a more agile work approach.

Consequently, some of the roles that were interesting to interview had already been removed due to the new working process. Most functions were still working according to the old way and most of the roles could be found and interviewed. Though, some roles had already been removed, but with help from our supervisor at Manufacturing Sweden, interviewees that had earlier worked as these roles were found. In addition, to get a better understanding of the new way of working interviews were first executed with a Group Manager and a Business Sub-portfolio Manager, which in turn put us in contact with a Senior Business Consultant (Table 1). It was considered important to have knowledge about the old way of working and bear that in mind when analysing the empirical data to find suitable suggestions.

Table 1. Interviews at Manufacturing Sweden

Title (no.)	**Interview structure**	**Time (min)**
Business Process Developer	Unstructured	Continuously
Logistics Range Manager (LRM)	Semi-structured	60 + 45
Design for Logistics engineers (DFLe) (2)	Semi-structured	60 + 45
Technical Preparation Engineer (TPE)	Semi-structured	60
Lead Geometrical Architect (GA) (2)	Semi-structured	60
Senior Engineer	Semi-structured	60
Principal Engineer	Semi-structured	60
Lead Engineer	Semi-structured	60
Director Logistics Prep	Semi-structured	30
Business Subportfolio Manager	Unstructured	60
Group Manager, Reqs & Verification Lead	Unstructured	60
Lead Project Manager Engineer	Semi-structured	60
Senior Business Consultant	Semi-structured	60
Senior Project Manager	Semi-structured	60

4.4.2 Benchmark

A benchmark of IKEAs product development processes was executed to identify findings of best practice on how logistics awareness can be implemented successfully in the product development process. Through conversation with our supervisor at Manufacturing Sweden and Chalmers University of Technology the focus of the benchmark company was settled in an early stage. First, it should be a company that has a strong position from a logistics perspective. Second, the company should not operate in the same industry as Manufacturing Sweden to be able to share our findings. Hence, the focus was on companies that could not be considered as competitors at all. Therefore, the benchmark will be performed on IKEA, a global furniture manufacturing company with a reputation for being leading from a logistics perspective. Our supervisor at Chalmers University helped us to find a contact person at IKEA. The choice of interviewees was made together with the contact person after defining the scope of the master thesis. Hence, the contact person in turn put us in contact with three functions at IKEA: Product Design Developer (PDD), Business Area Sourcing Specialist (BASS) and Product Design Engineer (PDE) (Table 2). These three functions were chosen since these roles are involved in the product development process during the design of the product. The roles possess knowledge about how logistics is integrated in the product development process. The interviews were semi-structured and were held with one representative from each function. Hence, the initial questions used in the interviews are presented in Appendix C where the interviews lasted for one hour.

Table 2. Interviews at IKEA

Title	**Interview structure**	**Time (min)**
Product Design Developer	Semi-structured	60
Product Design Engineer	Semi-structured	60
Business Area Sourcing Specialist	Semi-structured	60

4.5 Research validity & reliability

It is important to be critical when collecting information, in order for the report to be credible (Denscombe, 1998). Two concepts that are used to ensure credibility are *reliability* and *validity*. The reliability is directly connected to the methodology and the major critic to a qualitative approach is that it is too subjective. It means that the qualitative research is influenced by the researcher's opinion of what is important. Hence, the importance of being transparent in the methodology is vital.

To increase the reliability of the interviews, another person can participate, in parallel with the interviewer, to interpret answers and data (Patel & Davidsson, 2011). In all interviews executed in this report, both authors of the report participated to increase the reliability. Therefore, during interviews the respondents' answers could be interpreted and registered by both authors. In addition, the interviews were recorded to further increase the reliability. However, the interviews were mainly performed with one or two representatives for each role from Manufacturing Sweden and IKEA. Consequently, the collected data reflects the interviewees opinions, hence the information is biased because of each person's own values and thoughts. Consequently, to gain a broader perspective a questionnaire was created based on the earlier interviews to strengthen the statements made. The questionnaire was distributed to the Design Engineers (DE) at Technology (TECH). The interviews at IKEA were performed with one representative from each function and accordingly the collected data reflects thoughts and ideas. Furthermore, to increase the reliability of the report the authors tried to keep an objective mind throughout the interviews at both companies.

Validity means that the results gathered during the report are in line with the theoretical framework and the purpose of the report (Bryman & Bell, 2015). To ensure this, the analytical framework, case study and benchmark has consistently been analysed back and forth during the report. To increase the validity, complementary interviews at Manufacturing Sweden have been performed to verify collected information and feasibility of ideas. In addition, each section of the interviewee's role description has been sent to each interviewee at both Manufacturing Sweden and IKEA for control and confirmation. The information collected in the case study has also been controlled and verified by the supervisor at Manufacturing Sweden. In addition, the benchmark was performed at IKEA. Hence, Manufacturing Sweden and IKEA operate in different industries, providing different products and a direct comparison between the companies was difficult. Though, since the scope of the study was to analyse the processes, interesting findings between the organisations could be found.

5. Case Study

In this chapter the Product development process at Manufacturing Sweden will be explained with focus on the Design for logistics process. Different roles involved early in the product development process have been identified, both logistics roles from Operations (OP) as well as other roles from Technology (TECH) will be explained. In addition, the interviewees' thoughts and ideas will be explained. The information is retrieved from interviews with respective roles and the DVP project handbook if no additional information is stated.

5.1 Product development process

To achieve an effective product development process, it is critical to execute product development projects in a structured way. Manufacturing Sweden has a project handbook (DVP PH), which provides a framework on how to execute a project. The handbook describes *"which deliverables that must be considered from the time an idea for a product change or a new product is considered through development, industrialisation, commercialisation and delivery to the customer"* (Internal platform, 2021). The main focus of the handbook is to develop the right product concerning the parameters Quality, Delivery, Cost and Features (QDCF), that meet or exceed the expectations of customers. These parameters are used to evaluate the progress of a project.

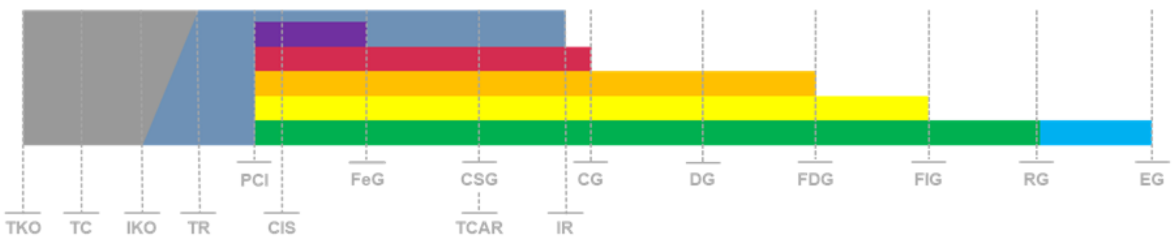

Figure 10. DVP Project Process

The DVP PH framework consists of Product Development and Technology Development, which in turn are divided in several phases that include gates and project decision points (Figure 10). The gates work as checkpoints between the phases, where needed deliverables must be achieved in order for the gate to open and the project to proceed (Manufacturing Sweden, 2020). Project Decision Points is where the decision of the project founding is made, whether it is accepted or rejected.

Technology development includes two phases; Technology Creation and Application and Integration. Product Development consists of the six following phases; Feasibility study, Concept development, Solution development, Final verification, Industrialisation and Commercialisation and Follow-up phase (Figure 10) (Manufacturing Sweden, 2020).

The start of a project is initiated at the Product Change Initiation (PCI). Before, a Pre-PCI investigation is executed to confirm that the project is viable and “High Level Project Prerequisites” are submitted. Project Prerequisites is a documentation of the agreed targets concerning the product design from all stakeholders. The Project Prerequisites document consists of four maturity stages, the first is customers’ expressed targets. In the second stage, expressed targets from stakeholders and the main driving targets are selected. In the third stage, the Project Prerequisites are completed. Accordingly, after this stage, stakeholders should defer from adding further requirement driving targets. The last stage consists of the final Project Prerequisites, which includes the decided and rejected targets of the stakeholders that should reflect the chosen concept.

The prerequisites are the foundation to the Requirement Specification. Here, the targets are translated into requirements, which is defined as a constraint of the product’s condition or capability that must be achieved or the functionality of the product. The Requirements Specification is developed in parallel with the Project Prerequisites and is completed at the Concept Gate (CG), to later on be finalised at the Development Gate (DG) (Figure 11).

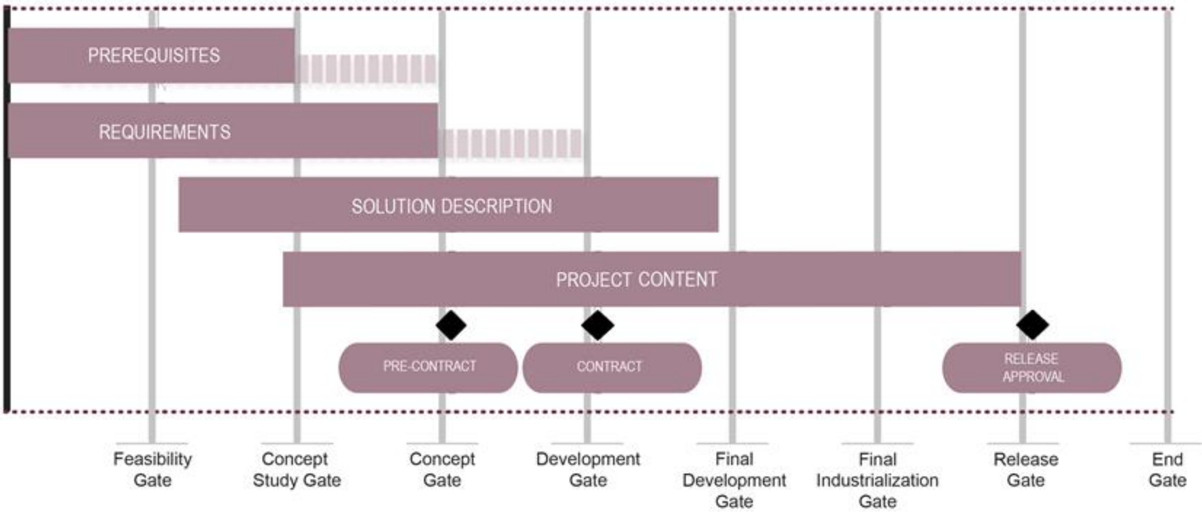

Figure 11. Project Defining Documentation

The design starts with concept evaluation and continues to the Final Development Gate (FDG). During the design process several releases of the product are completed that reflect the maturity of the product, these releases are called A-, B- and C-releases (Figure 12). The A-release is executed around the CG and is a first draft of the product´s design. The B-release is finalised before the DG and at this point the design interface needs to be mature. The final maturity release is the C-release at the FDG, where the designed parts must be complete, and no changes should be made. When the full configuration is verified, including logistic equipment's and flows, the Production Release is completed.

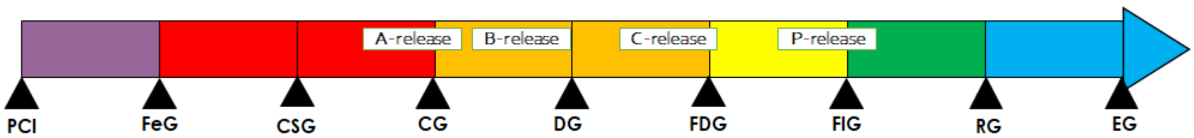

Figure 12. Maturity releases of the product

5.2 Design for Logistics Process

The product development process is a complex process with multiple requirements from several stakeholders that want to have an impact on the product. "*Design for Logistics is the engineering part of logistics that aims at influencing the design of the product during the* *product development process to impact positively on costs, the environment, and protection of the parts quality*" (Manufacturing Sweden, 2021). The DFL process (Figure 13) has been developed in order to have an impact on the product development process and will be explained further. However, the process has newly been modified and these modifications might not be fully integrated yet. Hence, the data collected from the interviews may differ from the theoretical Design for Logistics process.

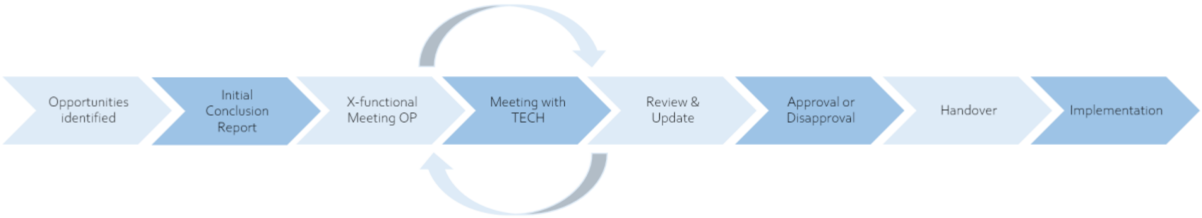

Figure 13. DFL Process (Manufacturing Sweden, 2021)

The first stage in the Design for Logistics Process is to "*identify opportunities to influence the part design to improve the logistics cost and CO2"* (Manufacturing Sweden, 2021) in the scope of the project. First, an analysis is performed to investigate the opportunities of DFLe to put new requirements on the product. The requirements can for example be identified at a project meeting held by the Operations Manager (OP PM), in a design review meeting or by a Logistics Project Manager (Log PM) or Technical Preparation Engineer (TPE). In the meeting between Log PM and OP PM, the Log PM investigates the project scope and identifies components that affect logistics. To facilitate the identification of components of interest a Critical Parts List of components that contribute to high logistics costs is used. These components represent approximately 80% of total logistics cost and are generally characterised by components that have high potential for improvement, e.g., bulky and/or components with high volumes. The project scope is thoroughly investigated, and the requested changes are compared with the Critical Parts List. When a component of interest is identified a case is created and uploaded in an individual platform**,** where the DFLe receives it, and accordingly the analysis of the case starts.

The next stage is for DFLe to investigate possible opportunities and to create an initial conclusion report. This is executed after the CAD model of the product has been provided by Technology (TECH), during the A-release and should be finalised as quickly as possible to affect the B-release. TPE and Log PM are responsible for providing the needed data input for the investigation of the project to DFLe. When all information is received by DFLe an analysis is executed with support from other stakeholders, to reach a final requirement of the part change requested. The report of the product change is created when the analysis is finalised and should include how the change affects cost and CO_2-emissions. The effects of the change are illustrated by comparing “Friday” vs “Monday”. Friday illustrates the current state of the original component and Monday illustrates the future state that the changes will imply. Consequently, by identifying logistics triggers and big challenges of the project in the beginning, additional costs can be predicted and avoided. When the report is finalised, it is distributed to all logistics stakeholders.

Thereafter, an “X-functional meeting” is conducted within Operations (OP), where DFLe presents their report and receives input from the logistics stakeholders. The purpose of the meeting is to balance and align the logistics requirements on the part design within OP, before delivering them to Technology (TECH). Otherwise TECH does not know which requirements should be prioritised if the requirements contradict each other.

When the requirements from OP are aligned, a meeting with TECH is organised in order to present and discuss the proposed changes of the part. Functions involved in the meeting are DFLe, TPE and Design Engineers (DE). The TPE is DFLe’s speaking partner concerning the product and the assembly phase.

Finally, TECH will decide if the design change request is approved or disapproved. Conclusively, the DFL case study will be closed and is handed over from DFLe to Log PM who will follow up that the product change is fulfilled and implemented.

5.3 Roles involved early in the Product Development Process

Many functions are involved during the product development process and depending on the nature of the project, the selection of roles from these functions varies. All projects have a leader, called Chief Project Manager (CPM) that is supported by Planning and the Project Assurance Manager (PAM). The Project development process includes a Project Management Team (PMT) that consists of several development functions; Engineering, Aftermarket, Operations, Finance and Purchasing (Figure 14). Each development function has a Project

Manager (PM) who is responsible for planning, leading, communication and involving the right people in a specific area. Consequently, many roles are involved in different stages of the product development process.

The design of the product is settled early in the product development process, therefore this report will concentrate on the functions Engineering and Operations. These functions take place within Technology (TECH) and Operations (OP) and are involved through the whole product development process. The following sections explain both the roles of logistics in OP, as well as the roles within TECH that are involved early in the product development process.

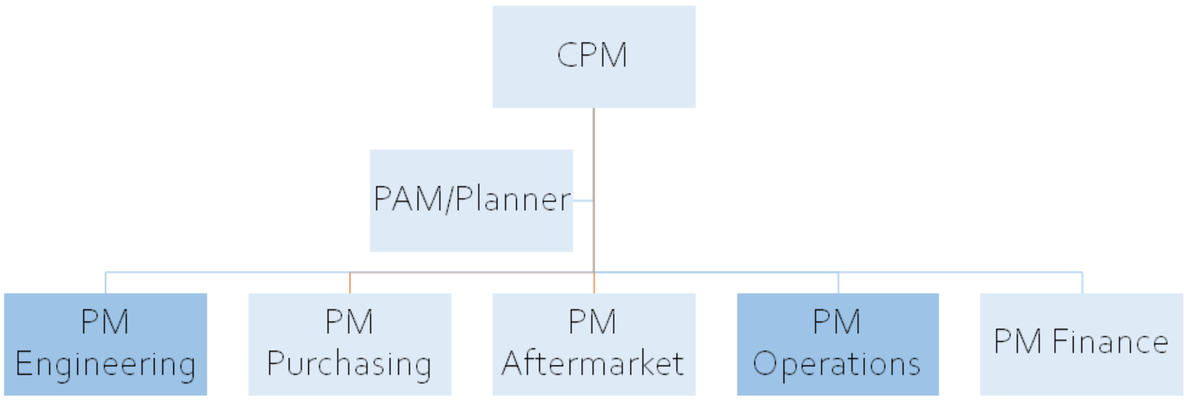

Figure 14. Project management core team

5.3.1 Operations (OP)

Several functions from OP are involved early in the product development process. The roles that are responsible for setting the logistics targets and requirements early in the product development process are Logistics Range Manager (LRM) together with the Design for Logistics engineers (DFLe). The DFLe's speaking partner who is responsible for presenting the requirements on the part design from OP, is the Technical Preparation Engineer (TPE). Consequently, the work and mission of these roles, as well as thoughts and ideas will be explained in this section.

Logistics Range Manger (LRM)

The role involved in the early part of the product development process from a logistics perspective is the LRM. The LRMs are involved before the Project Change Initiation (PCI) gate in the Pre-PCI study and contribute through the PCI gate to the Feasibility Gate (FeG) (Figure 15**).** The mission of LRM is "*to be Responsible for Production Supply Chain in all pre-PCI activities related to his ranges"* (Manufacturing Sweden, 2021) It means that the LRMs are responsible for the support of all logistics investigations, from the supplier to delivery of the product. The work also includes to understand the project scope and to evaluate its impact on logistics by delivering high level prerequisites, which are the opportunities or threats connected to the project. High level prerequisites are defined as prerequisites that can be identified in an early stage where there is little knowledge of the product, the product definition is far from being settled and there are still a lot of available options.

LRMs are responsible for delivering three blocks of activities during the support of a pre-study project. These three blocks are; RnD hours estimation, Investment frame and Targets and requirements. RnD hours estimation is a forecast of the hours spent to support a project by the logistics function divided by gate and function, to calculate the cost and time. Investment frame is an investigation of the logistics investments (for example special packaging) that the project may imply. The LRMs have a high focus on "Special packaging", which is parts that require a unique package, since developing special packages requires investments that can be very expensive. Target & requirements are, as mentioned earlier, the opportunities or threats connected to the project scope. In a project, target descriptions are given which consists of impacted logistics areas identified by several stakeholders. From there, LRMs work is to scale down and translate them into high level requirements, to be easier understood. The requirements are set to secure that the targets can be met in the project. These are called high level requirements due to the fact that these are identified early in the product development process when there are still a lot of uncertainties. The main focus of the LRM is to explain and visualise the logistics concerns or opportunities, and to set high level requirements since it is of high importance to understand the impact in order to affect the product. Conclusively, when the LRM has completed all activities, the conclusions are handed over to the Logistics Project Manager (Log PM) and its Project Manager Team (PMT). Log PM are in charge of the logistics stakeholders and are the ones who Design for Logistics engineers (DFLe) reports to in the project.

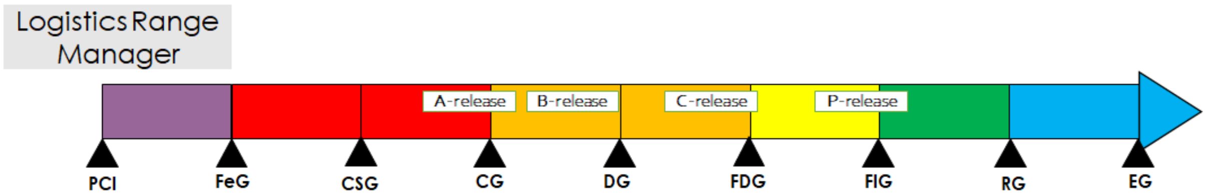

Figure 15. Involvement of the LRM in the product development process

Design for Logistics (DFL)

The DFL function started in 2012 and is mainly focused on Europe and the USA, where employees are currently stationed in USA, France and Sweden. DFL gets involved when a part design change is identified and participates in the product development process from the pre-PCI study to the Final Development Gate (Figure 16). The mission of DFL is to be "*a built-in value of the product development process that contributes to decrease the total acquisition cost"* (Personal communication, 17 May 2021). This means that the Design for Logistics engineers (DFLe) should investigate the parts and its design during the product development process from a logistics perspective. In addition, contribute to a decrease in logistics cost related to; running cost in production, avoid new investments for packaging, filling rate and safe transportation. The DFLe mainly investigates the packing density since it affects the fill rate of the transport, where the goal is to increase the number of components transported per square meter.

At the start of a project multiple concepts are developed. A concept is defined as a possible solution to the initial development of the current project. The DFLe's job is to analyse the components, gather pros and cons with the solution and compare them against each other, to finally reach a change request on the part design that will support the logistics' targets. When the request of the DFL has been approved by all logistics' stakeholders and Technical Preparation Engineer (TPE), the investigation is thereafter handed over to Technology (TECH). Conclusively, TECH reach a decision and the most suitable concept is selected at the Concept Gate (CG). The development of the chosen concept's design starts at the Concept Gate and proceeds to evolve on a detailed level until the Final Development Gate (FDG). DFL are mostly involved from the project start to the CG where investigation of the different concepts of the project takes place. After the CG and until the FDG, DFL follows up changes that might occur and analyse the potential effects on logistics. At the FDG, when the product is ready, DFL will no longer be involved since the product is finalised and no further changes are allowed.

The DFLe's works completely virtual in the High-level process with several systems and tools. It means that Computer Aided Design (CAD) models are used to illustrate the effects of the part change request in 3D. DFL have created 3D models of the packages and currently almost all the models of the standard packages are available in the internal database. Special packages are also available, since these CAD drawings are requested from the supplier, though they are not organised in the internal database. All cases are registered and updated frequently during the work progress by the DFLe in an internal database, where the case is saved. Therefore, if a similar case will occur the old case in the internal database can be used as a guideline.

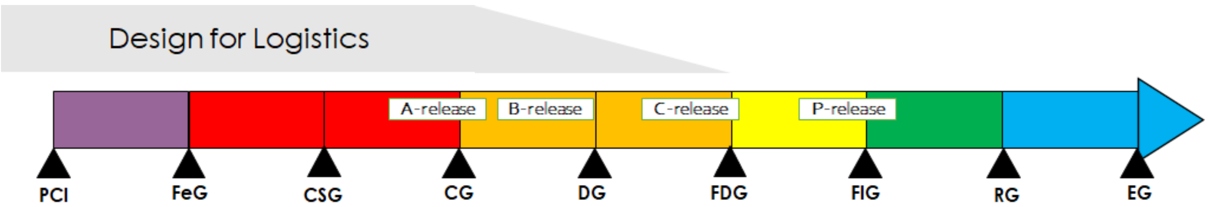

Figure 16. Involvement of the DFL in the product development process

Technical Preparation Engineer (TPE)

TPE's work in the product development process is mainly executed between the Feasibility Gate (FeG) and Concept Gate (CG) (Figure 17). The mission of TPE is to "push" manufacturing requirements from Operations (OP) to Technology (TECH) during the product development process. Hence, TPE functions as the speaking partner of OP and is a "*key player in the process of pushing joint requirements from OP*" (Personal Communication, 5 May 2021).

The work of the TPE starts through inputs from the project received from different stakeholders, OP Project Manager (OP PM), Manufacturing Strategy Manager (MSM) or the initiation of a pre-study. Through the work process, TPE collaborates cross-functional with TECH, mainly the Engineering Task Leader (ETL). The work proceeds through cross-functional meetings within OP where the mission is to develop an aligned framework of requirements from Manufacturing and the Logistics' parts change request. When the requirements are compiled, the TPE is responsible for distributing these to TECH.

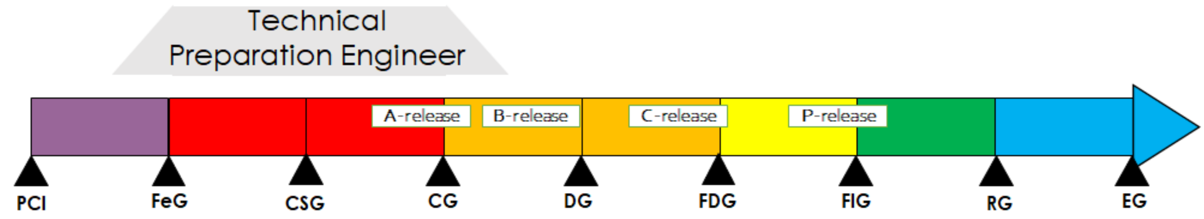

Figure 17. Involvement of the TPE in the product development process

Reflections from Interviewees at Operations

During the interviews interesting findings were made from the participants (Figure 18). Consequently, the interviewees thoughts and ideas will be discussed in the following section. Therefore, the following section is based on personal opinions from the interviewees and only represents the participants' thoughts and ideas, not the whole function.

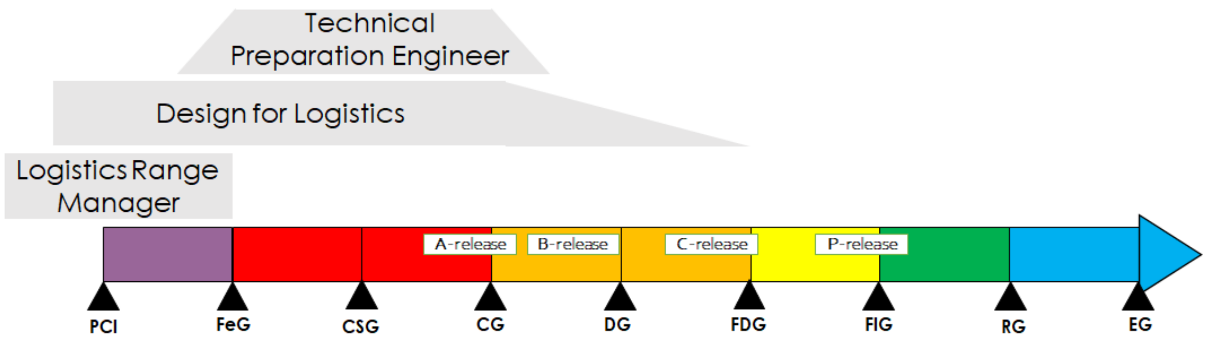

Figure 18. Involvement of roles from Operations (OP)

The involvement and work of the Design for Logistics engineer (DFLe) works rather well in the product development process, where several product changes have been initiated according to the interviewees. The response from Technology (TECH) is also considered good but it can be hard for them to meet the logistics demands, since the primary focus is on the market and customers' demands. The DFLe argued that an education or presentation of DFL's work to TECH might enhance the knowledge of logistics. However, this was seen as a short-term solution and an integrated process would be a more effective approach. Another opportunity that was expressed was to integrate DFL earlier in the product development process, as well as increased interaction between functions through a direct channel.

A Design Engineer (DE) expresses that there are multiple requirements to consider from different stakeholders, where the functionality, cost- and manufacturing requirements are prioritised. This is because, as an interviewee mentioned, "*they need to be fulfilled, since the part needs to do its job and to be easily manufactured"* (Personal communication, 24 March 2021). Nevertheless, the importance of logistics has grown but the knowledge and effects are still limited. Two parameters that are used to illustrate logistics impact are cost and CO_2-emissions. These two parameters can be well illustrated by comparing the original product cost and CO_2-emission to the new ones, hence possible savings can be well illustrated. CO_2-emissions on the other hand is a relatively new parameter in DFLs conclusion report with an impact that is harder to grasp according to the interviewees. This is because of the difficulties in how to balance the CO_2-emissions compared to other parameters. The DFLe can though see a change in behaviour and hopes to get more requirements approved with the increasing importance of CO_2-emissions.

It is argued that the product development process works well today, however there are several opportunities for improvements. The interviewees mentioned that DFL sees potential for improvements in many areas and small changes can contribute to big improvements. The low number of employees also limits the DFLe and Logistics Range Manager (LRM) possibilities to participate in meetings, and therefore important information can be missed. The DFLe feels that the information from the project meetings is not delivered automatically, hence information needs to be chased. Another expressed opinion on information sharing during the interviews, was that *"information is available, though it is hard to retrieve the right information"* (Personal communication, 16 March 2021). This opinion was expressed because many functions work within individual platforms and therefore sometimes forget to save the data where involved people can easily retrieve it.

One interviewed Technical Preparation Engineer (TPE) expresses that the process of distributing requirements has flaws and concerned parties do not always receive Operations

(OP) requirements in time. Consequently, the TPE must inform the Engineering Task Leader (ETL) and Design Engineers (DE) about OP's requirements. In addition, the interviewed TPE experiences that the regular meetings that should be held between the ETL and TPE are not working as it should, therefore the TPEs must request information and updates from ETL for it to be shared. In addition, the interviewed TPE experiences that the majority of the TPEs have a background in manufacturing. Therefore, if unexpected changes occur during the product development process quick actions can be provided from a manufacturing perspective, but if the problem concerns logistics it is argued that the TPEs often lack knowledge within this area. The interviewed TPE thinks that if the problem concerns logistics, the problem is more difficult to solve and takes longer time. The interviewed TPE's lack of logistics' knowledge can also contribute to neglected logistics' requirements, due to the difficulty of convincing other stakeholders during the balancing of requirements. According to the interviewed TPE it would be beneficial to receive input from Logistics (LOG), through participation in the cross-functional meetings and by improving the distribution of the requested part changes.

The requirements from OP often contradict many of TECH's and other stakeholders' requirements. A feeling that the interviewed TPE has is that OP is at a disadvantage since the impact of many requirements are hard to visualise in cost and therefore downgraded compared to others. For example, the manufacturing requirements are most common to visualise in time to assemble, not costs. It is however important since *"it is important to visualise the effect of potential changes in cost to drive changes"* (Personal communication, 5 March 2021). The TPE states that measurable requirements of sustainability concerning e.g. fill rate and transportation mode would also be beneficial. According to the interviewed TPE *"the logistics' perspective is involved too late in the product development process* (Personal Communication, 5 May 2021).

5.3.2 Technology (TECH)

In the product development process, TECH is responsible for the development and design of the product. During the product development process TECH receives multiple demands and requirements from several stakeholders. The mission is to satisfy the customer by developing a product that meets the expectations and at the same time consider the different stakeholders' requirements in the best possible way, which is a complex task due to the high number of requirements. Therefore, several functions from TECH are involved early in the product development process, since that is where the design of the product is settled. The mission and reflections of the TECH roles Geometrical Architect (GA), Design Engineer (DE) and Engineering Task Leader (ETL) will be explained further in this section.

Geometrical Architect (GA)

A role from Technology (TECH) that is involved early in the product development process is the GA (Figure 19). The mission of the GA is to develop the geometrical dimensions of the soon to be developed component. It means to define the interface to surrounding components, which illustrates the physical external boundaries where the component should fit within. The GAs work in parallel with the Project Leaders (PLS) for Engineering and have a responsibility area for the product and virtual CAD models. They work together in a CAD meeting, where all design initiatives are coordinated, and their feasibility is checked.

The GAs work with multiple requirements where the task is to consider all requirements from the different stakeholders. The stakeholders involved are for example Operations (OP) and Aftermarket, where the GA participates as a speaking partner for all. GA balances the different requirements against each other and illustrates the consequences of different options to the stakeholders. It is done in so called Geometrical Architects Meetings (GAM) in order to make a proposal. The requirements that GA prioritises when the interface to surrounding components are defined, are the geometrical requirements and law regulations.

If the GA does not succeed to balance the requirements so the stakeholders are satisfied, it is the Project Leader's (PLS) responsibility to balance the requirements. In some occasions the question can be taken even further up in the hierarchy if needed. Logistics are rarely involved in the work of the GA, but occasionally law regulations create requirements, which therefore affect logistics. Though, inputs concerning logistics requirements regarding the design of the component are rarely received from either Logistics. When the interface to surrounding components is defined and completed it is handed over to the Design Engineers (DE).

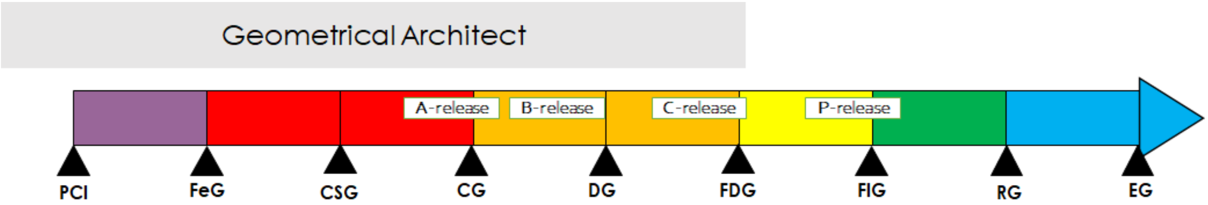

Figure 19. Involvement of the GA in the product development process

Design Engineer (DE)

DE is another role from TECH that is involved early in the product development process, mainly from Project Change Initiation (PCI) and Final Development Gate (FDG), but also all the way to Release Gate (RG) (Figure 20). DE is the role that is responsible to develop the design of a component based on several demands of the stakeholders, in an early stage. According to the interviewee, it means that *"the Design Engineer works as the spider in the web during the design process"* (Personal Communication, 9 April 2020). The DEs connect requirements and demands from stakeholders, to develop the best design of the product. The DE works in two internal platforms when designing the parts in the product development process.

The initiation of a new project starts when a need from a client, usually from a business area or legal requirements, is expressed. From the beginning of the project, the DE identifies stakeholders related to the project, e.g., Product Design (PDe), Purchasing, Operations and creates a "stakeholder list". Operations are involved around the Feasibility Gate (FeG) with input, but the work of verification starts at the Development Gate (DG), and mainly concerns manufacturing. As mentioned earlier, the DE receives the pre-study from the Geometrical Architects (GA), where the interface to surrounding components are defined, as well as requirements from the feature leaders. In addition, several other requirements from the identified stakeholders within the organisation need to be considered during the development of the component. From the stakeholder list the DE chooses which requirements to prioritise concerning the project, since it is often impossible to meet the requirements from all stakeholders and therefore it becomes a trade-off in which ones should be superior. Consequently, the requirements need to be balanced, which means that the requirements are compared against each other in order to know how to prioritise them. It is executed in a

"Geometrical Architect Meeting" (GAM) where the GAs act as moderators. The meeting works as a problem discussion meeting where, for example, the DEs present problems that have occurred during the design of the product. Thereafter the balancing and trade-offs between requirements are pursued, in order for the DEs to know what requirements should be ranked higher when proceeding the design.

The requirements that are prioritised highest are within two main areas. To begin with, the legal requirements are of highest importance in order to produce a product that fulfil regulations. The functionality requirements are another area of high importance since the final product obviously has to work as it should. Moreover, manufacturing requirements are also important in order for the products to be produced as efficiently as possible. However, there are multiple other requirements during the product development process e.g. cost, legal requirements. The nature of the requirements plays a big role when balancing the requirements in the trade-off, i.e. requirements based on regulations have to be fulfilled. Therefore, the flexibility of the product's design is limited depending on what type of components that are developed i.e., when the concept is similar to old ones and might only need small modifications to already well-developed components.

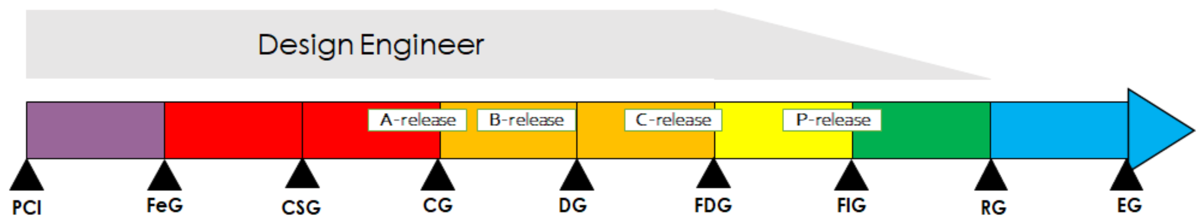

Figure 20. Involvement of the DE in the product development process

Engineering Task Leader (ETL)

ETL are also involved during the product development process (Figure 21). The start of the ETL's involvement in a project is initiated when the project is delivered from the ETLs managers. Product Planning (PPL) is responsible for delivering the prerequisites of the design in the project to the ETL. Thereafter, the mission of the ETL is to develop a product together with PPL based on the delivered prerequisites. Hence, ETL investigates which requested expectations and demands that are possible to achieve and how to achieve them. Several stakeholders are involved with different requirements, consequently many of the requirements contradict each other. Concerned parties in the project are informed of the possible requirements of the project through a meeting, and the process of choosing requirements starts. Depending on the size of the project it is a long process, where the goal is to create the commercially best product through trade-offs between all requirements. To be able to reach a decision several meetings concerning the requirements' trade-off is held continuously through the project where the requirements are sent back and forth several times. The design of the product is settled early in the product development process, hence most decisions are made early in the project.

The requirements are prioritised differently depending on the project. However, the ETL argues that a pattern can be noticed through the projects that requirements of high prioritisation usually are manufacturing, cost and maintenance. ETL works in several internal databases to create and document the details of the product design.

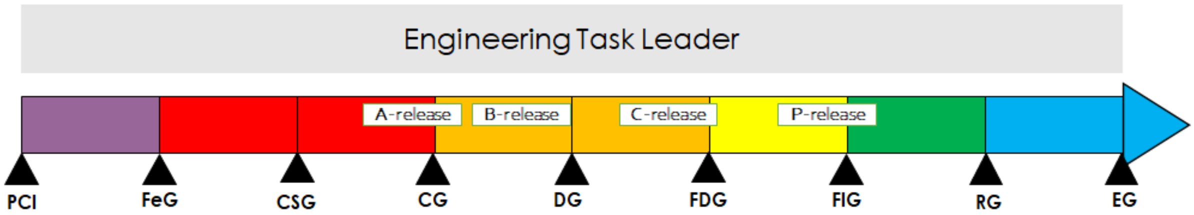

Figure 21. Involvement of the TPE in the product development process

Reflections from Interviewees at Technology

During the interviews interesting findings were made from the participants (Figure 22). Consequently, the interviewees thoughts and ideas will be discussed in the following section. Therefore, the following section is based on personal opinions from the interviewees and only represents the participants' thoughts and ideas, not the whole function.

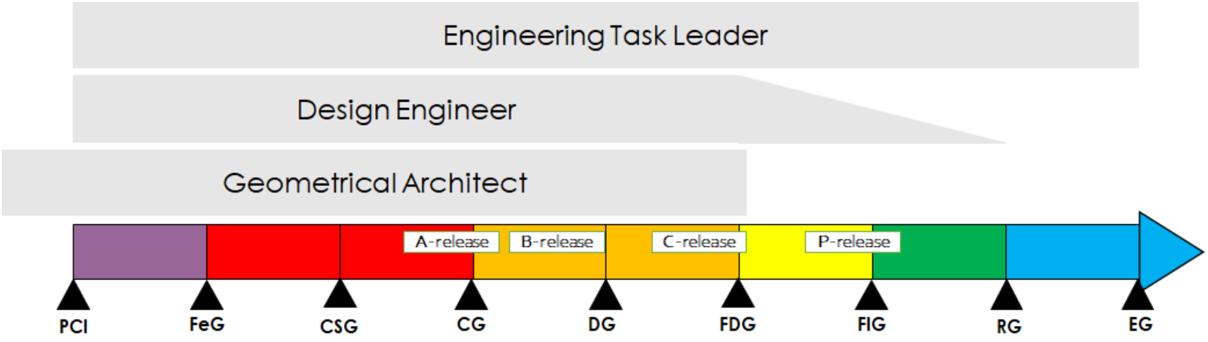

Figure 22. Involvement of roles from Technology

The interviewed Geometrical Architect (GA) argues that the GAs involvement in the product development process is too early in order to consider requirements such as logistics in the process of defining the interface to surrounding components. However, the GA expresses that it does not matter if the product is divided into several components which later on might facilitate the logistics process.

One of the interviewed Design Engineers (DE) worked with components that are bulky and hard to transport, which accordingly contributes to high logistics' cost. However, the interviewees express that DEs do not focus on logistics costs because of several reasons. One of them is because there is no tool available for the DEs to consider the logistics cost depending on how the component is designed. Hence, it is argued that a tool that could be used to illustrate the impact components have on packages would be beneficial in order to show the effect of logistics. DEs focus on the "FCA cost" (excluded logistics' cost) and not the landed cost (included logistics' cost), hence the difference is not illustrated according to the interviewee. It was also argued by the DEs that if the costs connected to logistics could be visualised early in the product development process, the impact would be easier to grasp and needed design changes would be more obvious. Nevertheless, it was argued that a document already exists with all requirements gathered for the DEs to check off when designing. The interviewee could however not find any logistics requirements included in the early phase of the document, only later when Operations (OP) are involved. The list is according to an interviewee unstructured with too many requirements included today, hence it is not fully utilised. Nevertheless, since Manufacturing Sweden is under organisational changes, this document is to be updated in order to facilitate the usage of it. An interviewee mentioned that this is a great chance to integrate the logistics requirements in order for them to be considered in the product development process.

Another reason for the logistics' requirements to be considered is the importance of communication between the Design for Logistics engineers (DFLe) and DE. This is important since, according to a DE, to *"get a better understanding of the DFL's needs"* (Personal communication, 20 April 2021). Another interviewee mentioned that the logistics' requirements *"is rarely brought up and thought of during the design phase, an education would help greatly with that"* (Personal communication, 20 April 2021).

Another opinion that was expressed during an interview with a DE was that transportation is cheap, accordingly logistics is consequently not prioritised. The logistics costs that are considered in the product development process are, according to the interviewee, the outbound logistics cost to customers. The interviewee argues that *"the logistics perspective has never existed during the design process and the component is not optimised for logistics' requirements"* (Personal communication, 9 April 2020). In the design process of the packaging, the focus of the DE is rather on the component's "safety" e.g., so it does not get dirty or scratched, instead of logistics efficiency.

The interviewed Engineering Task Leader (ETL) is often involved from the start of the project to the end of the project. Since, it is, according to the interviewee, valuable to observe the product in the end to see which problems that may occur and learn from it. Though, it is argued that the majority of the ETLs do not follow the product all the way to the end of the project, only in the start phase. The interviewee also expresses that there are many meetings on several different levels throughout the process that are very time consuming. Meetings should be held at the different maturity releases, where a checklist is used to make sure everything has been followed thoroughly, but it is not always done according to the interviewee. ETL works with different contact persons, i.e. Technical Preparation Engineer (ETL) towards Manufacturing., that brings the question further to concerned parties. According to the interviewee it is important to have contact persons, but not too many since it would be too complex and time consuming.

The trade-off between the requirements is a complex process where according to the interviewee, almost everyone thinks that the functions are focused on each own area. However, the interviewee argues that each function involved wants to reach the best final result, and contradictions of requirements are usually solved through discussion. The interviewee expresses that it is of high importance to clearly illustrate the cost savings for logistics to strengthen the requirements. Nevertheless, the CO_2-emissions can be difficult to balance as well as hard to compare to other parameters concerning the development of the product. However, law regulations are highly prioritised in the product development process, and now regulations regarding environment and emissions are becoming more common. The DEs argues that this is something that is closely connected to logistics, and therefore can be an enabler for logistics requirements to become more prioritised.

The ETL's work with logistics is limited today. However, according to an interviewee, when it is for example an effect of law regulations it is considered. During the process of balancing requirements, logistics and manufacturing usually contradict each other since manufacturing would prefer if the components are large and easy to assemble, while logistics want the opposite in order to have a high fill rate. The knowledge of logistics is also limited and highly dependent on the experience. The interviewee gained knowledge of the DFL function through a presentation when the function started several years ago.

5.3.3 Organisational changes

The product development process consists of many roles where each role has its own responsibility. This has been clearly defined in internal documents concerning the product development process at Manufacturing Sweden. However, during the interviews it was shown that the new way of working is not as clear today since Manufacturing Sweden is currently under organisational changes. The company works towards an Agile Project Management approach, which is defined according to Monteiro de Carvalho and Oliveira Santos (2020:97) as "*a highly adaptable life cycle with the progressive construction of requirements from short iterations of planning and execution"*. The earlier product development process will be developed into "Project Streams" and accordingly be executed in a more agile way. This means increasing cross-collaboration between the functions, and working more adaptively with continuous feedback from stakeholders etc. Still however, many interviewees see the new way of working as somewhat confusing since the implementation of the agile approach is still under progress. Because of this, some roles as well as existing meetings where knowledge was transferred between the functions, are currently being eliminated. The new approach will however also focus on cross-collaboration and new ways of working will be introduced. The cross-collaboration will be represented in teams that will consist of representatives from each function, in order to gain and share information. It was also, as mentioned, found that a new document with gathered requirements is to be developed to be used in the new way of working.

6. Benchmark - IKEA of Sweden

In this section the findings during the benchmark study, performed on IKEA that is leading from a logistics perspective, will be explained. The product development process at the company will be explained as well as their view on logistics and other interesting thoughts and ideas. Information was collected from three interviewees that are involved in the product development process, which were a Product Design Developer (PDD), Product Design Engineer (PDE) and a Business Area Sourcing Specialist (BASS). Hence, these roles will be in focus.

6.1 Product development process

The product development process begins with a Range Planning Team (RPT) that investigates opportunities in order to decide which new products to develop. These opportunities could be e.g. customer demands or a gap in the market that can be filled. These opportunities are later on delivered as a range brief to the Product Development Team (PDT) whose job is to develop the product accordingly (Figure 23). Consequently, the RPT are responsible for deciding “what“ product to develop and the Product Development Team (PDT) decides “how” the product should look like. This structure is applied in the business units across IKEA where each unit has a specific responsibility area, e.g. bedroom or living room. The Product Development Team (PDT) consists of cross-functional roles within the organisation, in order to have input from different perspectives. Hence, information and knowledge can be shared and gained between the functions to later on reach the best possible solution for everyone.

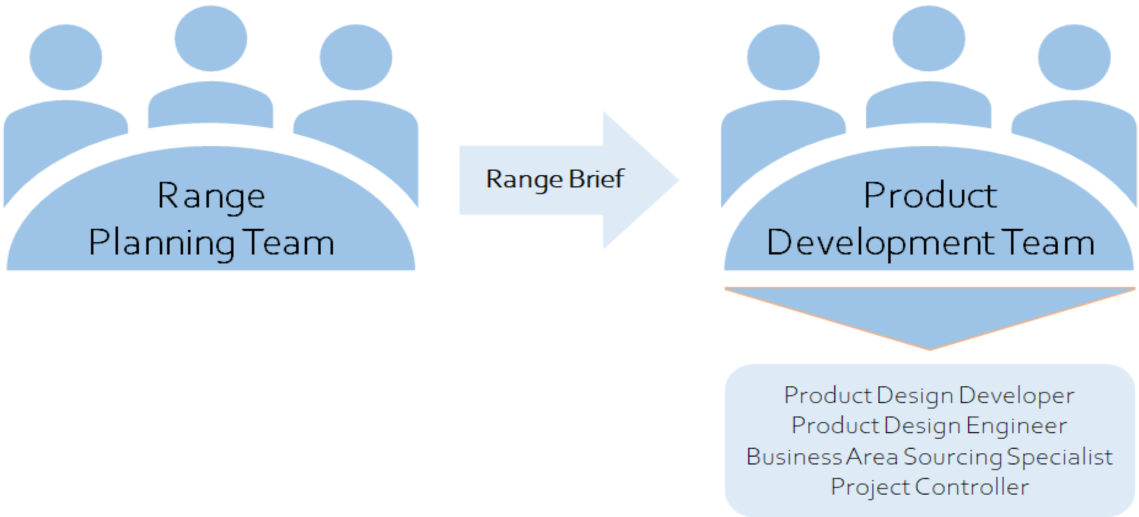

Figure 23. The product development structure of IKEA

The roles involved in the PDT are Product Design Developer (PDD), Product Design Engineer (PDE), Project Controller (PC) (Figure 23). In some business units the sales representative and the Business Area Sourcing Specialist (BASS) are also included in order to provide the PDT with information. Hence, each function is involved early in the product development process, and therefore has an influence on the product design. The PDT analyse the information delivered in order to see if there are any potential risks or opportunities from all perspectives that might occur later in the process. This is an iterative process that proceeds until each area is satisfied with the result, or when the project is finalised. The PDT has meetings every third week in order to keep up with the development of the product. In addition, IKEA has an integrated system, where product documents are stored and are accessible to all. This is according to an interviewee, good since if information needs to be retrieved, it can be done.

The Product Design Developer (PDD) is a project leader that assures that the developed product fulfils the customer demands and requirements from the functions involved. The PDD examines the range brief delivered from the Range Planning Team (RPT) together with the rest of PDT, in order to evaluate problems and opportunities connected to it. The Product Design Engineer (PDE) however leads a group of specialists concerning the technical aspects during the product development process. This is where, for example, the logistics aspects are brought up since the Packaging Engineer (PE) is included in these specialists. The Business Area

Sourcing Specialist (BASS) is responsible for the sourcing activities in the product development process and ensures that product development is aligned with the supplier's production capabilities. Each Product Development Team (PDT) is, as mentioned, responsible for its own business unit, but with the same team structure. Because of this, the communication across the company functions is easy since according to an interviewee, *"it is easy to know who to contact in order for them to send me further to the right person"* (Personal communication, 10 May 20201).

6.2 Reflections from Interviewees

The requirements that are top priority for IKEA are the legal requirements, since these are preconditions for the product to enter the market, according to an interviewee. However, internal requirements on quality are also set from the beginning based on the standpoint of IKEA, commercial need, as well as other parameters. Though, these are argued to be prioritised differently in each project, but the focus of the requirements is always to satisfy the customer demands. However, each function's input is seen as equally important and all requirements are taken into consideration during the product development process. This is important, because as an interviewee mentioned, *"When everyone brings their information to the table, it will help us reach the best solution for everyone"* (Personal communication, 10 May 2021). Hence, there are many requirements to consider, but it is argued that the designers see this as a necessity in order to reach the best solution. By involving each function early in the product development process where the design of the product is settled, the possibility to have an influence on the product design is greater as an interviewee mentions. This is due to the fact that the product is more flexible for changes and improvements can be facilitated, which is according to the interviewee, appreciated by the designers. Consequently, by involving concerned functions early in the product development process, the best possible solution will be reached according to an interviewee.

The interviewees also argued that IKEA is characterised by continuous meetings and communication throughout the projects. Information exchange occurs both formally as well as informally at e.g. meetings, in hallways or through emails. It is easy to get a hold of people where everyone is very helpful, which according to an interviewee creates *"a nice atmosphere to work in"* (Personal communication, 10 May 2021). It was therefore argued that the communication is undemanding and transparent which according to the interviewee, creates a holistic perspective where the organisation works towards the same goals. Therefore, as earlier mentioned, it is argued that no function is downgraded compared to the other hence the logistics requirements are equally considered as the others. Because, as an interviewee mentioned, if the logistics requirements are not considered in the product development process, *"it has to be paid for later since the changes will be more difficult, and therefore more expensive"* (Personal communication, 10 May 2021). This knowledge was argued to be gained from close collaboration in the PDT, but it was also mentioned that education was available, in order to gain knowledge of e.g. other functions. Another example of knowledge gained through the close collaboration in the PDT, is for example when the PDD mentioned that *"changing the length, height or width of the product can have huge effects on the packaging and filling rate"* (Personal communication, 10 May 2021). The interviewee argues that the whole supply chain is considered during the development of the product to know how to facilitate the logistics process from many stakeholders' perspectives. One example of this, is that each package is designed depending on where it is going to be visualised for the customer. For example, if the product is to be picked up directly from where it is displayed the package needs to be both functional and visually attractive. If the product is supposed to be picked up from self-service or warehouse the packaging is more focused on function. However, to have this type of thinking within the company, an interviewee argues that this holistic thinking needs to be obvious for a long time in order for it to be integrated.

Conclusively, IKEA has according to an interviewee, a holistic mindset where each function is equally important. The customer is always in focus, hence the will to work towards the same organisational goals in the company is obvious. To be able to do this, it is argued that communication is vital. This was however, according to an interviewee, easy since the company is characterised by continuous meetings and communication throughout the project. It is also easy to get hold of people due to the product development structure, which facilitates the exchange of information. Accordingly, the knowledge of other functions was argued to be good due to the close collaboration in the team structure. Therefore, logistics awareness is integrated across the company functions, and accordingly has *"a central role in the organisation"* (Personal communication, 10 May).

7. Analysis

The empirical findings clearly show that there are behavioural and organisational factors affecting the integration of logistics awareness, both enablers and disablers. Each function has its own goals and deliverables that must be achieved, which in turn often diminishes the holistic organisational goal. The possibility of integrating the logistics awareness will further be discussed through the developed framework with regards to the empirical findings, as well as the literature study.

Requirements

To begin with, the organisational and behavioural factors of introducing logistics requirements in the product development process, resulted in both enablers and disablers. In the empirical findings, most Design Engineers (DE) argued that there already were too many requirements today and they therefore had a negative attitude towards introducing new ones. This is because the design effort will increase due to the lack of knowledge regarding the new requirements, as well as time to take more requirements into consideration than there already is. Because of this, the logistics requirements might be downgraded compared to the already existing ones. Contradictory, it was a whole other attitude at IKEA where the designers bear many requirements in mind. The designers saw this as a necessity in order to reach the best solution for all stakeholders involved, hence integrating each function early in the product development process was obvious. However, it can be argued that the company's products are difficult to compare due to the difference in complexity. Nonetheless, the designers still argue that the changes of the design are more flexible in the early part of the product development process, hence the functions have more influence. However, IKEA has had an integrated logistics perspective for a long time now, which is required to create change of attitude towards logistics, according to the interviewees.

In the questionnaire performed at Manufacturing Sweden, a prioritisation of the requirements; manufacturing-, functionality-, cost- and logistics were asked to be made. The functionality- and manufacturing requirements were ranked to be most important since, as one interviewee mentioned, "*they need to be fulfilled, since the part needs to do its job and to be easily manufactured"* (Personal communication, 24 March 2021). The result showed that the cost requirements are ranked third, whereas logistics requirements are ranked fourth. Some even argued that logistics requirements rarely are brought up, which implies that there is a lack of logistics awareness in the product development process. However, during the interviews at IKEA, it was mentioned that each requirement was equally important, and no function was downgraded compared to the other. Because of this, the customer was always in focus. It is though difficult to know if the interviewees opinions reflect all people involved, since only one representative from the roles Product Design Engineer (PDE), Business Area Sourcing Specialist (BASS) and Product Design Developer (PDD) was interviewed. However, the equal view of each function is still important in order to balance requirements correctly.

During the empirical study on Manufacturing Sweden it was shown that sustainability is becoming more important. Especially, the reduction of CO_2-emissions was brought up as an important aspect to be considered. According to an interviewee, another enabler for the integration of logistics awareness would be the visualisation of costs, which could show the impact that logistics has on cost. Hence, it was argued that the will to take the logistics requirements into account may increase. This indicates that the Design for Logistics engineer's (DFLe) information is not reaching all DEs in the projects, since the initial conclusion report delivered to Technology (TECH) visualises both costs and CO_2-emissions. Furthermore, in the questionnaire that was made in order to strengthen the statements from the qualitative study, many DEs argued for the importance of the logistics requirements due to the cost savings, successful assembly in factories as well as the environmental aspects. The mixed attitudes towards introducing logistics requirements in the product development process conclusively showed that the behavioural factors play a big role. Each individual has its own background and experience, therefore some attitudes were positive, while some were negative. However, the will to work towards the same organisational goals was more obvious when the interviewees had experience of work within other functions. The holistic view was more apparent as well as the understanding of other functions needs and requirements.

During the empirical study it was found that there already exists a document with requirements that need to be fulfilled before proceeding in the product development process. This document was unknown for some interviewees since it was barely used due to the unstructured design as well as the already many requirements that exist. It was also found out during the interviews that barely no logistics requirements were included in the document. The document was divided into the stages of the product development process, where the logistics requirements was only included in the later stages. This was shown during an interview where the document was presented, and the interviewee could not find any logistics requirements in the early part of the product development process within the document. Nevertheless, since Manufacturing Sweden is currently under a re-organisation, there is a new document with requirements to be developed. This could be, according to an interviewee, a great opportunity to integrate new requirements in order to facilitate the integration of logistics awareness. However, the requirements has to be integrated in an understandable way, in order to have a positive effect on the creativity and innovativeness of the designers. Accordingly, as the interviewees mentioned, the existing document was not used due to the unstructured design which implies that the introduction of new requirements need to be structured. The Critical Parts List however, is a structured list where components that stand for high logistics costs are stated. This might be a way to integrate the logistics awareness earlier in the product development process, since the knowledge about which components that stand for high logistics costs will be visualised. However once again, there are already many requirements and the integration need to be done in a structured and convincing way in order for the new requirements to be considered. The DEs argued that having knowledge about the logistics impact would increase the will to consider logistics requirements. It was also argued that if the impact was visualised with numbers, e.g. cost, it would be even more convincing to consider.

Knowledge

Knowledge about other functions plays a huge role in the integration of logistics awareness and could accordingly increase the holistic view of the organisation. It was however noticed during the interviews that many Design Engineers (DE) were not acquainted with the work of Design for Logistics (DFL), which could explain the lack of knowledge DEs have about the function. Accordingly, the DEs might be biased and only focus on the already existing requirements. Therefore, the impact that small design changes can have on cost savings are not known for the DEs, which accordingly is a disabler for the integration of logistics awareness. However, it was argued by an interviewee that if the Critical Parts List could be integrated earlier in the product development process, knowledge about the components that stand for high logistics cost might increase. Another opportunity the interviewees brought up was that an education in how to think when designing for logistics would be beneficial, since it was argued that *"design for logistics is rarely brought up or thought of during the design phase, and an education would help greatly with that"*(Personal communication, 20 April 2021). The Design for Logistics engineer (DFLe) argues that something more long term needs to be put in place, while the DEs saw this as an important step in order to *"get a better understanding of DFL's needs"* (Personal communication, 20 April 2021). Accordingly, this could also be applied for the Geometrical Architect (GA), in order to gain knowledge about the function. It was however argued that an education or presentation could increase the awareness about the impact that logistics has, which therefore also might enhance the Technical Preparation Engineers (TPE) knowledge about logistics. Accordingly, the knowledge might facilitate the TPE's ability to discuss from a logistics perspective, when delivering the Operations (OP) input to Technology (TECH). However, in the new way of working at Manufacturing Sweden, teams will work collaboratively to share and gain information from each function. This structure in the development process is similar to the product development structure of IKEA with the Product Development Teams (PDT). An interviewee mentioned that when there were continuous meetings where information was exchanged, knowledge about other functions increased. However, at Manufacturing Sweden the understanding could, as mentioned earlier, also be easier to cope with if the impact was visualised in numbers such as cost. This is already done today in the DFL initial conclusion report, which accordingly shows that the information does not reach all people needed. This could also create a holistic view of the organisation and accordingly create a positive attitude amongst the employees. According to the literature study this was shown to be important in order to have a well-functioning information sharing in the company. However, it is not easy due to the many functions that exist in organisations today.

Communication

Communication is as mentioned important in order to share knowledge and information in a facilitated way. It is however difficult due to the many company functions that often exist within large companies. Because of the many functions, information often has to travel through many processes before reaching the right person. This is however supposed to be facilitated with the new Design for Logistics process (described in chapter 5.2), but the process is still new and therefore not fully integrated yet. This was noticed repeatedly during the case study, since some reflections from the interviewees contradicted from the process that already existed. For example, the interviewed Technical Preparation Engineer (TPE) requests information such as fill rate and transportation mode, but this information is already included in Design for Logistics (DFL) initial conclusion report. Another example is that the Design Engineers (DE) request information about the impact logistics has visualised in costs in order to get a better understanding of it. However, this is also included in DFL's initial conclusion report. Hence, the information that Design for Logistics engineer (DFLe) brings to the cross-functional meeting within Operations (OP) is argued to not have the reach needed. This could depend on several reasons, where one of them is that the DFL process is still rather new. Therefore, the Design for Logistics process needs to be better integrated in the development process in order to facilitate the information flow.

It is also argued that the TPE who is the speaking partner for DFL has limited knowledge of logistics and is therefore not able to discuss from a logistics perspective. At IKEA the speaking partner for logistics is the Product Design Engineer (PDE) who is the leader of the technical specialists. It was argued that the logistics requirements were delivered in the same time as other requirements were delivered to the PDT, hence they were equally valued and had a greater impact. However, the knowledge regarding logistics at Manufacturing Sweden could be solved with, as mentioned earlier, an education or presentation of DFLs work. It was also discussed that the newly recruited TPEs could have a background of some generic logistics knowledge, in order to enhance the ability to discuss from a logistics perspective. However, an education was seen as a temporary solution and might not work in the long term. Though, it was argued that this could be beneficial since there are many DEs that are not aware of the existence of DFL.

The communication is as mentioned important in order to have a facilitated information flow. Today the initial conclusion reports from the DFLe are delivered to Technology (TECH) around Concept Gate (CG), while the work of Design for Logistics engineers (DFLe) is already pursued from the pre-PCI gate. However, since DFL deliver the initial conclusion report with the rest of OP, it was shown that OP and TECH are working in parallel. The Geometrical Architect Meetings (GAM) are already executed at the Feasibility Gate (FeG), hence the building of concepts is already pursued. Therefore, little information from the DFLs perspective is shared in the early part of the product development process which accordingly leads to less flexibility in the product design changes. However, it was argued in the interviews that some individual initiatives had been taken to receive and share information in the early part of the product development process across the functions. Because of this, input from the DFL has been delivered early in the product development process and accordingly a decrease in cost has been achieved. Interaction will increase and as the literature study discussed, continuous communication increases transparency within the company.

Another finding was that an internal platform also may enhance the facilitation of information flow. Today Manufacturing Sweden has an internal platform where data is shared, however it is difficult to retrieve. This is because, as an interviewee mentioned, *"information is available, though it is hard to retrieve the right information"* (Personal communication, 16 March 2021). It is also argued that many functions work in specific platforms when executing individual work, and therefore not sharing it on the internal platform with the other data. However, IKEA mentions that all data is saved in a common platform. An interviewee therefore mentions that if information is needed, it can be retrieved through the internal platform. It is though difficult to know if this applies to all functions within the company, some might have individual platforms when working that the interviewees are not aware of, hence not as easily accessible.

The new way of working at Manufacturing Sweden with teams will, according to an interviewee, require more meetings than there are today in the product development process. However, this new way of working is similar to the product development structure of IKEA with the Product Development Teams (PDT). Furthermore, since IKEA has the same structure in each business unit, it was argued that it is easy to get a hold of people within the company. Additionally, the PDTs have continuous meetings where information is exchanged on a constant basis, therefore the communication is easy according to an interviewee. This implies that DFLs involvement in the new way of working with teams could be beneficial, since the communication across the company functions might be enhanced.

8. Concluding Discussion and Recommendations

Throughout the research on Manufacturing Sweden and IKEA many interesting findings were made. Manufacturing Sweden has developed within logistics during recent years and are therefore on the right path to becoming a more logistics-oriented company. In this chapter the research questions will be answered, but also the conclusion and recommendations will be presented.

8.1 Answering Research Questions

- *Which enablers and disablers for logistics awareness in the product development process are presented at Manufacturing Sweden?*

There are many organisational and behavioural factors concerning the integration of logistics awareness. The factors found on Manufacturing Sweden are divided into enablers and disablers, which means factors that either hinder or facilitate the integration of logistics awareness. These are gathered and visualised in Figure 24, where the enablers are stated with a positive sign and the disablers with a negative sign. The figure was created in order to structure our findings, and accordingly answer our first research question.

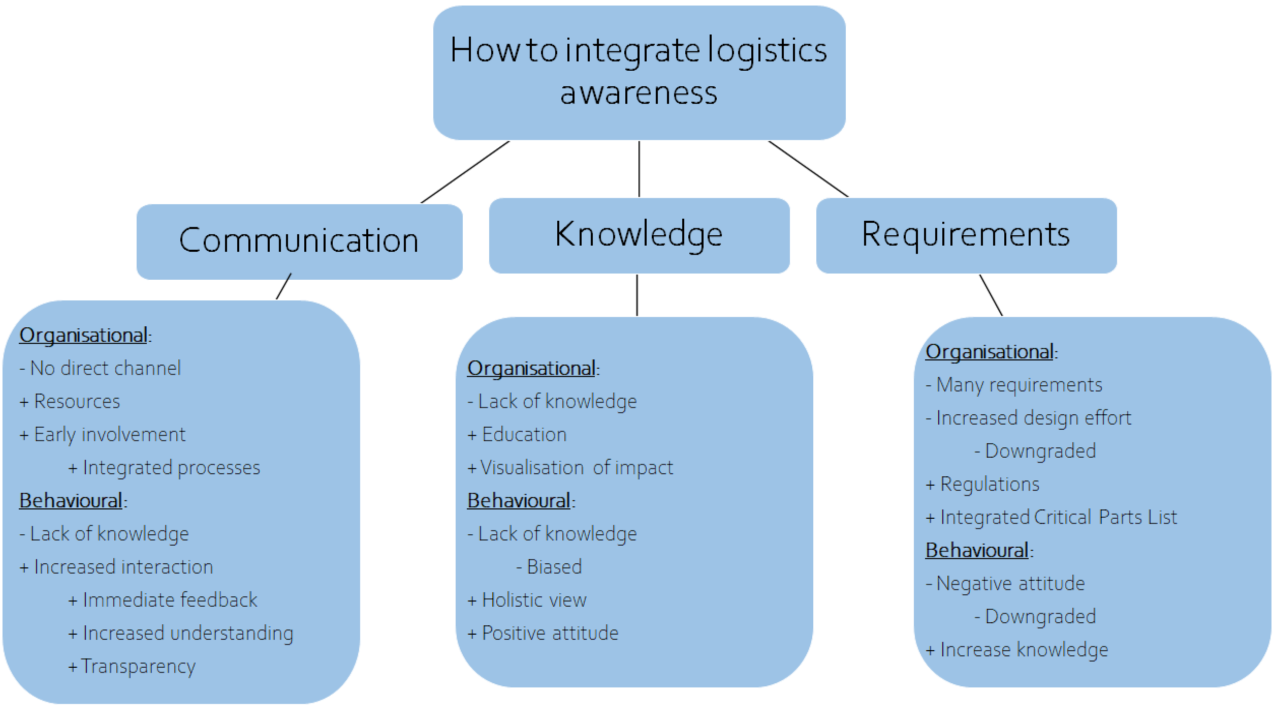

Figure 24. How to integrate logistics awareness

- *How can logistics awareness be integrated at Manufacturing Sweden's product development process with regards to behavioural and organisational factors?*

The findings made in the first research question led to identified opportunities at Manufacturing Sweden, hence the second research question could be answered. The opportunities on how to integrate the logistics awareness in Manufacturing Sweden's product development process will further be stated in bullet points and some visualised in Figure 25 to facilitate the understanding. The grey coloured arrow in Figure 25 of the "DFL input" is where the initial conclusion report is integrated today, while the green one is the recommended area of input to TECH. However, the initial conclusion report will still be delivered where the grey arrow is located, since the work of DFL requires the CAD models that are delivered at the A-release.

- DFL should be involved earlier in the product development process than the function is today
    - Deliver input at the Geometrical Architect Meetings (GAM) in order to be involved earlier across the company divisions
    - Share the Critical Parts List at the GAM as well as to the Design Engineers (DE) and Geometrical Architects (GA), to increase knowledge about the components that drive logistics costs.
- An education and presentation for the GAs, DEs and Technical Preparation Engineers (TPE) should be executed in order to enhance the logistics awareness
- Create a structured internal platform to increase the sharing of information
- Integrate the DFLe in the "teams" in the new way of working to be able to deliver input early in the product development process
- Logistics (LOG) should participate in the creation of the new requirement document

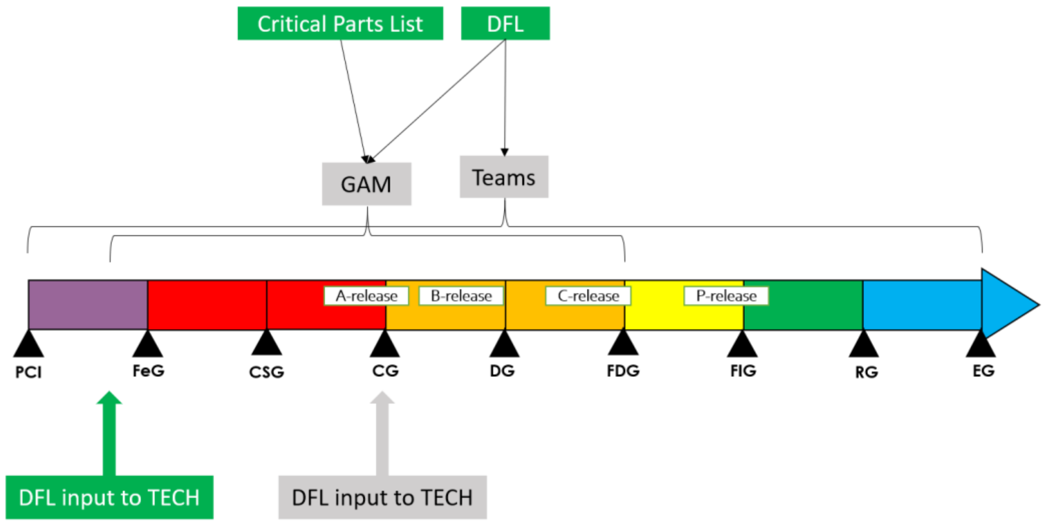

Figure 25. Suggested improvement to increase the logistics awareness in the product development process

8.2 Conclusion

During the research it was shown in both the case- and literature study that the number of existing requirements plays an important role to integrate new ones in the product development process. The behavioural factors found were based on personal attitudes regarding integrating new requirements, while the organisational factors were based on e.g., unstructured requirement documents. However, it was also shown that a holistic view of the company resulted in better understanding of other functions requirements, which implies that knowledge facilitates the integration of logistics awareness. The knowledge will increase the holistic view of the company and therefore increase the will to work towards the same organisational goals. The behavioural factors found were the importance of a holistic view of the company, while the organisational factors were based on cross-collaboration in the early phase of the product development process. In order to enhance the cross-collaboration, communication is important. It was especially shown to be important in large companies with complex structures, in order to have quick access to information. Accordingly, it was found that the development of new products was facilitated due to the increased communication in several channels, e.g. email, internal platform and meetings. Therefore, it was found that the behavioural factors were increased interaction, which implies transparency, immediate feedback and increased understanding between functions. The organisational factors found were the importance of a direct channel to communicate through, but also the importance to communicate across the divisions early in the product development process. This is important in order to have an impact on the design of the product.

8.3 Recommendations

The recommendations for Manufacturing Sweden will be presented in the areas of requirements, knowledge and communication in order to facilitate further work.

Requirements

To facilitate the integration of logistics awareness, the integration has to be structured and understandable in order to be used. Therefore, the logistics requirements should be integrated in the new document to be developed. Hence, it is recommended that Logistics (LOG) get in contact with the developer of the new document which accordingly can lead to that the logistics requirements can be more prominent. Another opportunity to integrate the logistics requirements in a structured and understandable way, is to integrate the Critical Parts Lists earlier in the product development process. This should be integrated at the Geometrical Architect Meeting (GAM) or when the Design Engineers (DE) are designing the components. Foremostly, it should be integrated at the GAM since this meeting is executed early in the process, hence a bigger influence could be achieved. However, the Critical Parts List should also be distributed to the DEs in order to enhance the logistics awareness and to integrate the logistics requirements, when the component is designed. Accordingly, the Design for Logistics engineers (DFLe) will have more resources to focus on other components excluded from the Critical Parts list, since the ones included have already been considered early in the product development process. These recommendations will accordingly be a structured integration of requirements, however the will to work toward the same goal is important in order for this to work, which will further be described in the knowledge section below.

Knowledge

Many Design Engineers (DE) are not acquainted with the work of Design for Logistics (DFL), which implies that knowledge about the small changes that can lead to cost savings are missing. In order to solve this, a recommendation would be to integrate the Critical Parts List at, as mentioned, either the Geometrical Architect Meeting (GAM) or when the DEs design the component. This way the knowledge about which components that stand for high logistics cost will be enhanced. Another recommendation is an education in how to design for logistics, or a presentation of the DFL function that will enhance the knowledge of the DEs and the Geometrical Architects (GA). This will accordingly increase the understanding of the logistics function and therefore the will to work toward the same organisational goals will be enhanced. The education also applies to the knowledge of the Technical Preparation Engineers (TPE) in order for them to discuss from a logistics perspective at the cross-functional meetings. The new recruitments of TPEs should also have logistics knowledge in order to be aware of the logistics' impact. Because of this, the logistics perspective of the TPEs will be enhanced during the process of delivering the input of Operations (OP) to Technology (TECH).

Communication

In order to facilitate secured processes for information sharing, there are several opportunities that can be investigated. One of them is that the Design for Logistics process needs to be better integrated in the product development process. It is a rather new process which could imply that it needs time to be integrated. However, a presentation for the involved people within the process will enhance the understanding, and accordingly the process will be performed correctly. The company has an internal database today where information is shared, however it is argued that the right information is hard to retrieve. Therefore, the existing internal platform needs to be more structured in order to facilitate the sharing of information. However, since this is a big step, it might be difficult. Instead, the functions should share relevant information with each other through the same platform. It is also recommended that access to the Critical Parts List should be provided for the relevant functions involved in the product development process. Another recommendation to facilitate the communication is that the Design for Logistics engineers (DFLe) should participate at the Geometrical Architect Meeting (GAM) to deliver information through a direct channel. Hence, the input from DFL should be provided to TECH at the GAM, which will lead to an input from DFL before the A-release instead of afterwards. However, the initial conclusion report will be difficult to deliver earlier than the A-release since the DFLe needs the CAD models to calculate on costs and CO_2-emissions (Figure 25). The earlier delivered input will increase the transparency between the functions, hence information and knowledge can be shared and accordingly design changes will be facilitated. Additionally, in the new way of working, the DFLe should participate in the teams to be able to have influence as well as sharing knowledge early in the product development process. Therefore, the Logistics (LOG) function should either increase its resources, or a screening of the DFLe's meetings will be necessary.

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Appendix A – Interview Questions Case Study

Interview Questions (Case study)

- What is your title and what do you do?
- What is your role in the product development process?
    - In which stage are you involved?
    - Which people/department do you receive your facts from, and when?
    - What information do you receive?
    - Which data system do you use?
- Which people do you report your work to, and when?
- How do you share your information and result, with which functions?

How do you collaborate with other departments/colleagues, both officially and unofficially? And with whom?

Do you think that you have good collaboration with your colleagues/departments today?

- Official? Unofficial?
- What about it is good/bad?

Do you feel that your input matters? (more/less than other departments/function)

Do you feel that other departments/functions have knowledge regarding your area?

Do you think that it is important that they have knowledge about it?

- Do you have any ideas on how this could be improved?

- What do you think is good about the process today?
- What could be done to facilitate/improve your work?
- Do you have enough resources at your department?

Appendix B - Questionnaire

Your view on logistics

Statements ranked from 1 to 5, where:

1 = Disagree with the statement

5 = Agree with the statement

1. My knowledge about logistics is good?

① ② ③ ④ ⑤

2. I think it is important to take logistics into account?

Yes

No

3. Why is it important?

4. Why is it not important?

5. I am well acquainted with work of "Design for Logistics"

① ② ③ ④ ⑤

6. I think there are too many requirements to take into account when I design

① ② ③ ④ ⑤

7. I think I have too much workload today.

① ② ③ ④ ⑤

8. Are your cooperation with other departments good today?

Yes

No

9. Why is it good?

10. Why is it bad?

11. What requirements do you consider to be most important when designing? (Multiple options available)

Functional requirements Manufacturing requirements

Requirements of cost Logistics requirements

12. Why do you think this/these requirements are more important than the others?

13. During the design process I have close collaboration with… (By this we mean different roles that you work closely with from other functions, when e.g. problem occur)

14. Have you ever worked within a different department?

Yes

No

15. Which department or area was it with?

16. How would you feel if requirements regarding logistics were to be implemented?

Good

Bad

17. Why?

18. How would you feel if requirements regarding you got education in how to think when designing for logistics?

Good

Bad

19. How would you feel if you an education in how to think when designing for logistics?

Good

Bad

20. Why?

21. How would you feel if the communication between your department and Design for logistics department were to increase?

Good

Bad

22. Why?

23. Design for Logistics would join the meeting where requirements are balanced?

Appendix C - Interview Questions IKEA

- What is your title and what do you do?
- What is your role in the product development process?
  - In which stage are you involved?
  - Which people/department do you receive your facts from, and when?
  - What information do you receive?
  - Do you work in the same data system as other functions?
- Do you have cross-collaboration meetings?
- How do you consider logistics in you work?
- Which requirements are most important?
  - Do logistics requirements play an important role?
- How are the effects of logistics illustrated?
- Do you have any education to improve the logistics awareness?
- How is the will to change in you company?
- Do you have an integrated system?
- Do you have enough resources at your department?
- Your company are very successful from a logistics perspective, why do you think that?