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Distribution of large-size products in a global supply chain

Design alternatives for the distribution of large antennas at Ericsson

Master's Thesis in the Master's Programme

Supply Chain Management

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Abstract

Designing a distribution of products where customer requirements are met, and the environmental impact and cost are reduced is an important part of a company's supply chain performance. The design of the distribution of products is hence important to address. The thesis has been conducted in collaboration with Ericsson, a multinational networking and telecommunications company. At Ericsson, the study has been performed within the business segment Microwave which provides Microwave telecommunication networks where multiple products are constituting an order. The distribution of large antennas has been identified as a product group that is affecting the supply chain performance negatively in regards of the distribution cost, environmental impact and lead time. Hence, the thesis aimed to find suggestions for changes of the current distribution of large antennas to reduce lead time, cost and environmental impact.

To achieve the purpose, an understanding of the Microwave supply chain was important as Ericsson offers complete network solutions. The current structure may be described as "one size fits all" having a centralized structure with one outbound shipping point in the general case. Currently, the antennas are sourced from three different suppliers who deliver antennas in different forms, fits and functions. The challenges that have been identified with the current distribution structure is related to the lack of flexibility, performance evaluation, product-adoption, information sharing and alignment with the competitive factors of Ericsson Microwave. The analysis of different distribution strategies was developed in collaboration with Ericsson through a workshop and qualitative interviews where several solutions were evaluated using the created theoretical framework. The first suggestion relates to direct distribution where antennas are shipped from the supplier site to the customer without intermediary handling points. The second suggestion include the usage of a regional intermediary located closer to the customer. A third suggestion is to implement regionalised supply where antennas are sourced from regional production sites. Finally, the concept of postponement as well as reconstruction of the antenna design were identified as two alternatives which may positively effect antenna distribution.

To stay competitive and have the ability to answer to changing requirements, there's a need for a more flexible supply chain being able to respond differently to different customers. It has therefore been concluded that there is no standalone solution, several identified alternatives should instead be implemented to achieve a flexible and more responsive distribution and supply chain. To succeed, a comprehensive investigation regarding legal and trading aspects needs to be conducted to further explore how a future distribution of large antennas could be designed.

Keywords: Global Distribution, Telecommunication, Distribution Flexibility, Network System, Environmental impact of Distribution.

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List of abbreviations

ATO – Assembly-to-order

BOQ – Bill of Quantity

CODP– Customer order decoupling point

EAB – Ericsson AB

EDC– Ericsson distribution center

EMS – Ericsson manufacturing site

ERP – Enterprise resource planning

ESH – Ericsson supply hub

HU – Handling unit

KAM – Key account manager

KPI – Key performance indicator

LC – Local company

MTO – Make-to-order

MTS – Make-to-stock

ODM – Order desk management

PO – Purchase order

PTO – Purchase-to-order

RFQ – Request for quote

SO – Sales Order

1. Introduction

This chapter aims at giving an introduction to this study by introducing the background for the subject. Followingly, the aim and the research questions of the thesis will be presented as well as the delimitations.

1.1 Background

Due to the increasing changes in the business environment, the supply chain of a company has become a force to increase the competitiveness of a company (Melnyk, Narasimhan, & DeCampos, 2014). Globalisation has spread company operations and sourcing worldwide. Additionally, new actors are intruding new markets creating an increased competition. For companies operating in a global environment, the strategic supply chain is a quest for competitive advantages managing political, economic, cultural and social complexity (Skjøtt-Larsen, Schary, Mikkola, & Kotzab, 2007). A supply chain is defined by:

"a global network of organizations that cooperate to improve the flows of material and information between suppliers and customers at the lowest cost and the highest speed. The objective of a supply chain is customer satisfaction." (Govil & Proth, 2002, s. 7)

The main consequences of global sourcing and operations are longer supply lead times, increased consolidation points, usage of several transport modes and unreliable transit times (Bowersox D. J., Closs, Bixby Cooper, & Bowersox, 2013). Companies' ability to access material and deliver to markets decrease as the time and distance between production and points of supply and consumption increases (Ross, 2015). The extended supply lead times give rise to an inflexible and less reliable supply chain facing challenges to meet the customer requirements (ibid). A challenge though arises between meeting customer requirements quickly and making the supply chain more cost efficient. A contradiction is hence acknowledged which creates challenges for companies to decide upon what strategy to use (Rushton, Croucher, & Baker, 2017)

To bridge the gap between demand and supply, management of logistics is one of the critical functions that companies need to have (Ross, 2015). Rushton et al. (2017) define the components of logistics as materials management and distribution. Logistics is a competitive resource in the global supply chain context as it enables companies to span geographical barriers and may create value through fast and cost-efficient delivery of products (ibid). Delivery lead times and flexibility are important factors for winning an order as the technical and product specific features are more or less considered as "given" by customers (Christopher, 2011). Hence the service provided through logistics processes is important for companies. One part of logistics is distribution, which represent the storage and flows from final production through to the customer (Rushton et al., 2017). Distribution directly affects both supply chain cost and customer value which makes it a key driver of overall profitability of a company (Chopra & Meindl, 2013). Searching for ways to improve delivery service while lowering or maintaining costs is important for a global distributor (Ross, 2015). One way to achieve this is to develop alternative distribution structures. In many cases, the existing distribution networks of companies has evolved with limited planning and business changes are not always reflected in logistics operations development (Rushton et al., 2017). Knowing how distribution can be improved and moving towards this change is thus important for companies (ibid).

When studying and managing logistics a dominant paradigm has been related to commercial interest, thus organising logistics to maximize profitability (McKinnon, Browne, Whiteing, & Piecyk, 2015). However, the concern for the environment has increased among public and government which has put pressure on companies to reduce the environmental impact from logistics operations. The environmental effects and costs of logistical activities mostly arise from freight transport operations, thus the movement of goods. Noise and vibration, poor local air quality, accidents and contribution to global warming are some of the negative effects sourced from distribution of goods (ibid). Through implementing a sustainable supply chain where fuel and resources are used more efficiently, companies can achieve supply chain cost reduction (Millar, 2015). This kind of supply chain strategy is not only beneficial in a cost perspective, but also to be more attractive to other businesses and consumers and in turn drive business growth.

The telecommunication business market is complex, being globally present and dealing with country-specific regulations concerning frequency attributes as well as international trade (Battu, 2014). A company within the telecommunication market with global presence is Ericsson. Ericsson offers solutions of information and telecommunication technology, currently carrying 40% of the world´s mobile traffic through their networks (Ericsson, 2019). A business segment within Ericsson which has experienced a need for improvement in distribution performance and environmental impact is Ericsson Microwave. The climate impact sourced from Ericsson was addressed in an article where Ericsson, together with two other major companies, were claimed to release more greenhouse-gases worldwide than the total consumer-based emissions in Sweden (Gustafsson & Stiernstedt, 2018). This led to the questioning of the responsibilities taken by these large actors.

Telecommunication networks include a combination of hard- and software that through an interaction enable communication between two or several geographically distant devices (Battu, 2014). When operating such a network, there is a need for several different products functioning simultaneously to enable communication (ibid). Hence, several products which are sourced globally need to be coordinated to enable a network to be installed. Large antennas, as defined by Ericsson Microwave, include antennas with a diameter of 1.8-3.7 meter and has a supply lead time longer than the other products in the product portfolio, thus impacting the time-to-customer negatively. Further, the product group's bulkiness and size are negatively impacting distribution cost and environmental impact. Due to the need for a customized setup to a customer base spread all over the world, Ericsson Microwave needs to handle demand from a variety of customers considering supply chain cost, environmental impact as well as delivery performance which is a boundary to stay competitive.

1.2 Aim and research questions

Based on the background, the aim is formulated as below:

The aim of the thesis is to find suggestions for changes of the current distribution of large antennas to reduce distribution lead time, distribution cost and environmental impact.

The aim give rise to the following research questions:

Ericsson is a global company operating world-wide and there are several departments with different responsibilities involved in the supply of large antennas. Skjøtt-Larsen et al., (2007) argues that if wanting to manage the supply chain of a company, a prerequisite is to understand it. As distribution is a part of the whole supply chain, it is of importance to understand the environment in which the supply chain is operating and what stakeholders that are involved. Thus, the first question is formulated as following:

- *How is the current supply chain of large antennas designed?*

Answering the first question will hence give an overview of the supply chain which will constitute the basis of the thesis. Followingly, to find potential improvements there is a need to address what issues the organization is facing in the current distribution which leads to the second research question:

- *Which key issues can be identified in the current distribution of large antennas?*

To improve the distribution of large antennas and address the identified issues, there is a need to identify alternative solutions for distribution considering distribution lead time, distribution cost and environmental. The third research question is therefore:

- *What alternative suggestions for distribution can be identified for large antennas?*

1.3 Delimitations

The thesis was conducted in collaboration with Ericsson Microwave Supply and consequently the scope of the thesis was limited to the Microwave Product Portfolio. The thesis studies the supply chain from first-tier supplier to customers and is limited to only study one-way supply of products, thus the thesis does not include returns or the handling of damaged products in a reversed material flow. The study will include establishment of new mobile transport networks and will thereby exclude orders of spare parts.

The administrative function of the supply chain was treated on a general level with limited considerations to the current practices and processes. Thus, the detailed routines and activities as well as support from IT-systems at Microwave Supply were not taken into considerations in the suggestions for changes. The study is performed at a strategic level and hence, operational improvements were not in focus but rather changes and developments representing a greater impact on the supply chain performance in the long term. In addition, the thesis is limited to not consider implementation strategies for suggested changes.

2. Method

The chapter aims to explain how the research was conducted to answer the research questions. Thus, the following chapter include a presentation of the research process, strategy and method used to fulfil the aim of the thesis. Additionally, the quality of the research is addressed.

2.1 Research process

The research process was divided in three steps and structured as seen in Figure 1. An initial literature review was conducted followed by a formulation of the problem to define the scope of the research. The selected product group, large antennas, constitutes of heavy and bulky products and are today alloying the possibility to satisfy customer requirements due to long lead times and a costly handling. In addition, the product group is defined by Ericsson as critical to enable an improvement of the supply chain performance. The first step of the study was concluded by breaking down the problem to identify an aim and the research questions of the thesis. The research questions should act as a guidance throughout all parts of a research study (Bryman & Bell, 2015). Therefore, the research questions were used as the basis in the continuous steps in the research process, from the creation of a literature framework to data collection and analysis. Thus, three research questions were formulated as "*How is the current supply chain of large antennas designed?"*, "*Which key issues can be identified in the current distribution of large antennas?*" and "*What alternative suggestions for distribution can be identified for large antennas?*

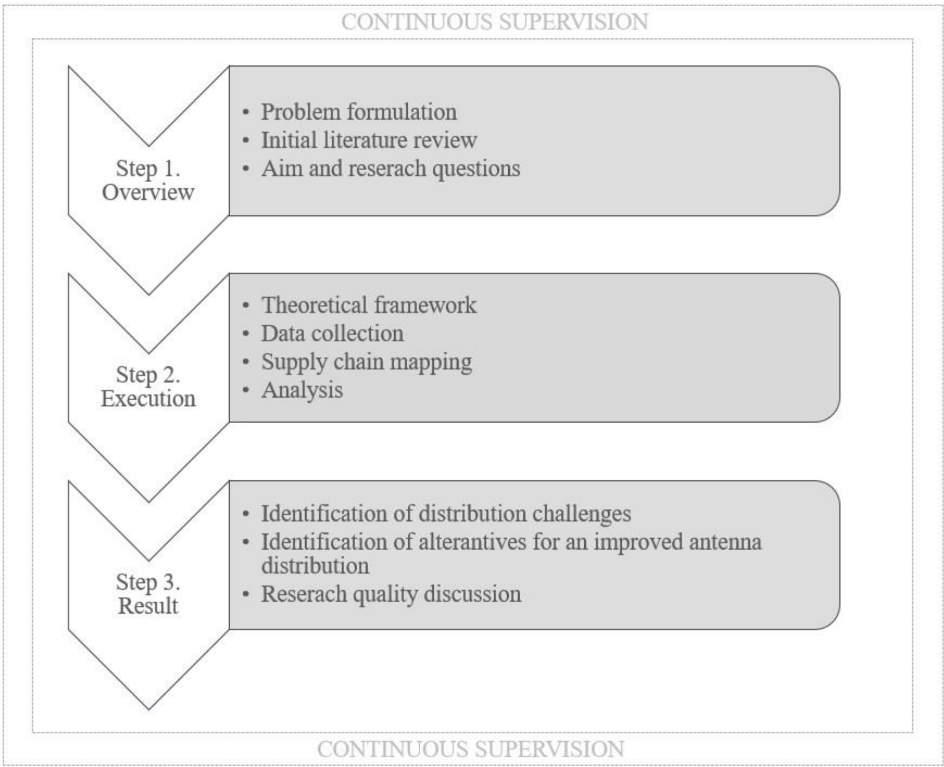

Figure 1 - A presentation of the thesis structure including the three process steps.

Thereafter, the execution section was initiated with the aim to achieve the following steps:

1. Define factors for a successful global distribution
2. Create a supply chain mapping of Ericsson's supply chain
3. Map the supply chain of Ericsson towards defined success factors
4. Identify adjustments to reach possibilities for a successful distribution strategy

The above steps were influenced by Skjøtt-Larsen et al. (2007) process of understanding a supply chain that involves the development of a framework for analysis, the recognition of the supply chain nature and the identification of all processes that are involved. To succeed, the execution section includes an extensive literature review to enable the creation of a theoretical framework. The literature review was performed in an iterative manner throughout the study. The execution step also included data collection where the data partly was used to map the current supply chain and partly to evaluate suggestions for changes. Followingly, the theoretical framework was used to map the factors identified in the literature against the empirical findings. Thus, acting as the foundation for the research analysis and discussion. Figure 2 illustrate how the theoretical and empirical findings were used to answer the three research questions.

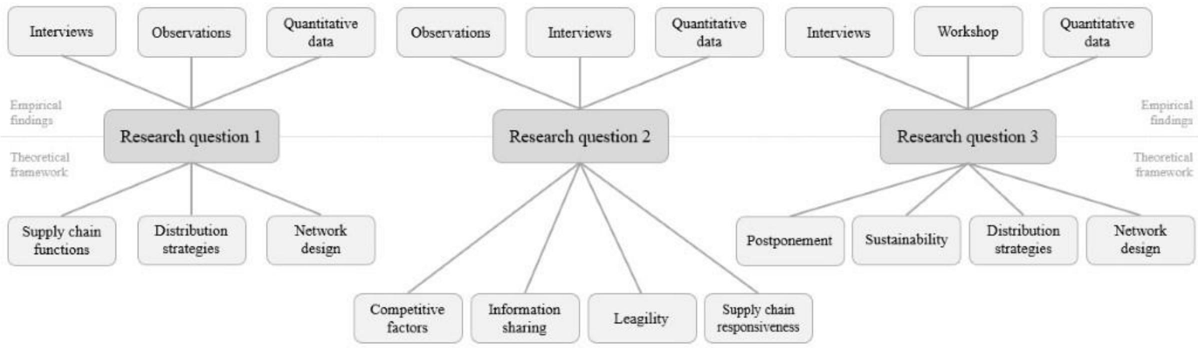

Figure 2 - Mapping of empirical and theoretical findings to answer the research questions.

The completion of the analysis initiated the final step of the research study where the conclusion was formulated, answering the research questions and thereby fulfilling the aim of the thesis. Further, a discussion about the research approach and results was conducted. Throughout the process, continuous supervision was provided by a supervisor at Ericsson Microwave and a supervisor at the Supply and Operations Management department at Chalmers University of Technology.

2.2 Research strategy

The strategy of a research shows the orientation the research is conducted within (Bryman & Bell, 2015). In the thesis, a mixed model strategy was used meaning that the research strategy will be of both a qualitative and quantitative character. When using a qualitative strategy, knowledge is acquired through deep understanding of connections and how occurrences are linked (Eliasson, 2013). To grasp the context and fulfil the aim of the thesis, deep understanding and evaluations of occurrences was important. Through using a qualitative strategy, questions could be asked and answered in an open and broad manner which was desirable in the thesis. In addition, to strengthen the result of the study, numerical data was collected. Hence, a quantitative strategy was utilised since it is commonly used when the usage of measurements and numbers are of importance for the research study (Eliasson, 2013). The usage of a mixed model strategy is increasing the validity and generalisability of the result (Easterby-Smith, Thorpe, & Jackson, 2015). The mix-model strategy was used to fulfil the aim of the research by both understanding incentives and by being able to collect measurable data. Thus, to map and examine the supply chain of Ericsson Microwave through in-depth interviews as well as to use the collection of important numerical data to strengthen the improvement possibilities.

Furthermore, theory was used as a frame of reference to support the discussions throughout the thesis. By the study of literature, a theoretical framework was created including success factors of a global supply chain. After the mapping of Ericsson Microwave's supply chain, the theoretical framework was used to analyse the empirical findings. A deductive view on the relationship between theory and research was used in the thesis. Thereby theory provides the basis for deriving a hypothesis which is further contrasted to empirical findings (Bryman & Bell, 2015). In this method, collected data are compared with theory as the purpose of a deductive study are to test the theory (Wallén, 1996). Theory then guide the data collection process, resulting in a set of findings (Bryman & Bell, 2015). A strategy of moving back and forth between data and theory is called iterative, which was applied in the thesis and is presented further below.

2.3 Research method

A research method is the technique used for data collection, which is a crucial step to generate a useful result (Bryman & Bell, 2015). To answer the specified research questions a theoretical framework was created and additionally, quantitative and qualitative data was collected. The following section will present the methods used in detail.

2.3.1 Literature review

The study was initiated with a brief literature review as seen in Figure 1, which was essential for the problem formulation of the study. Subsequently, a more extensive literature review where literature regarding supply chain management and distribution strategies were studied. In addition, literature concerning supply chain performance and global supply chains were reviewed. The theoretical framework was applied to Ericsson's supply chain to evaluate the current situation, to identify areas of improvement and evaluate suggestions for a changed distribution strategy. The literature review was performed in an iterative manner as a continuous review of literature progressed throughout the study.

When performing the literature reviews, the database Summon provided by Chalmers Library was frequently used to find relevant books and articles. In addition, Google Scholar was used for the literature search. In these searches, several search words were used such as "global supply chain", "direct delivery", "distribution strategy", "green logistics" and "supply chain environmental impact".

2.3.2 Primary data collection

In addition to the literature review, empirical data was collected. When collecting data, the data can be separated between primary-and secondary data (Blomkvist & Hallin, 2015). Primary data is characterised by being first-hand data collected through e.g. interviews or emails (Yin, 2017). To fulfil the aim of the thesis, interviews and observations were conducted as first-hand choice to collect information and gain understanding of the supply chain from different perspectives. In addition, a workshop was conducted to complement the data collection.

2.3.2.1 Interviews

Conducting an interview enable collection of data that capture another person's explanation of an area (Yin, 2017). The interviews were conducted in a qualitative manner, which bring flexibility to the interview process (Bryman & Bell, 2015). Qualitative interviews are advantageous since being able to capture findings by the interviewees reasoning (Blomkvist & Hallin, 2015). The qualitative interviews were partly used to conduct several interviews with the same interview object and partly to be flexible regarding the order of questions focusing on the interviewee's flow rather than strictly following the interview question framework. The interviews were held either in an unstructured or a semi-structured character where in the latter one, the interview guide included predefined questions with the possibility to ask additional questions. By using semi-structured interviews, the same questions can be asked to multiple interview objects and enable a comparison between different answers (Bryman & Bell, 2015). All semi-structured interviews had the same structure to be able to compare the results afterwards, but some adjustments were made to match the specialisation of the interviewee. The unstructured interviews were held without a set of predetermined question but focused on a certain topic. This is beneficial since inviting the interviewee to freely speak about the specified topic without steering the direction of the interview (Bryman & Bell, 2015). This interview type was used initially to rapidly capture different perspectives of the supply chain and the antennas. All interviews, both the unstructured and semi-structured, were initiated by a brief introduction of the aim of the thesis and the objective of the interview.

The purpose of the interviews was to gather information about the supply chain of large antennas and the potential for changing the distribution strategy. To succeed, interviews were held with representatives from product introduction management, purchasing of antennas, supply chain management and transportation planning among others. During the interview, notes were taken and in addition, all interviews were recorded to enable transliterating to minimise the risk of missing important details. Most of the interviews were held in Swedish. Therefore, the recordings were of good help to ensure that the translation between Swedish and English was done accurately and that reasonings were interpret in the right context.

2.3.2.1.1 Selection of interviewees

When conducting interviews, Easterby-Smith et al. (2015) state that sampling of interviewees is the first step in the data collection process. A step that include the ensuring of a purposeful sampling (ibid). Therefore, a purposive sampling was used during the initiation of the interviews where a list of possible interviewees was created together with the supervisor at Ericsson. Later, a snowball sampling was used to identify new possible interviewees where an interviewee recommended possible future interviewees. This method is preferable when the researcher knowledge and/or contact network is restricted (Bryman & Bell, 2015). As Ericsson is a large organization the snowball sampling was helpful. The interviews were conducted during a longer period of time to allow for reflections and hence be able to determine when all required data had been collected.

As mentioned above, to get different perspectives and to grasp the current situation of Ericsson it was of importance to interview employees with varying backgrounds and positions to achieve a comprehensive result of the empirical study. It was initially necessary to gain knowledge about the supply chain and the distribution strategy whereby people directly involved in the Microwave supply chain and the antenna distribution were selected and interviewed. Both from the perspective of supply and demand. In addition, to get information about the strategy and the initiatives that are progressing today to improve the supply chain performance, interviews with employees at management level were conducted. All interviewees have been anonymised, but the role and information about the interviewees is presented in Table 1.

Table 1 - Information about the conducted interviews.

Date	Role	Interviewees	Tag	Type of interview
2019-01-21	Supply and Demand Planner	2	SDP 1 / SDP 2	Unstructured
2019-01-24	Account Manager	1	Account Manager	Unstructured
2019-01-28	Transport Solution Lead 1	1	TSL 1	Unstructured
2019-01-29	Inbound Supply Manager 1	1	Inbound SM 1	Unstructured
2019-02-18	Supply Chain Manager 1	1	SCM 1	Unstructured
2019-02-21	Supply Chain Manager 2	1	SCM 2	Semi-structured
2019-02-26	Supplier Manager / Inbound Supply Manager 2	2	Supplier Manager / Inbound SM 2	Semi-structured
2019-02-28	Supply Chain Control Tower	1	SC Control Tower	Semi-structured
2019-03-22	Tactical Distribution Manager / Supply Chain Manager 4	2	Tactical Distribution Manager / Supply chain Manager	Semi-structured
2019-03-25	Supply Chain Performance Manager	1	SC Performance Manager	Semi-structured
2019-02-26	Head of Supply Chain Design & Control	1	Head of SC Design & Control	Semi-structured
2019-03-29	Supply Chain Manager 2	1	SCM 2	Semi-structured
2019-03-29	Supply Chain Manager 3	1	SCM 3	Semi-structured
2019-03-29	Head of Hub Operations	1	Head of Hub Operations	Semi-structured
2019-04-01	Supplier Manager / Head of Supplier and Dimensioning Management	2	Supplier Manager / Head of SDM	Semi-structured
2019-04-02	Transport Solution Lead 2	1	TSL 2	Semi-structured
2019-04-02	Supply Chain Manager 4	1	SCM 4	Semi-structured
2019-04-05	Senior Supply Delivery Manager	1	Senior Supply Delivery Manager	Semi-structured
2019-04-09	System Manager Antennas	1	System Manager Antennas	Unstructured

2.3.2.2 Workshop

As a complement to the mentioned qualitative interviews, a workshop was performed in the middle of the study process which aimed at gathering ideas about a future distribution strategy. Thus, one objective of the workshop was to capture knowledge about the current processes and environment of the company to utilise in the analyse of a future distribution strategy.

The workshop participants were employees from Ericsson who are involved in the supply chain and distribution of antennas. The selection of participants was based on the different roles and knowledges needed for the workshop activities and was made in collaboration with the supervisor at Ericsson. In addition, an external lecturer within Supply and Operations Management from Chalmers University of Technology participated in the workshop. The participant's roles are presented in Table 2. The workshop was initiated with a short introduction to the topic and a presentation of the current distribution strategy to set a background for all participants. Thereafter, the workshop was organised around four different rounds with complementary assignments where the participants were divided in three groups. Bryman & Bell (2015) argues that smaller groups are to recommend when a discussion is wanted, and the participants have a lot to say.

Table 2 - Presentation of the workshop participants.

Role of Participant	Number of Participants
Supply Chain Manager	3
Inbound Supply Manager	1
Senior Supply & Demand Planner	1
Head of SC Design & Control	1
External Lecturer	1

The first round was organised around the question *"What drives each of the measurements distribution cost, distribution lead time and environmental impact?"* to brainstorm about factors in the supply chain that drives the above-mentioned performance measurements. In the second round, the groups were asked to brainstorm about *"Alternative ways to distribute large antennas from the supplier to the customer"*. Initially, the participants were asked to brainstorm individually to minimise the risk of being influenced by other participants at the first stage. Thereafter, a discussion in the groups was initiated. The results from this round were gathered where after clusters of main categories were created from the different brainstorming ideas. Proposals that were similar or the same was put together to create a cluster. These clusters were brought forward to the third round. The third round was organised around the questions *"What advantages does this alternative bring?"* and *"What disadvantages does this alternative bring?"* where the questions were answered for each cluster.

The fourth round included an assignment related to the prioritising of the clusters created in round two. For the prioritising, a matrix was used where the two dimensions was the size of the effect from the improvement and cost to implement the improvement. The three groups were asked to prioritise the alternatives and then present the alternative they thought should be given highest priority.

The key objective of the workshop was to brainstorm about the future distribution strategy and hence capture the knowledge of all workshop participants. The outcomes of the workshop were used to complement the empirical findings from the interviews. In addition, the results were used as a foundation for aftercoming interviews to point the direction of further data collection.

2.3.2.3 Observations

To get an initial understanding of the supply chain of Microwave and to identify challenges in the supply chain strategy, observations of different group meeting were performed. Group meetings that were visited were mainly the weekly meetings of the department of Microwave Supply Design and Control but also production planning meetings. During the meeting observations at Ericsson, the method of a "complete observer" was used where no interaction between the meeting participants and the observers took place (Easterby-Smith et al., 2015). The observations were used to understand the current structure and development of the supply chain at Ericsson.

2.3.3 Secondary data collection

As a complement to the primary data collections, secondary data was studied and analysed throughout the thesis. Secondary data is data collected by others and can be official documents or company-related policies (Yin, 2017). To complement, internal documents about strategies, policies and processes of Ericsson was studied.

In addition, quantitative data from the internal ERP-system was collected with the help of the Ericsson supervisor to capture among other things trends in sales. The quantitative data was collected from a period of two years (2017-2018) as it was argued to be required to acknowledge the demand patterns for large antennas. According to Ericsson employees, the demand pattern for large antennas was valid to use as a basis for the analysis in the study. The collected quantitative data related to the customer demand, information about customer location and usage of transport modes.

2.4 Quality of the research

To ensure results and contributions with high quality, the methods used in this study were evaluated concerning three major aspects: reliability, validity and ethics. How these aspects have affected the research is presented below.

2.4.1 Reliability

Bryman and Bell (2015) state that reliability refers to whether a study can be repeated or not and can be divided into external and internal reliability. The external reliability relates to the ability to replicate the study and is according to Bryman and Bell (2015) challenging to ensure as studies are conducted in a specific setting and environment. To increase the external reliability and reduce the risk of biased answers, many interviews were conducted. To ensure the internal reliability, all interviews were conducted with both authors of the thesis present, as internal reliability concerns to which extent the research team agree upon what was heard (Bryman & Bell, 2015). In addition, all interviews were recorded to ensure the eliminations of misunderstandings.

2.4.2 Validity

Ensuring that what is said to be observed, identified and measured is actually done is one of the definitions of validity (Bryman & Bell, 2015). Trustworthiness may be used as a criterion for evaluating qualitative studies. An effective method to ensure the validity of research findings is triangulation (Yin, 2014). With triangulation, several sources of data collection and information are used to reduce the bias of the research (ibid), since qualitative interviews bring a risk of collecting subjective data (Bryman & Bell, 2015). Therefore, several data collection methods have been used to secure the validity of the study. In total, 19 interviews were held including a total of 23 interviewees where multiple interviews with people in similar positions were conducted to enable comparing of important details, thus increasing the validity. In addition, assumptions were confirmed and/or dismissed by comparing the interview data with internal data or data collected from observations.

2.4.3 Ethical aspects

Conducting research in business and management, the researcher usually is the least powerful player (Easterby-Smith et al., 2015). Hence, the ethical challenges of this study can be argued to be limited. However, some precautions were considered during the study. The thesis was performed in an ethical way by enhancing the four main areas of ethical issues: harm to participants, lack of informed consent, invasion of privacy and deception (Bryman & Bell, 2015). Therefore, the participants were not addressed by their name to make sure that they have the possibility to contribute to the research study in a closed environment. All interviewees were beforehand informed about the study and their contribution to the study. In addition, all interviews were conducted in an environment where the interviewee felt comfortable, most commonly in their office. Another important aspect is the confidentially issues that were addressed by sending several drafts to Ericsson to eliminate confidential information. In addition, to ensure that no wrongful information concerning company specific information was published.

3. Theoretical framework

The following chapter presents the theoretical framework of the study and explains the theories used to analyse the empirical findings. The framework covers the theoretical areas of supply chains including supply chain design and strategy. In addition, theories relating to distribution.

3.1 The fundamentals of a supply chain

The concept of a supply chain relates to networks closely coordinated to cooperatively compete with other networks (Skjøtt-Larsen et al., 2007). A network consists of multiple companies that collaborate to operate more efficiently and to leverage strategic positioning (Bowersox et al., 2013), and to stay competitive in a global market (Skjøtt-Larsen et al., 2007). This is in line with the statement by Cooper and Lambert (1997) who argue that actors in the supply chain should attempt to optimise the result of the whole supply chain instead of sub optimisation in each organisation. This can be created by collaborative goals and activities with other actors. The sharing of risk and rewards across the supply chain affects long-term commitment of channel members positively (ibid).

The supply chain stretches from the source of supply to the final distribution to the customer and should be viewed as a static view at a specific point in time creating a linear sequence of handling a product or service (Christopher, 2011) as seen in Figure 3. The material in the supply chain flow forward heading at final delivery to the customer (Bowersox et al., 2013). The information flow is directed at both directions whilst the order and transaction flow origins from the customer and are moving backwards in the chain (Skjøtt-Larsen et al., 2007).

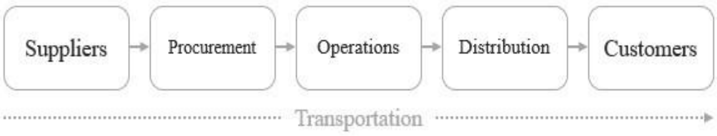

Figure 3 - Linear sequence of the material flow in a supply chain, influenced by Christopher (2011).

The concept of the supply chain has been developed from the value chain created by Porter (1985) who describes the value chain containing primary activities and supportive activities as seen in Figure 4. The configuration of this value chain become sources to a company's competitive advantage. The value chain describes the internal activities that guide and protect the supply chain from outside disturbances. Skjøtt-Larsen et al. (2007) argue that the chain is influenced not only by internal factors but by external factors such as local and global issues, the industry and competition. This implies that activities of a supply chain need to be reorganised, added or eliminated if necessary, to improve the performance and respond to internal- or external changes (ibid). The need for high-performing supply chains to adopt continuous improvement and be aware of changes in customer demand and cost is further emphasised by Bowersox et al. (2013). Thus, the central issue in a company's global supply chain often origin from the structure of the supply chain itself.

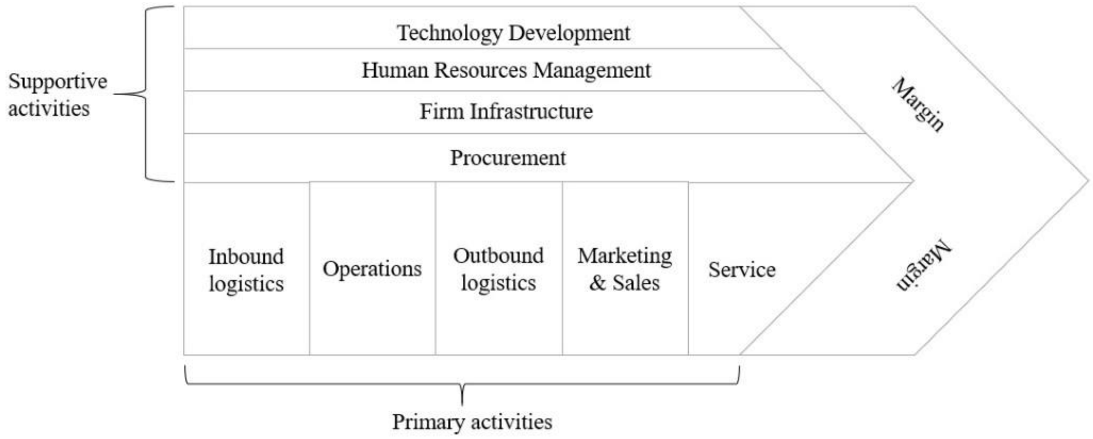

Figure 4 - Model of the value chain of a firm (Porter, 1985).

In the supply chain, the role of logistics is gradually changing from a distinct support function to a core business function (Damen, 2001). Rushton et al. (2017) define the components of logistics as transport, inventory and warehousing, thus materials management and distribution. Materials management refers to the storage and flows into and through the production process whereas distribution is the storage and flow from the final point of production to the customer (ibid). Porter (1985) distinguish logistics flexibility referring to the ability of a firm to adjust inventory, warehousing and transportation of physical products to meet customer needs. Consequently, the outbound logistics function balance customer service level and cost (Basu & Wright, 2016). Bowersox et al. (2013) mention the concept of perfect orders that once were an exception but have now become an expectation. A perfect order relates to a delivery of the desired product and quantity at the right location, the right time whilst being damaged-free and performed with a low cost (ibid).

3.2 Designing a supply chain

According to Bowersox et al. (2013), the design of a supply chain includes decision-making regarding the optimal number and the location of various nodes, e.g. warehouses and manufacturing sites. Hence, answering to which markets to serve by which node and the inventory strategy at warehouses are important (ibid). Thus, geography is crucial when designing a supply chain (Rushton et al., 2017). Further, Skjøtt-Larsen et al. (2007) argue that the identification of necessary activities and the actors that should perform these activities are the two first steps when designing the supply chain to meet customer requirements. This identification relates to the fact that a redesign of a supply chain is more likely to succeed if it is recognised as a multidimensional activity addressing all the functions and components in the supply chain (Cooper & Lambert, 1997). On a strategic level, there are five activities that are included in the supply chain; buying, making, moving, storing and selling which also are the starting point for the tactical and operational levels (Govil & Proth, 2002). The strategic level focus on the long term while the tactical level includes day-to-day decisions in respective activity (ibid).

3.2.1 Buying

There are several names for the buying process where three of the most common are sourcing, purchasing and procurement (Stanton, 2018). Traditionally, procurement was focused on achieving the cheapest price whereas now, the processes and links to suppliers are what define the supply chain (Skjøtt-Larsen et al., 2007). Procurement has a proactive role of designing and managing networks of connections and is essential for strategy as it allows companies to focus on core competences through sourcing processes, services and components outside of the organization. Rushton et al. (2017) argue that sourcing decisions affect and influence the supply chain design where for example distant sourcing requires different supply chain structures than goods sourced locally. Further, predictable demand should be met by sourcing globally whilst unpredictable demand instead should be met using local suppliers to gain flexibility benefits and lead time reduction (ibid).

When sourcing products, Don (2014) distinguishes between single sourcing and multiple sourcing. The concept of single sourcing implies that demand for an item is fulfilled from one single supplier whilst the multiple sourcing refers to the fulfilling of a product demand from several suppliers. The number of suppliers utilised for the fulfilment of a demand impact the complexity of the procurement process and the internal resources needed to fulfil the demand (ibid). Further, the utilisation of single sourcing or multiple sourcing affect the relationship with the suppliers (van Weele, 2018). Single sourcing is preferable when collaborative relationships are needed whilst multiple sourcing often are utilised to create a better negotiation position (ibid).

The portfolio purchasing model created by Kraljic (1983) define products according to the dimensions supply risk and profit impact. Depending on these two dimensions, four different product categories are created as seen in Figure 5. The categories act as a guidance when determining what relationship to establish with the supplier (Araujo, Gadde, & Dubois, 2016). For product with a high supply risk and a high profit impact, partnerships with the supplier is preferred whilst for a product with low supply risk and low profit impact, efficient processing should be focused on (ibid).

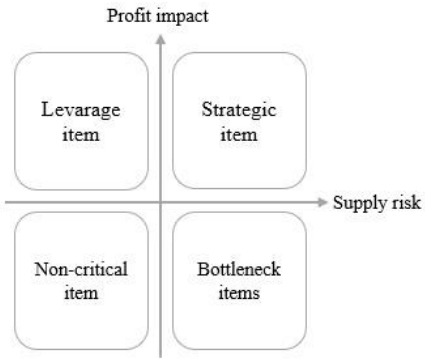

Figure 5 - Portfolio purchasing model (Kraljic, 1983).

3.2.2 Making

Making refers to the transformation of components into a product or service that provides value to the customer (Stanton, 2018). Companies can use different product environments, based on what the company is making and what the customers need. Make-to-order *(MTO)* and Make-to-stock (*MTS)* are two of these environments (Stanton, 2018; Kolisch, 2001). In addition, Kolisch (2001) include Assembly-to-order *(ATO)* as one of the manufacturing environments. The tree concepts are visualised in Figure 6.

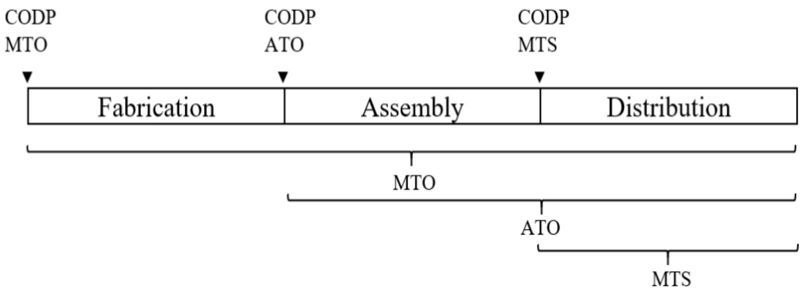

Figure 6 - Manufacturing environments, adapted from Kolisch (2001).

In an *MTO* manufacturing environment products are produced when a customer order is received. Accordingly, a customer order initiates all supply chain activities from procurement to final assembly (Kolisch, 2001). In this environment the customer order decoupling point (*CODP*), where activities are firstly initiated based on a customer order and not forecasted demand, is located early in the chain as illustrated in Figure 6. Similar to the *CODP*, Andries and Gelders (1995) state that the point in time when the production is based on a real order and not a forecast is called order penetration point. After the order penetration point, all products being produced are dedicated to a specific customer. If the order penetration point is located in the beginning of the production process, the production is driven by a customer order which can be likened with the *MTO* environment presented by Kolisch (2001). Hence, generating a material flow with low inventories (Andries & Gelders, 1995).

An order penetration point close to the customer bring a process where customer orders are fulfilled from inventory, thus bringing high safety stocks (Andries & Gelders, 1995). Consequently, *MTS* enable fast customer response time as products are available in inventory hence customer orders can be filled directly (Stanton, 2018). In this system products are produced according to forecasted demand (Kolisch, 2001) which comes with a risk as when and how much a customer will purchase is based on speculations (Stanton, 2018). In addition, storing goods in inventory lead to tied up capital and eliminates the possibility to customise products. For this reason, this environment is suitable when it is possible to forecast accurate demand and when the procurement and production lead time is longer than customer lead time (Kolisch, 2001).

In an ATO environment material is held in stock and assembled when a customer order is received, hence standard components forms a unique product (Kolisch, 2001). According to Govil and Proth (2002) a company may change from MTS policy to *ATO* policy to align management of production control with strategic goals. Rushton et al. (2017) describe a system where production can be made according to push or pull. In a push system the manufacturing is done according to expectations of orders (existing and forecasts) while the pull system refers to manufacturing according to known orders. The former refers to the idea of avoiding final stock.

3.2.3 Moving

Moving a product from one location to another, covering the beginning of the supply chain to the customer, is referred to as transportation (Chopra & Meindl, 2013). The transportation of goods is a key function in the supply chain acting as the physical link between demand and supply, thereby enabling material and resource flow (Naim, Potter, Mason, & Bateman, 2006). As transportation is a component which contribute to the costs that appear in a supply chain the use of appropriate transportation is very much linked to the success of a supply chain. According to Frazelle (2018) transportation activities are some of the most expensive activities in the supply chain. Naim et al. (2006) argues that the commonly utilised "one size fits all" strategy of transportation leads to increased costs as well as the inability to fulfil customer expectation. Hence, the transportation of goods enable balance between responsiveness and efficiency as the location of facilities and inventory can be adjusted (Chopra & Meindl, 2013).

Deciding what transport mode to use is one of the decisions that needs to be addressed within distribution systems (Zijm, Klumpp, Regattieri, & Heragu, 2019). Speed and cost are two factors that are important to consider in regards of transport mode. The different modes used are air, rail, truck, sea or pipeline which all bring different transportation transit times (Chopra & Meindl, 2013). Speed is important when distributing goods over long distances, where rail, ship or air are frequently used (Zijm et al., 2019). The transportation transit time have a direct impact on the inventory in the supply chain (Skjøtt-Larsen et al., 2007), as the transit time impact the tied-up capital in the supply chain. Operating globally means that products need to be transferred between locations far from each other (Skjøtt-Larsen et al., 2007).

In transportation set-ups, one way to distribute products is to utilise third-party logistics providers (Cooper & Lambert, 1997). This involves the decision to either keep management of activities inhouse or outsource to a third-party logistics provider (Basu & Wright, 2016). Damen (2001) distinguish two trends in the logistics world where logistics services are requested for longer distances covering an international and world-wide scope instead of a national. Secondly, the requests are more dynamic with rapid changes. Both trends involve the engagement of more parties acting together to cover the greater distances and act upon the frequent changes.

Transportation of goods are said to be one of the major causes of the rising greenhouse gases (Christopher, 2011). With the globalisation, products travel longer distances creating larger emissions from freight transportation. Thereby, the distribution structure of a firm is highly affecting the emissions (Min & Chung, 2017). A significant amount of emissions is originating from transportation which has initiated efforts in the industry to focus on the logistics operations to reduce the emissions where travel distance and fill rate are important parameters (Min & Chung, 2017), where fill rate refers to utilization of transportation unit volume and weight. Hence, the design of goods delivery networks needs to consider minimisation of both cost and environmental impact (Adenso-Díaz, Lozano, & Moreno, 2016).

Further, environmental performance can be added as an important characteristic of transport mode (Dekker, Bloemhof, & Mallidis, 2012) and Zijm et al. (2019) include sustainability among other as an important factor when choosing mode of transport. Two of the issues that are frequently discussed impact are the air pollutions and carbon dioxide (CO2) emissions from transportation where CO2 contributes to global warming (Kontovas & Harilaos, 2016). Kontovas and Harilaos (2016) state that CO2 emissions can be estimated through the equation below where an increase or decrease in emissions is dependent on three different factors.

$$CO2\ emissions\ (in\ tonnes) = V \times D \times F$$

V: transportation volume (in tonnes)

D: Average transportation distance (in kilometres)

F: The average CO2-emission factor per tonne-km

From the equation it can be seen that both volume and distance affect the emissions, thus if these decrease and F remain stable the level of CO2 emissions will decrease. According to Dekker et al. (2012) water transport can carry heavy loads and is thus CO2 efficient. Further, rail is more efficient than truck and in addition air transportation transport is not as CO2 efficient as the other modes presented in Table 3. Air transportation is an alternative used for mostly small and high-value goods as it is the most expensive mode in terms of cost per weight (Drake, 2011). Speed is often a significant factor when choosing this mode of transport which is emphasised by both Drake (2011) and Zijm et al. (2018).

Table 3 - Energy use and CO2 emissions for typical transport units of different modes, retrieved from Dekker et al. (2012).

Energy use/emissions g/t/km	**PS-type container vessel (11,000 TEU)**	**S-type container vessel (6,600 TEU)**	**Rail-Electric**	**Rail-Diesel**	**Heavy Truck**	**Boeing 747-400**
kWh/t/km	0.014	0.018	0.043	0.067	0.18	2.00
CO2	7.48	8.36	18	17	50	552

3.2.4 Storing

Warehousing is an important part of the business and supply chain strategy (Frazelle, 2018). Warehousing facilitates shorter responsive times, higher inventory availability, value-added services, customisation, returns and consolidation. Thus, having a large impact on the customer service. Locating warehouses close to customers enables a better response time to customers. Response time is defined as the time from when a customer order is received to when goods are delivered to the customer (Ross, 2015), or the time it takes to receive an order (Chopra & Meindl, 2013). Another benefit with warehouses, except from storing goods is the possibility for executing value-added services. This includes for example custom labelling, kitting, pricing, special packaging which has become a competitive supply chain differentiator. Further. warehouses are also enablers of consolidation as well as a way of establishing physical market presence. Costs that are generated from storing goods in inventories are related to the tied-up capital, payment for the building and the people working, keeping the inventory safe and the costs that incur when a product is stored too long in the warehouse and thus becomes obsolete (Stanton, 2018). The inventory cost of a product further depends on the state of the product. Raw material, unfinished or semi-finished goods as inventory are less expensive than finished goods (Andries & Gelders, 1995; Cooper & Lambert, 1997).

3.2.5 Selling

Selling relates to all market-oriented activities such as marketing and sales (Govil & Proth, 2002). Some of the questions that need to be answered, for handling long-term issues within this activity, are how to respond to competitor activities, how to better anticipate and meet customer requirements and how to coordinate and share information with other participants of the supply chain to be effective in the marketplace. The interface towards the customer is the selling function of a firm, whom is related to the marketing function of the firm (Rosenbloom, 1995). The selling function of the company is highly influencing the distribution performance as a high-performing distribution function is dependent upon the information sharing from the selling function (Ellinger, 2000). Consequently, the greater relationship the selling function have with its customers the higher the ability to collaborate towards mutual goals (Zijm et al., 2019). In addition, the higher the level of collaboration the higher quality of the information. The selling function possess information about future customer demand which is crucial for the logistics function to prepare the supply chain. The production function is on the other hand possessing information about the production capacity which is crucial information for the ability to supply the customers with required products. Hence, a cross-functional collaboration between the selling and logistics functions is crucial for a successful distribution performance (Ellinger, 2000). The information sharing between the two functions are of high importance as the selling function possess information about new customers and new product opportunities whereas the logistics function possesses important information about lead time and capacity (Jüttner, Christopher, & Baker, 2007). Jüttner et al (2007) present a model as seen in Figure 7 illustrating the working relationship between the function of supply chain management and the selling function.

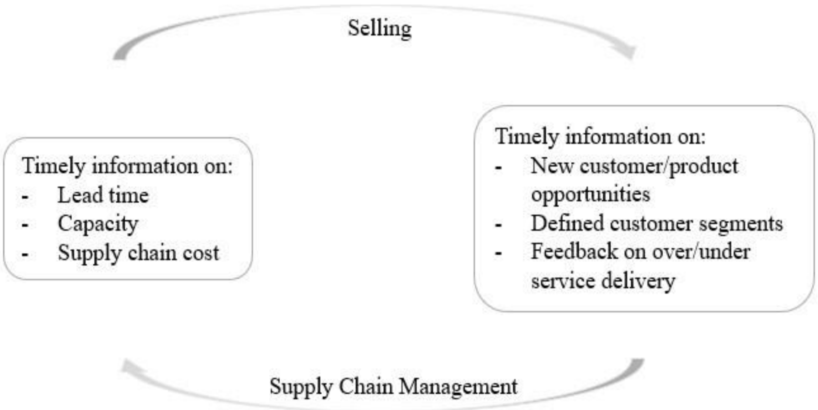

Figure 7 - The working relationship between supply chain management and selling.

3.3 Formulating a supply chain strategy

Fulfilling customer demand, all firms need to set its supply chain strategy and network design (Rushton et al., 2017). Hence, aspects such as customer requirements on products, delivery and service preferences impact the shape and design of the supply chain (Skjøtt-Larsen et al., 2007). To align the competitive strategy with the supply chain strategy of the company, the supply and demand uncertainty needs to be understood as this give signals relating to what level of responsiveness the supply chain should be designed for (Chopra & Meindl, 2013). Supply chain responsiveness includes a supply chain's ability to respond to wide ranges of quantities demanded, handle supply uncertainty, meet a high service level, meet short lead times, handle a large variety of products and build highly innovative products (ibid). Related to this, the ability to adopt a market-oriented supply chain is of importance (Waller, Dabholkar, & Gentry, 2000). A market-oriented organization perform segmentation to differentiate products and services to maintain and create pleased customers thus requiring differentiated supply chains.

3.3.1 Adapting the supply chain to product characteristics

Rushton et al. (2017) makes a distinction between functional products and innovative products where the functional products are characterised by a stable demand bringing the possibility to develop a cost-efficient supply chain. For innovative products however, the demand is more unpredictable hence requiring a more responsive supply chain (ibid). To cope with these different characteristics, Rushton et al., (2017) differentiate between lean and agile supply systems according to Figure 8. The latter one refers to the ability to respond to constant changes whilst lean policies refers to the ability to respond to competitive pressure utilising limited resources (Soltan & Mostafa, 2015). According to Rushton et al., (2017), the agile policies are more suitable for innovative products where the demand is unpredictable and supply lead times are short. For products with long supply lead times, adding of additional solutions to the agile policies may be necessary. For functional products with a predictable demand, lean policies are more suitable.

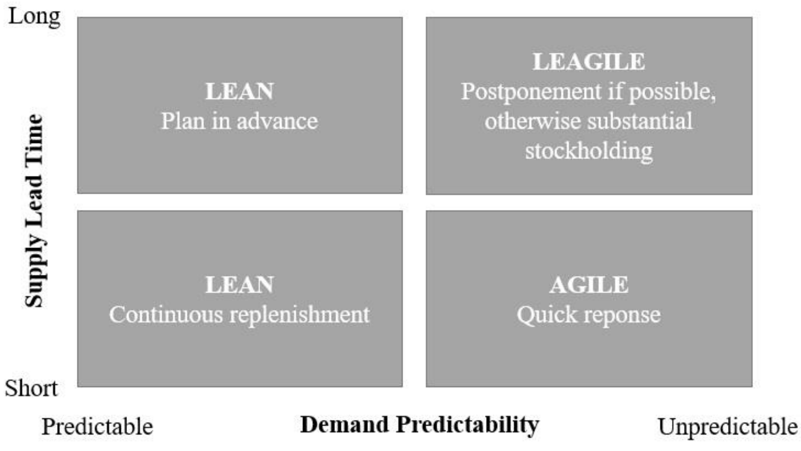

Figure 8 - Matrix based on supply and demand characteristics, influenced by Rushton et al (2017).

3.3.2 Postponement in a supply chain

The concept of postponement refers to transferring the point of customization to the latest point in time as possible (Ferreira, Tomas, & Alcântara, 2015), where customization refers to the extension of characteristics of a product or service according to customer specifications (Waller et al., 2000). Thus, allowing companies to meet changing customer needs, to differentiate products and to be more flexible (Waller et al., 2000). Two types of postponement are identified relating to manufacturing postponement and logistics postponement (Bowersox & Closs, 1996) where manufacturing postponement allow companies to gain benefits from economies of scale for some stages in the supply chain and thereafter delay the product differentiation to the point in which demand is generated (Ferreira et al., 2015). Logistics postponement refers to the storing of finished products in a centralised warehouse thus delaying the displacement of inventory. According to Ferreira et al. (2015), the drivers for postponement adoption are many ranging between dimensions of market, logistics and organization and leadership. Logistical drivers are among others delivery time and customer service whilst market drivers are the ability to handle demand uncertainty and variation in markets and customers. Further advantages brought from postponement is increased competitiveness, decreased cost due to reduction in lost sales, supply chain flexibility and increased reliability regarding delivery (Ferreira et al., 2015). This bring logistical benefits related to reduction of inventory cost and the ability to respond quickly to customer demand changes. Further, demand variability can be reduced by considering aggregated demand rather than an individual demand (Cheng, Li, Wan, & Wang, 2010).

A challenge with postponement is that it requires a high level of collaboration and visibility in the supply chain (Matthews & Syed, 2004) wherefore it is of importance to consider how other actors of the supply chain are affected (Garcia-Dastugue & Lambert, 2007). In addition, postponement increases the inventory level and require a higher level of coordination, supervision, material handling and technical services (Cheng et al., 2010).

3.3.3 Sustainability and environmental impact

One of the more important issues to acknowledge on a strategic level is sustainability, an issue that can be broken down to three elements: environment, economy and society (Christopher, 2011). For a company to be truly sustainable, efforts must be put towards each of these elements. The objective of sustainability is to contribute to the well-being of the future society whilst the objective of a supply chain is to contribute to the success of the firm by concerning long-term viability. Christopher (2011) argues that the two objectives are mutually supportive by having a supply chain that enhance a wide perspective and thus helping the business to increase the business wellness.

Within the environmental element, the negative impact caused by logistics has increased in attention (McKinnon et al., 2015). As further emphasised, the green dimension has increased in interest when analysing transportation logistics, apart from cost benefits, economic and other optimisation criteria, which thereby add the environmental dimension to the analyses (Kontovas & Harilaos, 2016). In line with the globalisation and growing trade volumes, the international transports, and thereby emissions, are increasing (McKinnon et al., 2015). Reducing emissions is one part of sustainable logistics, however in the long perspective more initiatives are needed for making logistics sustainable. A contradiction between cost reduction and gaining environmental benefits is often addressed, where a trade-off needs to be decided upon. However, McKinnon et al. (2015) state that costs may be reduced when the environmental impact of logistics is reduced. Thus, arguing for benefits gained in both dimensions.

3.3.4 Cost drivers and performance evaluation

The costs in the supply chain can be divided into manufacturing costs, primary transport costs (trunking), secondary transport cost (local delivery), facility costs (warehouses and depots) and inventory costs (Lovell, Saw, & Stimson, 2005). The inventory costs exist from end-to-end in the supply chain while the others can be associated with certain parts or points of the supply chain. Ross (2015) argues that transportation is regarded as one of the functions of inventory as time is needed to physically move stock and inventories are in transit. A need for having additional inventories to cover demand therefore occurs. This does in turn create transportation inventory costs which may be reduced through changing to a supplier located closer to the production plant and changing mode of transportation. This can be related to the argument presented by Lovell et al. (2005) where inventory costs are included in the whole supply chain. Further, Lovell et al. (2005) argue that an essential part of supply chain management and design is the understanding and control of the trade-offs between the costs. Through identifying the cost drivers of the respective cost, it is possible to identify groupings of products with similar characteristics. This gives an indication of the different supply chain requirements, hence the need for differentiated supply chain strategies for different product groupings.

The design of a supply chain has a direct influence on the supply chain performance (Chopra & Meindl, 2013). Hence, six different performance drivers have been identified (ibid) and are presented in Table 4. For a successful supply chain performance evaluation, it is important to identify a set of key performance measures (Jagan Mohan, Neelakanteswara, & Krishnanand, 2019). A set of performance measurements, also called key performance indicators: *KPIs*, are strategic metrics used to indicate the success of a supply chain strategy (Ross, 2015). Further, due to increasing external and internal pressures companies adopt environmental strategies for improving environmental performance as well as gaining competitive advantage (Ates, Bloemhof, van Raaij, & Wynstra, 2010). To bridge the gap between strategy and actual performance internal and external environmental investments are needed. Investing in internal measures to reduce environmental impact through for example environmentally friendly production processes and logistics processes has a stronger impact of environmental performance than external investments. The external investments are however not negligible. The external investments regard for example involvement of suppliers through mutual strategies and environmental goals as well as environmental programs.

Table 4 - Drivers of Supply Chain Performance.

Inventory	Includes all components and products, from raw material to finished goods**.**
Transportation	Includes all transportation and movement of products and components through the supply chain.
Facilities and Handling	Includes all facilities (warehouse or production site) in the supply chain.
Information	Includes all data and analysis related to the other drivers.
Sourcing	Includes all decisions regarding the responsibility for performing different supply chain tasks.
Pricing	Includes the effects pricing have on supply chain interaction to link supply with demand.

3.3.5 Competitive factors

Economies of scale was for a long time the success factor to reach competitive advantages (Soltan & Mostafa, 2015). Nowadays, there is a need to switch from the focus on economies of scale towards a focus on first-class performance in a global economy (ibid). Competition has changed and the factors for being competitive and winning orders have changed (Andries & Gelders, 1995). Soltan & Musafa (2015) present market qualifiers and market winners as two categories containing different competitive measurements. The measurements presented by Soltan and Mustafa (2015) are quality, lead time, service level and cost. Andries & Gelders (1995) presents five other competitive factors: quality, lead time and delivery reliability, product diversity, customization and direct deliverability. Andries and Gelders (1995) define the categories of competitive measurements as order enabler and order winner. Further, the thesis utilises the categorisation order enabler and order winner, where order enabler is the parameter that make a supplier an option for a customer. The order winner is instead the parameter that make the customer choose a company as a supplier. The ability to focus on the best mix of competitive factors and adapt the logistics towards this mix is one of the most critical strategic decisions for a company (ibid). Previously, price of the product and/or service has been the most important parameter but are now seen as an order enabler.

3.4 Distribution: a vital part of the supply chain

Distribution activities are a part of the supply chain of a company and provides the link between production and the customer (Skjøtt-Larsen et al., 2007), thereby the transfer of products from origin to destination (Partida, 2017). The main responsibility of distribution is to bridge the gap between supply and demand, hence between production and consumption as seen in Figure 9 (Rosenbloom, 1995). In a competitive market place, the distribution strategy must be responsive and fast while operating at low cost (Ladier & Alpan, 2016). Thus, the introduction of logistics flexibility is of importance as enabling a firm to respond quickly to changes in inbound- and outbound delivery, support and services (Qingyu, 2005). True flexibility is achieved without excessive cost, time or performance losses (ibid).

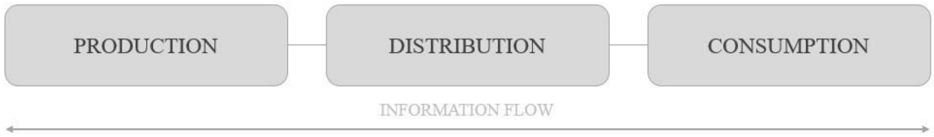

Figure 9 - Distribution acting as a bridge between production and consumption.

Chopra (2003) describe distribution as the steps relating to the movement and storage of products from the supplier to the customer. Distribution management regard physical transportation from the factory to the customer, through the different components of the supply chain (Basu & Wright, 2016). The main components of distribution management are distribution strategy, warehouse operations, stock management and transport planning (ibid). The design of distribution includes inventory, transportation, facilities and handling and information which summarised constitute the total logistics costs of a distribution network (Chopra, 2003). The distribution of a company plays a vital role not only for the significant impact on overall profitability, but also because distribution often is the interface between the customer and the firm impacting the customer experience (Chopra, 2003). Customers judge the service of the company depending on the distribution performance and flexibility.

3.4.1 Distribution Strategy

As transportation of products often is the largest cost in logistics, Bowersox et al. (2013) argue for the importance of the distribution strategy. Factors that influence the distribution strategy are warehouses, channel of distribution and their location, economic factors and location of service centres (Basu & Wright, 2016). When determining the most advantageous distribution strategy, key is to have the customers and products of the firm in consideration (Partida, 2017). Doing this, companies can react and deliver according to customer needs. Innovation in distribution strategies plays a vital role in a company's success to stay competitive in today's market place (Singh & Ratha, 2016), and the choice of an appropriate distribution strategy is highly important affecting the overall company performance.

Depending on distribution design, companies serve their customers differently (Chopra, 2003). Partida (2017) argues that the success of a distribution strategy depends on the alignment with the overall company strategy. The performance of the distribution should according to Chopra (2003) be evaluated along two dimensions: customer needs that are met and the cost of meeting customer needs. In addition to this, the environmental impact generated from companies' logistics activities should be introduced as a dimension of performance measuring (Millar, 2015; Zijm et al., 2019). Succeeding to reduce the environmental impact, future supply chains should be global when needed and local when possible (Zijm et al., 2019). Furthermore, the distribution design influence measures such as response time, product availability, customer experience and order visibility which all affect the first dimension: customer needs that are met (Chopra, 2003). The distribution design also affects the environmental impact by having a direct influence on emissions (Zijm et al., 2019).

3.4.1.1 A centralised distribution strategy vs a decentralised distribution strategy

Distribution strategies can also be separated as centralised or decentralised (Ross, 2015). Deciding whether to choose a centralised or decentralised distribution system is influenced by the critical factor of maintaining targeted customer service levels (ibid), where service level is defined by the minimum acceptable service provided to the customer (Hiles, 2000). The lead time in a centralised system is longer as products are distributed a longer distance from storage to the delivery point and customers or shippers are often directly affected by the outbound delivery cost that this system brings. Adenso-Díaz et a. (2016) also describe that the degree of centralisation is one of the key features when designing a logistics network. The benefits of such design are lower fixed costs. It is however highlighted that in some cases the centralised structure, or a network with one central depot, is not beneficial as it can have higher costs than a two-depot network (ibid). Björklund (2012) describe logistic centralisation as a reduction of number of nodes such as warehouses, terminals and production facilities where the reasons for centralisation often have enhanced economic factors such as increased delivery service and decreased transport costs. Ross (2015) argue that the centralised system contains minimal safety stocks, reduced operating overheads, have fewer channel warehouses, seek economies of scale, decreased inbound transportation costs, minimise total system cost and realise targeted service levels. Comparing to the statement by Björklund (2012), the transportation cost is thus dependent upon the situation. Other benefits of centralisation are increased availability of products leading to higher delivery service and reduced complexity of the system as an overview is enabled thus simplifying control (Björklund, 2012). The environmental downsides of the centralised structure are the increased transport distances, while the positive effects are the possibilities for increasing the filling rate, joint loading of goods and possibilities to use larger and more energy efficient transport modes. The benefits of a centralised distribution centre are the greatest for items with high value, low demand and unpredictable demand (Chopra, 2003).

The decentralised distribution is on the other hand characterised by the opposite effects compared to a centralised system (Ross, 2015). In this system the total costs increase where costs for local stocks in warehouses, costs to support channel warehouses and inbound transportation costs increase. However, the outbound transportation costs decrease as the decentralised distribution enable handling located closer to the customer with shorter delivery lead times. This is also mentioned by Adenso-Díaz et al. (2016), stating that the decentralised network offers better customer service as distance to customers, thus lead time, and transportation costs are generally lower. It is further stated that a decentralised distribution is preferred when customers are located far away from the manufacturing plant and are not clustered. Björklund (2012) emphasises the environmental benefits gained in a decentralised system as the possibilities to use the transport mode that is best suited for every node within the network compared to the centralised system where this might not be possible. The more consideration given to environmental factors compared to cost factors, the incentives of using warehouses rather than shipping directly to customers are larger, thus gaining economies of scale in the aspect of emissions (Adenso-Díaz et al., 2016). The main differences of a centralised and decentralised network are presented in Table 5.

Table 5 - Advantages comparing centralised and decentralised networks (Adenso-Díaz et al., 2016).

Centralised	Decentralised
Reduced learning costs	Time to reach the client
Less tied-up capital	Better service level
Reduced fixed warehousing costs	Reduced transportation cost
Lower stock level	Local exposure

3.4.2 Global distribution

Today, most supply chains are crossing borders and are international to some extent (Skjøtt-Larsen et al., 2007). When operating in a global context there are differences found in the reliance of intermodal transport methods, long transport distances, and the collaboration/interaction with different governments and companies. Skjøtt-Larsen et al. (2007) mention the challenge of adapting to multiple national systems containing different economic and political systems as well differing tax and legal systems. Thereafter, the infrastructure is differing heavily between different countries and this is a challenge for many global supply chains. According to Ross (2015), the lack of distribution infrastructure may be one of the most critical hinders to global trade, aside from government policies, legal, cultural and financial barriers.

As the global presence expand, the areas for costs controls and potential improvement grow significantly (Ross, 2015). When shipping goods between countries there are several points of unloading, reloading, transport consolidation, and warehousing. This increase the complexity as the management of a global network get more complex the greater number of actors involved (Skjøtt-Larsen et al., 2007). The costs that are part of both national and international distribution include costs for administrative warehouses and facilities, transportation, fleet maintenance, purchasing and value-adding processing, inventory and information processing (Ross, 2015). In addition, costs that are driven from global channel are for example costs for in-transit inventory, product packaging, customs duties, taxes, ensuring deliveries, having an international trade department and development of marketing channels.

3.4.3 Distribution Channels

The channel of distribution is the route from the point of production to the point of consumption taken by the products (Rosenbloom, 1995). Thus, a chain in which goods passes before reaching the final point of delivery. A distinction can be made regarding distribution channels where products either can be shipped directly from the supplier to the customer or be shipped through intermediate storage points (Simchi-Levi, Kaminsky, & Simchi-Levi, 2008). Direct delivery is often used by manufacturers who have an *MTO* strategy (Ross, 2015). A channel that constitutes of different distribution centres, warehouses and retailers is common when having an *MTS* strategy.

3.4.3.1 Direct delivery

Company responsiveness is a key customer requirement which has created a new corporate environment enabling direct delivery and ordering (Bowersox et al., 2017). Direct delivery, or direct shipment of products is a distribution channel that refers to the direct transportation of products from point of origin to point of destination without further handling between these points of locations (Nikolopoulou, Repoussis, Tarantilis, & Zachariadis, 2017). If inventories are needed, they are kept in stock at the manufacturer and the information flows from the customer, via a distributor to the manufacturer whilst the product flow directly from the manufacturer to the customer (Chopra, 2003).

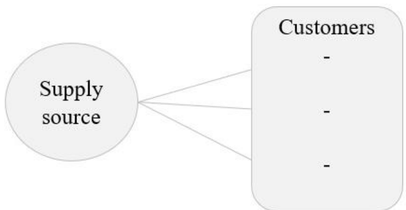

Figure 10 - Direct system of global trade (Ross, 2015).

One of the greater advantages with direct shipping is the possibility to centralise inventories at one place (Chopra, 2003). Storing at one location enable the aggregation of demand and a higher level of product availability. Since the inventory is kept at the manufacturer, direct delivery brings advantages related to reduction of cost due to the avoidance of distribution centre costs (Simchi-Levi et al., 2008). Ross (2015) present a model where global channels are divided in four systems, where the first one is illustrated in Figure 10 as the direct system. The benefits with direct delivery are related to the fact that there is no need for warehousing or shipment consolidation and hence less products in the distribution channel. Further, direct delivery offers the possibility to lower inventory costs by postponing customization until the customer order has been placed which is preferable when products are produced according to *MTO*. In addition, Simchi-Levi et al. (2008) argues that direct shipping enables lead time reduction.

The disadvantages with direct shipment relate to high transportation costs and reduced ability to aggregate demand when several suppliers are involved (Chopra, 2003). In addition, Ross (2015) argues that direct shipment brings drawbacks such as higher delivery costs, packaging and documenting costs. According to Simchi-Levi et al. (2008), an increase of transportation costs may occur due to the need for smaller vehicles for transportation. Further, Chopra (2003) mentions that customer experience may suffer with direct delivery since several transportations must be performed if the order contains products from other points of origin.

According to Simchi-Levi et al. (2008) a direct delivery strategy is preferable when firms are delivering large volumes that utilises the full capacity of the transportation vehicle. In addition, for direct shipping to be effective, there should be few sourcing locations (Chopra, 2003). Performing direct delivery require a decent information infrastructure since the visibility into the order processing at the supplier is crucial when the material flow is directed directly from the supplier. Chopra (2003) further mentions that order tracking becomes harder to implement since it often requires integration of all actor's information systems.

3.4.3.2 The utilisation of intermediary

A strategy that includes intermediaries commonly utilises distribution centres or warehouses (Simchi-Levi et al., 2008). Warehouses may be used in several different ways where the usage depends on characteristics of the supply chain such as manufacturing strategy, inventory policy and the ownership of the supply chain. An intermediary can reduce distribution costs based on three aspects; sources of supply are not in abundance, there are numerous destinations and transportation is expensive or difficult (Basu & Wright, 2016). Where the intermediary should be located is based on cost objectives for manufacturing facilities and warehouses. Chopra (2003) presents a model called distributor strategy where inventories are kept in an intermediate warehouse between the manufacturer and the final customer (Chopra, 2003). This model is similar to one of systems presented by Ross (2015), where a consolidation point is used between a foreign market and a supply source. To cope with uncertainty in aggregated demand, a higher level of inventories is required utilising this model (Chopra, 2003). This structure is commonly used for product with a higher demand. The warehouse serves as a buffer between manufacturer and customer, where the purpose is to decrease overall transport costs and decrease lead time by enabling products being shipped in bulk and being split/bulk break at the consolidation centre (ibid). According to Chopra (2003), postponement can be introduced to this structure. However, capacity for assembly must be developed.

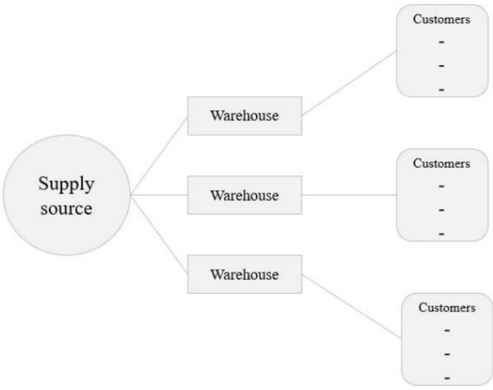

Figure 11 - Intermediary system with warehouses serving different markets (Ross, 2015).

Ross (2015) present another model utilising several intermediaries thus several warehouses, as illustrated in Figure 11. From this, warehouses can be located in foreign strategically places where it serves several countries and markets. Intermediate warehouse brings advantages related to reduction of inbound transportation costs where the utilisation of well-developed transportation routes is possible (Chopra, 2003). Consolidation of several products is important to enhance costumer experience. Further, intermediate warehouses provide flexibility towards customers as well as perform shorter lead times (Ross, 2015). The drawbacks are however the transport and administrative costs that arise when distributing to several other foreign countries. Further, the increased facility costs operating intermediate (Chopra, 2003).

4. Empirical findings

The empirical study is based on interviews with various experts relating to Microwave supply and the antenna distribution. Additionally, a workshop was held to brainstorm and capture internal ideas about possible improvements. The empirical findings of the study are presented below and will be further analysed in the following chapter. Initially, an introduction to Ericsson and the product portfolio is given. Thereafter, the Microwave supply chain and the involved actors are presented to be followed by a section about the distribution strategy. Followingly, the order process is presented. Lastly, suggestions for improvements and a customer case are presented.

4.1 Introduction to Ericsson

Ericsson is a provider of communication and information technology with a global headquarter located in Kista, Stockholm, along with additionally seven other offices located in Sweden. In addition, Ericsson have several local companies operating to serve local markets. The organization is divided into four business segments which are Managed Services, Digital Services, Networks and Emerging Business and Other. The largest customer which all different segments serve are telecom operators.

The study is performed in the Networks business segment who provide hard- and software as well as services needed for building, installing and developing mobile networks (Ericsson, 2019). The Networks business segment further contains a subsegment called Mobile Transport in which Microwave is included. The Microwave Supply Chain Management department has its lead site in Borås.

4.1.1 The product portfolio of Ericsson Microwave

Microwave is a business segment that provides a cost-efficient mobile transport network (Ericsson, 2019). A mobile transport network consists of minimally one start site and one end site where in between microwaves signals are transported to enable the utilisation of the network. Between the start- and end site, a varied number of sites can be placed. A site is any physical location in the network that receives or sends signals. A mobile transport network consists of several products that collaborate to enable the transfer of microwave signals. Thus, to establish and operate a network, several product types are needed. The products needed are in broad terms the following:

- Microwave radios
- Modems
- Base band units
- Waveguides
- Antennas

The microwave technique is based on microwave signals with different frequencies travelling between different sites. To eliminate disturbances between mobile transport networks, different networks are utilising microwave signals with different frequencies. The products included in the network have different functions. The purpose of the antenna is to “collect” the signals whilst the radio function as the transmitter and sender of the signals. The radio is preferably located close to the antenna (outdoors) but can also be located on the ground (indoors). A site that is located between the end and start point of the network require at least one radio in each direction, and additionally one radio on each side as backup. The minimum number of radios is thus four, but sometimes there are up to 16 radios at one site. At least one antenna is installed on each side, but there are situations when it is useful to add more antennas. The total number of each component therefore depend on the size of the network as well as technical preferences. A waveguide connects the antenna to the radio. In addition to this, several additional products are needed for a complete installation at the site where one example is the outer cabinet which protects the ground-based material from wind, rain and sun among others.

Creating a new mobile network can be a long process depending on several aspects such as the customer relationship, the size of the network and the political and financial stability of the customer. The time for designing a network can be up to 3 months. The total time from order lead to the completion of a finished network may vary from 6-9 months.

The products in Ericsson's microwave product family are named MINI-LINK and the frequencies supported by MINI-LINK range from 4 to 80 GHz. Within the portfolio several different variants of MINI-LINK radios are offered which enables Ericsson to serve different types of customer needs. The products in the portfolio can be sold in bits and pieces thus enabling flexibility. The portfolio offers complete solutions of mobile networks, hence including several products to be combined with a MINI-LINK radio. The MINI-LINK radios can be categorised in two groups: longhaul and shorthaul. Shorthaul is a group of products which are characterised of utilising frequencies from 6 up to 80 GHz and are typically used in urban areas where there is a high demand of fast connection as well as high capacity in terms of handling a large amount of data traffic. Longhaul on the other hand utilise lower frequencies where the ability to cover long distances is essential. These systems have the capacity to make hops that are up to 200 km (Ericsson, 2019). The choice of what frequencies to use in the network is dependent on several aspects such as geography, weather and what frequencies the customer is allowed to use. This permit is established by local authorities where the permit is needed to eliminate disturbances between different mobile networks.

4.1.1.1 An introduction to antennas

Large antennas, which are studied in the thesis, are mostly used for longhaul networks but can be used in shorthaul networks as well. When establishing longhaul networks, the distance between the sites is correlated to the frequency that is used (SCM 1). Choosing what antenna to use can only be determined when the frequency of the network is decided. Among the products in the Microwave product portfolio, the antennas are some of the bulkiest products needed to complete a mobile network. In addition, the Supplier Manager argues that the antennas are one of the more expensive products. An antenna order contains an antenna reflector, a radome, a feed, a shield/shroud, a mount and a side strut as illustrated in Figure 12. The antenna reflector sizes range between 0.1 m to 3.7 m in diameter and are distributed over 10 different standardised sizes: 0.1, 0.2, 0.3, 0.6, 0.9, 1.2, 1.8, 2.4, 3.0 and 3.7. A categorization has been made between small antennas and large antennas where the large antennas are the four latter antenna sizes, 1.8-3.7 m in diameter. The antennas ranging from 2.4-3.7 m in diameter exceed the standard measurements of transports and the antenna disk is thus divided in two pieces.

The items included in the antenna order can be divided into two groups: frequency specific items and non-frequency specific items. As the microwave signals are sent with different frequencies, the antenna must have an adaption to the frequency utilised in the network. The frequency-specific items are nonrelated to the antenna size and can therefore be combined with all types of antenna sizes. All items are standardised, but the configuration of the antenna order is order specific as the antenna size and frequency specific item is adapted to the customer order. Hence, the antennas are order-specific in that sense acting as the collector of the microwave signals.

4.1.2 The organisational and legal structures of Ericsson

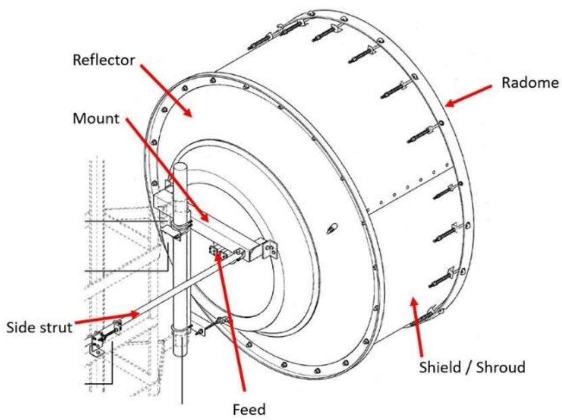

Figure 12 - Description of the included parts of an antenna order.

Ericsson is operating globally serving customers all around the world. To organise the global presence, the market that Ericsson serves has internally been divided into five geographical groupings with different characteristics and order volumes. The five geographical groupings are called market areas and are shown in Figure 13.

Figure 13 - Ericsson´s five market areas.

At Ericsson, the division of the geographical market areas is the organisational structure while the legal structure is found in the contracting of Ericsson AB(*EAB*) and Ericsson local companies (SCM 1) see Figure 14. The local company's function is to serve customers in the local area. They perform mainly sales activities and provide information regarding customer requests, sales lead and forecasts to Microwave supply. The local companies have access to technical support located in respective market area.

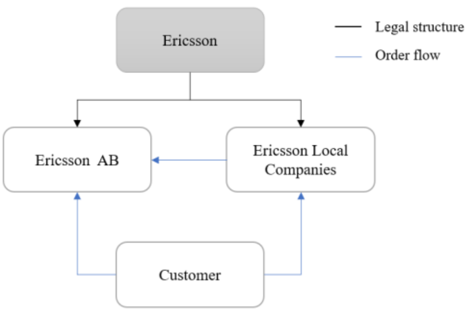

Figure 14 - The legal structure and order flow.

Depending on the country in which the company is located, different aspects need to be taken into consideration. There are different legal aspects to consider but it is also a question of financial and political stability in the country that affect the way Ericsson do business. For a country with financial and political stability, the local company is responsible for the contract. In a country where there is financial and political instability, *EAB* is responsible for the contract which also means that there is a need to deliver products from a legal Swedish entity. Therefore, the two contracts affect the distribution of the products. In addition, there are cases when Ericsson needs to pay customs taxes and adopt to the laws and requirements of the countries where the goods are to be shipped. For example, customs clearance, sealed loads and requirements of certificates of origin, stating that products are sourced from approved countries. This does in turn affect where the products are sourced and shipped from, hence affecting the distribution of goods. Table 6 show a comparison between the two contract types.

Table 6 - Comparison between the different contracts.

Local company-contract	EAB-contract
Financial stability	Financial instability
Political stability	Political instability
No legal prohibition	Legal prohibition

4.1.3 The supply strategy of Ericsson

For Ericsson as a company, the supply strategy has changed during past years from a strong cost-focus to a focus on boosting the supply chain to meet customer demands. Today, the strategy is focusing on digitalisation. The supply strategy of Ericsson is communicated downwards where each underlaying department is responsible for creating a strategy that is aligned to reach the wanted market position of Ericsson. Regarding the sustainability strategy, Ericsson works to understand and handle social, environmental and economic impacts and possibilities and integrates sustainability and corporate responsibility in the organisation (Ericsson, 2019). Ericsson has an aim to reduce carbon footprint by 35% of its own activities between 2016 and 2022. To reduce environmental impact within the area of product transportation, Ericsson has implemented a Transportation Management System enhancing consolidation, control and planning of transport.

For Microwave Supply, the strategy is communicated from the top management in the organisation. The strategy is used as a basis to create strategic goals, striving to reach the wanted market position of Ericsson (Head of SC Design & Control). To reach the created goals, focus is directed on four strategic capabilities. The strategic capabilities are visibility, automation, segmentation and fundamentals.

4.2 The supply chain of Microwave products

As the antennas are a part of a mobile transport network order, the distribution of antennas is influenced by the supply chain of all Microwave products. The following section will therefore present the supply chain of the Microwave products to describe the environment and context that the antennas are a part of.

In the supply chain, different categorisations of lead times are identified. Figure 15 illustrate the different lead times identified in the supply chain of Microwave products. To point out, these definitions are not internally utilised but have been distinguished to avoid confusion regarding the general term lead time. The sales lead time is the time passing between the identification of a customer order lead and the point in time where an order is received at Ericsson Microwave. The production lead time is the time between the point of a received order and the point in time when the product is produced. The distribution lead time is the time from when a product is finished to the delivery of products to the customer. The distribution time is further consisting of three different lead times: inbound transportation lead time, supply hub handling lead time and outbound transportation lead time.

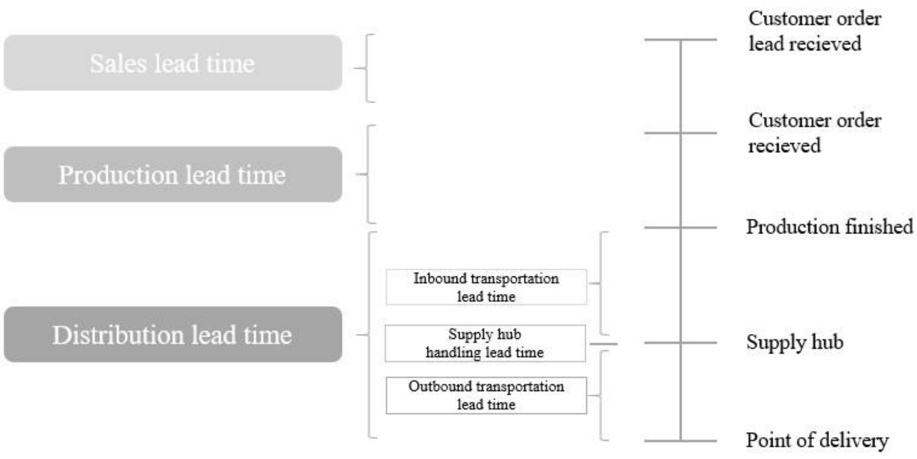

Figure 15 - Definition of different lead times.

4.2.1 The material flow in the Microwave supply chain

The Microwave products' supply chain consists of several actors providing and securing the delivery of the Microwave portfolio to customers located all over the world. The Microwave supply chain of today is standardised meaning that the supply chain is supposed to deliver the same service level and set-up to all customers (SCM 3). Figure 16 describe the material flow in the current supply chain of Microwave products which aims at delivering products to customers in the most time- and cost-efficient way, maintaining and expanding the current customer base. The included parts of the supply chain are suppliers, production, storage, transportation and customers. The storage facility in Sweden is called Ericsson Distribution Centre (*EDC).* The components flow from Nth tier suppliers to 1st tier suppliers where the N is different for different products and components. The scope of the thesis will span from 1st tier antenna suppliers to customers as presented in Figure 16.

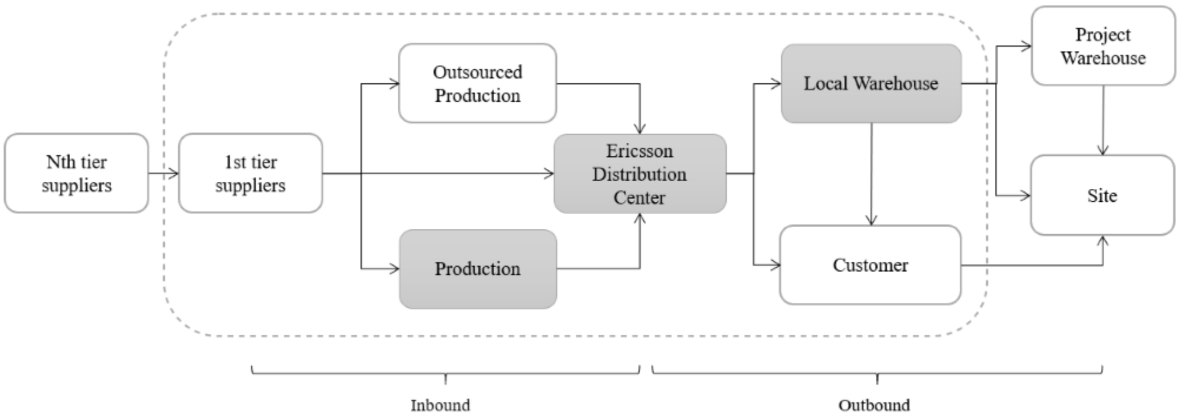

Figure 16 - Microwave Supply Chain.

In the overall supply chain, components from the 1st tier suppliers are delivered either directly to the distribution centre, to an outsourced production site or to an inhouse production site depending on the product type. The products passing through the production sites are radios for shorthaul and longhaul networks. Other products are purchased and delivered directly to the *EDC.* All products pass through the distribution centre where the customer order is picked and packed. Most commonly, all products included in a customer order are consolidated as one shipment before being shipped either to the customer directly or to the local company's warehouse. From the local warehouse, the products can be sent to a project warehouse close to the site. In other cases, the products are sent from the local warehouse or from the customer to the site for installation. The actors involved in the microwave chain can be categorised as:

1. Ericsson (EAB + Local Companies)
2. Customers
3. Suppliers
4. Third party logistics (*3PL*) providers

The ingoing parts of the general Microwave supply chain will be presented below.

4.2.1.1 Suppliers

Ericsson has several different suppliers spread over the globe and have close relationships with 1st tier suppliers but also with Nth tier suppliers to ensure the needed product quality. The sourcing of suppliers is performed at the sourcing department outside the scope of Microwave Supply Chain Management. According to SCM 3, different functions within the organisation have different focus requirements when it comes to sourcing which could be better aligned to better match the purchased quantity of material with actual demand. Hence, the total cost of purchasing could be reduced if finding smarter ways of sourcing material focusing on other aspects than the cheapest price.

4.2.1.2 Production

The production that Ericsson controls is related to the production of radios for both shorthaul and longhaul networks. The two categories of radios are produced in two ways:

- Shorthaul radio production performed by a manufacturing partner, Ericsson Manufacturing Site (*EMS*)
- Longhaul radio production performed in-house

The production of MINI-LINK shorthaul radios is outsourced to an external manufacturing company with production sites in both Hungary and India. However, the main production of MINI-LINK radios is done in Hungary. The production in India was established due to local requirements and serves mainly the domestic market. The *EMS* provides both module production and buffers of finished goods. Ericsson has a tight collaboration with the *EMS* and are involved in the planning of the production, improvements and product development. The general lead time of shorthaul radios is 21 days including production, inbound transportation and handling at the hub.

In Borås, a smaller production facility produces MINI-LINK longhaul. Ericsson does also have a production facility located in Brazil, where MINI-LINK radios are produced mainly for the domestic market, but some export is also performed. The supply site in Brazil provides buffer of finished goods and pick from stock. The longhaul radios have a lead time of 30 days including production lead time, inbound transportation and handling at the hub.

4.2.1.3 Storage

From the production, the products are sent to the *EDC* in Sweden which is a warehouse. The warehouse in Sweden is called *EDC* whilst the remaining Ericsson warehouses will further on be called supply hubs. Within the five different market areas Ericsson aims at having as few supply hubs as possible (SCM 1). Today, Ericsson has several supply hubs located around the world. The supply hubs are used by different business segments of Ericsson, and some are limited to only being utilised by a specific business segment. The Ericsson supply hubs are located in Germany, Brazil, India, Mexico, USA, United Arab Emirates, Singapore, China and Sweden.

A decision has been taken to store and handle Microwave products centrally in Sweden. The two supply hubs in Brazil and in India are occasionally utilised by Microwave supply through performing activities like storing of finished goods. In addition, functioning as a shipping point for the domestic markets. Apart from these, none of the hubs located outside of Sweden are currently used by Microwave supply.

The *EDC* in Sweden is operated by a *3PL* partner. The *EDC* Sweden works as a consolidation point for all Microwave inbound-and outbound material. Almost all orders within Microwave supply are distributed through the Swedish *EDC*. Buffers of finished goods are stored, and activities performed are picking, packaging and kit assembly. The supply hub is registered as a shipping point and does thereby have authority to export (SCM 1).

4.2.1.4 Customers

After transportation from the *EDC*, the products are delivered to the customer which either is the final customer, a local warehouse or a project warehouse. According to SCM 1, the local company is responsible for following up the delivery to customers.

4.2.2 Microwave Supply Chain Planning and Evaluation

The demand planning of Microwave products is performed on a radio level and is based on previous sales and current needs, where forecasts are updated within given intervals. Forecasting is done in three levels namely per market area, customer unit and customer hence improving the accuracy of future demand. The demand of accessories in the portfolio is tied to the demand of radios. Hence, changing the forecasts of radios will change the forecasts of other products. Most of the products in the portfolio are produced according to their respective forecasts. However, the large antennas are forecasted with the purpose of securing raw material. Thus, the antennas are not produced according to forecasts.

Today there are three central key performance indicators, (*KPIs)*, namely: end to end supply cost, end to end inventory days and delivery performance according to standard lead time. End to end inventory days considers all material that exist in the supply chain, from finished and packed goods at Ericsson local companies to components stored in the beginning of the supply chain.

4.3 The distribution of antennas

As a part of the Microwave supply chain, the antenna distribution is responsible for the movement of antennas from the supplier to the customer. As the antennas are the studied product group, the antenna distribution will be presented in-depth below.

4.3.1 The characteristics of the large antennas: customers, demand and lead times

The antennas included in the microwave product portfolio are not produced within Ericsson. Instead, the antennas are sourced from three designated antenna suppliers which means that Ericsson do not perform any value-added activities. The antennas are bought from the suppliers to fit the network configuration and are thereby bought upon specifications where the suppliers are responsible for the design (Supplier Manager). According to empirical findings, no testing of the products is done by the supplier, constituting parts of the antenna are only “kitted” and thus easy to handle at another location than at the supplier if needed.

The antennas are purchased for projects all over the world, see Figure 17. According to SCM 2, the large antennas are most often used in the longhaul product portfolio. They are however feasible with the shorthaul portfolio as well. Depending on network requirements and geographical location, different microwave signal frequencies are utilised. Thus, different frequencies are more commonly used in certain areas around the globe. This is related to how effective the microwave signals are sent through the air according to SCM 2. Since being most commonly used in longhaul projects, the antennas are often placed on high altitudes and are designed to operate in hard weather conditions according to SCM 1.

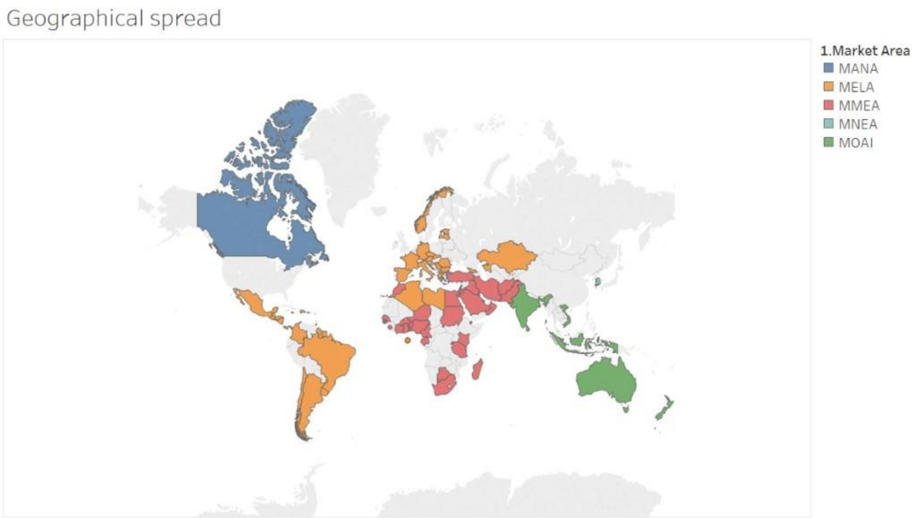

Figure 17 - Geographical footprint of large antennas.

The large antennas are commonly used for low microwaves frequencies. According to SCM 2, low frequencies are often related to a long distance between the antennas which require a large antenna to collect the microwave signals. The large antennas can collect microwave signals sent from a site located 200 km away. Therefore, the large antennas are usually utilised in projects where large telecommunication networks are built. The occurrence of such projects is quite low which affect the demand for large antennas.

Since the frequency utilisation is different around the world, the volumes sent to the five market areas differ. As seen in Figure 18, the biggest market area in terms of ordering of large antennas is MMEA followed by MOAI and MELA.

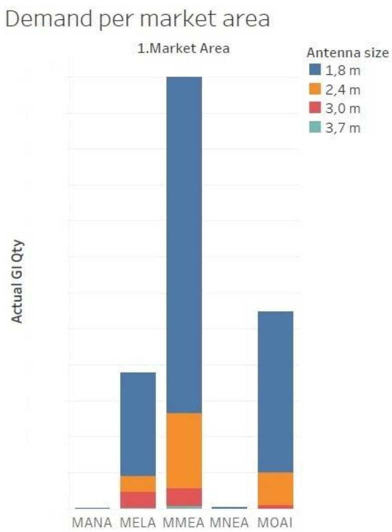

Figure 18 - Large demand per market area.

When comparing the demand for different antenna sizes in the antenna product portfolio, the large antenna demand is relatively low. However, the cost for handling large antennas are higher than the handling of small antennas. The demand for large antennas is fluctuating, as can be seen in Figure 19 and thereby, the demand is hard to predict and dimension. Due to the characteristics of the large antenna demand, the large antennas are purchased according to purchase-to-order (*PTO*) creating a situation with no inventory or buffers. A situation that is beneficial since the large antennas occupy much space at the *EDC* Sweden which generate high tied-up capital.

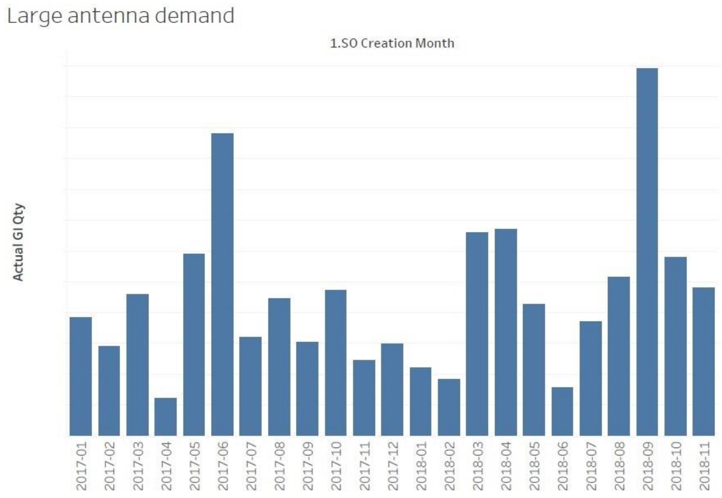

Figure 19 - Large antenna demand.

The lead time for large antennas from point of order to the point of delivery to *EDC* Sweden is currently 8 weeks (SCM 1; Supplier Manager) but may vary depending on if the customer in beforehand has forecasted the demand. The lead times depend on where the production site is located and where the final point of delivery is located. Thereby, the lead times might differ between the three suppliers. The contracted production lead time is 35 days where the inbound transportation lead time is included.

Comparing the production lead time for other products in the Microwave portfolio, large antennas have the longest production lead time. As many of the remaining products that are included in the total network have a significantly shorter production lead time, disturbances are created which lead to waiting time for these products. In addition to long production lead times, it is rare that all antennas in a customer order fit into one transport vehicle due to the dimensions of the large antennas.

4.3.2 The distribution strategy of large antennas

The distribution strategy of the Microwave product portfolio, including the large antennas, is based on a consolidation strategy where Ericsson utilise one centralised distribution centre, the *EDC* in Sweden. Products arrive to *EDC* Sweden where they are consolidated as one shipment and later sent to the customer. A centralised distribution strategy has been developed to cope with a product portfolio that is rapidly updated and thereby eliminate obsolete products spread over the world. Thus, the distribution strategy of Microwave supply is based on the characteristics of the Microwave product portfolio according to SCM 1. Since most of the products in the product portfolio are small, the freight cost is not that high, and the space needed to store the products is quite small. For these products, it would be costlier to have them spread around the world and increase the tied-up capital. Hence, the strategy has been developed for products that are frequency dependent, are relatively small or have a short life cycle with frequent product developments. Thus, the distribution strategy is designed for small products which is a product group where large antennas do not fit in. In addition, the decision to transport all products to the *EDC* in Sweden is based on the possibility to consolidate the products in one shipment to the customer which for some customers are a must due to legal and custom clearance aspects.

"*the goal with the supply chain strategy is to ensure delivery and to meet and fulfil Ericsson's customer requirements*" – Supplier Manager

As seen in Figure 20, the distribution strategy stretches from suppliers to the delivery to a local warehouse or a customer from where the products are transported to the site depending on the conditions in the contract. The scope of responsibility for Microwave Supply has recently increased to include the transportation to the customer. Previously, the responsibility stretched from procurement of components to the completion of pick and pack at *EDC* Sweden. The increase in responsibility require in-depth understanding and measurement of the included activities and steps.

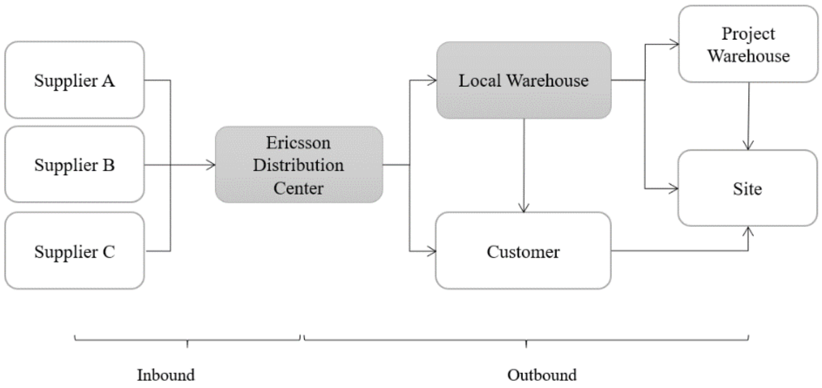

Figure 20 - The distribution strategy of large antennas.

4.3.2.1 Antenna Suppliers

Currently, Ericsson has three different suppliers of antennas where the differentiating factors among these mainly are price and form, fit and function. Consequently, the antenna supplier with most advanced technical features have the highest price per antenna whilst the antenna supplier with the least advanced technical features has the lowest price per antenna. Up until recently, Ericsson had only one supplier of antennas which enabled a well-functioning way of working. The introduction of the two latter suppliers was according to Inbound Supply Manager 2 partly based on the decision to reduce the dependency situation to the first supplier and partly to enable a greater value proposition for customers by offering antennas at different price categories. In addition, by having several suppliers Ericsson can compare prices and push the supplier to cut costs in their operations. Depending on the customer and its budget, different suppliers are preferred to meet the customer requirement. The suppliers are located in Europe, Asia and South America. The purchased volumes from the different suppliers are differing over time.

4.3.2.2 Distribution Centre

The antennas are sourced from the three suppliers as mentioned above and transported to the *EDC* in Sweden. When arriving, the packaging that shields the antennas and the belonging accessories are unloaded. The packaging is mainly composed by wooden material to keep the products intact. *EDC* Sweden is regarded as a consolidation centre meaning that ideally, the antennas are not stored longer than the time needed for all products in the order to be ready for shipment. However, the current fill rate at the *EDC* Sweden is 95% according to SCM 2 which implies that products are not only consolidated but also stored. This creates a lack of space at *EDC* Sweden. When all products are ready for shipment, the order is picked and packed. As the products are packed, a handling unit *(HU)* number is generated which enable the booking of transportation for delivery to the customer.

As previously mentioned, most large antennas are passing through the *EDC* in Sweden. However, SCM 2 states that in some rare exceptions the orders are transported from the supplier and passing through the supply hub in Singapore or Brazil, bypassing Sweden. The main issue utilising the supply hubs outside of Sweden is how to consolidate the antennas with the other products in the order as one shipment, when the customer require complete shipment (SCM 2).

4.3.2.3 Transportation

Regarding the inbound transportation, the three antenna suppliers are delivering the antennas with varying inbound transportation lead time depending on the location of the supplier production site.

For the outbound transportation, the antennas are loaded onto a truck and are either delivered directly to the customer or to a local warehouse. Additional transportation modes might further be used before the antennas reach the final point of delivery. Due to the size of the large antennas, the packaging is large and shield the fragile antennas. Hence, a lot of unutilised space is created when transporting the large antennas as there is no possibility to stack the antennas. One truck can load 8 antennas with a diameter of 2.4m. In addition, the antennas are rarely packed with other material as additional pallets do not fit in the transportation vehicle. This generate a low fill rate in the transportation units which require a lot of trucks which according to SCM 2 bring problems finding enough transportation capacity.

The parameters that are needed in order to book an outbound transport is the weight, volume, origin country, destination country, mode of transport and flow according to the Senior Supply Delivery Manager. The share of used transport modes for transportation of large antennas are shown in Table 7. The first-hand choice, and default mode in the ERP-system, when it comes to transportation modes is boat or trucks. If wanting to change the transportation mode, TSL 1 explains that there is solely one person in each market area that can approve the change. This feature has been introduced to reduce the usage of air freight since despite the system default mode, air freight is used in some situations when delivery deadline is approaching. If the transportation mode is changed, TSL 1 states that Ericsson is often burdened by the cost which further emphasize the unwillingness to use air freight since it rapidly eliminates the order margin for Ericsson.

Table 7 - The share of used transport modes for large antennas.

Size (m)	Air	Truck	Sea
1,8	35%	14%	50%
2,4	44%	6%	49%
3,0	17%	34%	48%
3,7	22%	6%	72%

Antennas are purchased from the suppliers on DAP incoterm which means that the suppliers are responsible for the inbound transportation and thereby the planning of transportation. Inbound Supply Manager 2 argues that the advantage with DAP is that Ericsson is the demand specifier eliminating the following of goods. Two of the disadvantages with DAP are the additional cost and the lack of control. On the contrary, products are sold on FCA Inco-term which means that Ericsson is responsible for the outbound transportation.

4.3.3 Experienced challenges relating to the distribution of large antennas

One of the challenges emphasized in the interviews relates to the fluctuating demand. For smaller orders which has been forecasted, the suppliers manage to deliver as promised. For large peak orders that have not been forecasted however, it is challenging to deliver according to customer requirements. The suppliers have a certain production capacity and for large project with a large number of ordered antennas, that capacity is exceeded. SCM 2 describes that the peak demands drain the supply chains going as far as to the supplier of ore. This creates several problems where the customer in extreme cases may cancel the order but more commonly, the time until the invoice is paid gets prolonged.

The set-up of the distributions strategy itself is mentioned as a distribution challenge. SCM 2 argues that the distribution channel enables consolidation and control, but it does contribute to higher cost and environmental impact than needed thus increasing the negative impact to the performance measurements. Several interviewees highlight the fact that most of the customers are located south of Sweden and therefore a lot of value could be gained from structuring the distribution channel in other ways.

Further, the performance in relation to the supply cost is to high (Head of Supply Chain Design & Control; SCM 3) There are several costs with potential to the reduced or eliminated. One way is to improve the ways of working and moving from being reactive to being proactive according to SCM 3.

4.4 The order process from customer lead to final delivery

The order process from the customers point of view is initiated by sending out a request for quote, *RFQ*, to several suppliers in order to compare and find the most suitable supplier. For the customer, short lead time is the most important aspect when choosing an appropriate supplier (TSL 1). Continually, the company who can deliver the shortest lead time is often the company who wins the contract and the order. This is further confirmed by TSL 2 who means that this is one of the most important aspects. According to SCM 2, the order winner is often cost and lead time, where the lead time discussion is performed after the price determination. However, the technical competence is also emphasized as being an important selling point of Ericsson.

The creation of a microwave network includes several stakeholders both internally and externally and requires preparation. Naturally, the customer who is the operator of the to-be-created microware network solution is present as requirement specifier. For a network within a bigger city, examples of involved stakeholders are the government and property owners giving approvals for different permits. Some of the needed approvals is related to building permits for the masts, building permits from property owners to install products on e.g. the walls and roofs. Above all, a permit relating to the frequency to be utilise is needed which is approved from the government. SCM 2 mentions that in a mobile transport solution, the microwave network is most commonly ordered lastly. Hence the strong focus on lead time. Further, SCM 1 states that the order from the customer cannot be placed until the confirmation of frequency is made which may affect the customer experience despite being out of Ericsson’s hands. At Ericsson, there is a technical sales support who is involved in the network design with the responsibility to develop a solution and decide upon what products that need to be included to fulfil the requirements of the network. The technical sales support collaborates with the solution team where solution architects are involved in the creation of a design that suits the customer. From this, a bill of quantity that contains the needed products and the total cost is created and presented to the customer. If the customer approves the bill of quantity, either *EAB* or the local company write a contract and the order process is to be started. From here, the key account manager is responsible for feeding the information from the bill of quantity to a specific system where after a translation is performed from this system to the ERP-system. When the order is translated, the order is visible for the supply department as a purchase order from the local company, see Figure 21.

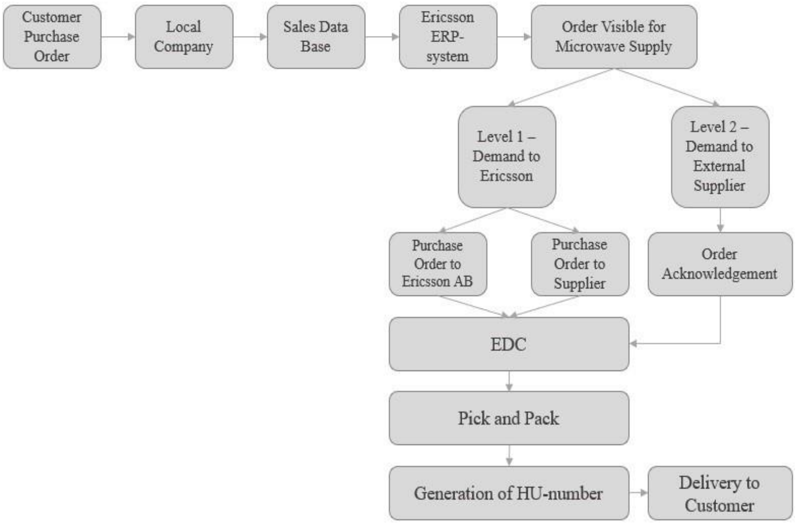

Figure 21 - Order flow map.

The supply chain activities start earlier reacting as soon as the key account manager catches a sales opportunity from a customer. A sales lead is created which the key account manager is supposed to report to Ericsson to use in the forecasting process. This information is important to be able to secure inbound material at the suppliers (Account Manager; SDP 2; SDP 1). However, Account Manager state that the sharing of information about customer leads has been quite bad in the past. The lack of information sharing about incoming orders has created problems. Without forecasts, it is a challenge to respond to high demand volumes.

In an order, both *EMSs* and suppliers are involved. When the order is visible in the ERP-system, a check is performed to know whether the ordered products are in stock or if there is a need for Ericsson to order products from their suppliers. If the latter alternative is required, then the system automatically gives an order handling time of 3-10 weeks depending on the type of product. For orders to external suppliers, a purchase order is created which generates an order acknowledgement according to level 2 in Figure 21. For orders to the site in Borås, the order planning team receives the order where after planning of the order is done. When the order is confirmed, a confirmation is sent to the key account manager who is responsible for the communication with the customer.

When an Ericsson demand is generated, there are two different paths to follow in level 1 according to Figure 21. Either, a purchase order is sent to production sites within Ericsson's responsibility who initiate their production and deliver the finished products to the *EDC* Sweden. Or, a purchase order is created and sent to suppliers who deliver products that are needed for the microwave solution, for example antennas. Regardless which path the products have travelled, all products are sent to *EDC* Sweden for pick and pack. Three days are allocated for these activities. At this point earliest, a handling unit (*HU*) number is generated for each box or pallet which enable the transportation planners to book a transport from the *EDC* to either the customer directly or to the local company. The generation of a *HU*-number establishes documents that are needed for the transportation planning, custom clearance and further enable the creation of an invoice. This invoice is essential when exporting since it presents the products included in the shipment and the order value.

Due to legal and trading aspects, some customers need a compete shipment of the order which means that all products are shipped in one single shipment. In these cases, the stocked products are reserved until the remaining materials are delivered to *EDC* Sweden. For other customers, SCM 2 states that it is possible to send the products held at stock first where after a second delivery is performed containing the remaining material from the suppliers. The customer requirement to ship a complete delivery is something that SCM 1 argues to have the possibility to be questioned more often. For some customers it is a must but for some, it is only a wish. SCM 2 argues that most commonly, the large antennas are the products that delay the order delivery since the production lead time for large antennas is longer than the remaining products. This means that some products are held in stock waiting for all products to arrive at the *EDC* to further be delivered to the customer.

4.5 Suggestions for how to improve the antenna distribution

The following section will present suggestions for improvements of the antenna distribution. The empirical findings were identified during a workshop as well as during interviews which were conducted to follow-up the results from the workshop. The workshop generated seven different categories of potential alternatives for improvement: direct delivery, expanded utilisation of supply hubs, postponement, regionalised supply, increased fill rate, reconstruction of the antenna design and transport mode. As fill rate and transport modes is highly related to the order planning process, these alternatives have not been investigated further but is rather seen as parameters to be improved regardless of which alternative to implement. Table 8 presents the advantages and disadvantages brought up at the workshop regarding the different alternatives.

Table 8 - Presentation of advantages and disadvantages of the improvement suggestions.

Suggestions	Advantages	Disadvantages
Direct delivery	Shorter transport lead time Less handling Shorter transport distance Reduced cost Reduced CO2-emissions	Custom clearance Difficult to consolidate as one shipment Complete shipment Introduction of administrative tasks No ERP-system support Traceability
Expanded utilization of supply hubs	Shorter transport lead time Greater flexibility Make-to-order Reduced cost	Increase inventory cost Great product variation Double transport cost
Postponement	Increased flexibility Greater demand responsiveness Reduced transport cost	Introduction of administrative tasks Increased tied-up capital Increased inventory cost Competence required Assemblage at Ericsson
Regionalised supply	Shorter lead time Shorter transport lead time Reduced CO2-emissions	Increased inventory cost Increased product variety for suppliers Fluctuating demand
Reconstruction of the antenna design	Increase fill rate Reduced transport distance Reduced transport cost Reduced CO2-emissions Easier handling	New business model Increased complexity Competence requirement

4.5.1 Direct delivery

The alternative to perform direct delivery was emphasized several times during the study and was brought up in different variants. The most obvious alternative is the one where the purchasing structure of today remains where Ericsson is responsible for the sourcing of antennas. However, the antennas will be transported from the suppliers directly to the customer warehouse or to a local warehouse in Ericsson's regime without passing through the *EDC* in Sweden.

For customers located close to an antenna production site, antennas optimally should be delivered directly from the supplier to customer (Supplier Manager). Hence, eliminating the transportation through the *EDC* in Sweden to further be transported back to the customer. A prerequisite for direct delivery is however an increased flexibility in the customer contracts according to Supplier Manager. SCM 4 argues that it is possible to establish direct shipment in both categories of contracts, presented in 4.1.2, as long as there are no restrictions that necessitate a bypassing through Sweden due to legal aspects. Supplier Manager argues that in order to succeed with direct delivery, several departments within Ericsson must collaborate. The departments to be involved are for example sourcing, trading and the legal department.

An advantage brought up by SCM 4 is that direct shipment enables a faster distribution since the distribution lead time often is heavily reduced eliminating the pass-through by the supply hub. This is especially preferable for heavy material. If the material is heavy and there are no legal requirements of shipping directly from the plant, it is preferred to save lead time and cost through direct distribution (SCM 4). Supplier Manager further argues that an advantage with direct delivery is the possibility to eliminate large transport costs.

One element that needs to be considered if implementing direct delivery is the issue generated when having a financial flow and an order flow that is differentiating from the material flow. As the material flow will be directed directly from the supplier to the customer, this will be differenced from the order and financial flow that will go through Ericsson.

Direct shipment is possible in other business segments of Ericsson. To cope with legal aspects in these situations, Ericsson has created a decision tree with certain aspects to consider before sending orders directly. According to this decision tree, the geopolitical aspects and the characteristics of the products is highly affecting the possibility to utilise direct shipment. For some orders, a special distribution must be performed despite having longer distribution lead time as geopolitical restrictions limit the distribution. Another disadvantage is according to Supplier Manager, the splitting of the shipment where the order will be divided in several shipments. In addition, several interviewees have emphasized the lack of system support to perform direct delivery.

4.5.1.1 Case scenario of direct distribution

Recently, a permanent supply chain based on direct delivery was established distributing radio base systems between two countries, where the total lead time was reduced with 50% (SCM 4). Previously, the material produced in China was shipped and consolidated to one shipment in Sweden, and thereafter sent to the customer. When the new supply chain was established from the production site, the lead time was reduced thanks to an establishment of direct shipment to the customer. Thus, saving time and money. The establishment required a clear communication with the customer and an explanation of the potential benefits with the new distribution channel. Even though it was an *EAB* market and orders therefore needed to go via *EAB*, products were shipped directly from the plant to the customer. The whole project took about five months to complete as there were several actors involved in the project, from top management level to customers. The long implementation time were caused by the fact that the customer service could not be jeopardized, and a lot of establishments were needed. Establishment of distribution lanes, transportation companies and agreement contracts were needed for the set up. Apart from the involvement of Ericsson, the customer had to secure import licenses and approve import directly from the production country.

Within this case, the change management was experienced to be the biggest challenge as it was important to be very persuasive and alert on convincing the stakeholders about the importance of this project (SCM 4). Several instances needed to be involved such as the Ericsson operation model, trade finance and the trade compliance department.

4.5.2 Expanded utilisation of supply hubs

There are several different supply hubs in Ericsson's regime, see 4.2.1.3. The alternative to expand the supply hub strategy for consolidation and utilise more hubs than solely the *EDC* in Sweden was brought up as an alternative. The antennas would thereby be sent from the suppliers to the supply hub closest to the customer either to be consolidated with the remaining products or to be shipped in a separate shipment.

One purpose of the hub is to function as a consolidation centre and thus deliver a complete system to the customer through delivery from the hub (Head of Hub Operations). According to SCM 4, the hubs are preferred to gain benefits of consolidated shipments and thus avoiding several deliveries to customers. Being able to consolidate products and send them as a complete delivery is of great value. If sending split packages with goods from different countries and thus multiple deliveries to the customer, several payments of duties are required, and several invoices will be created (SCM 4). SCM 4 mention that through consolidating material it is possible to minimize the number of times the duties are paid which Head of Hub Operations argues to be one of the core abilities of the hubs. In addition, complete shipment is of great value as it eliminates the need for a local warehouse where the products can be consolidated as one shipment.

Utilising the current supply hubs in the Ericsson organization may according to SCM 4 be tricky. The hubs located in India and Brazil are currently not tied juridically to Sweden which creates juridical issues. Regarding the hub in Germany, there is currently no capacity for handling large antennas, but it would be easy to expand the capacity and set up a structure for this handling (Head of Hub Operations). Further, the requirement for enabling a utilisation of the German Hub is limited to expanding the storage space and introducing handling planning and order management. There are no other requirements for accepting a handling of antennas at the hub. The location of the hub in Germany has many benefits, as an example it is possible to transport goods by train.

Supplier Manager argues that a disadvantage with the utilisation of hubs is the fact that nothing is forever. There is a risk that processes are developed for one hub where after that hub is closed and the resources dedicated for the development of these processes would in some way be wasted. Further, SCM 2 argues that a disadvantage with moving the centralised *EDC* abroad is the need to act and behave under laws that are not Swedish.

An ongoing discussion is performed regarding the usage of the hub in India where the local companies would purchase the antennas from Ericsson India instead of *EAB*. In a similar way it is also possible to use the hub in Brazil as two of the three antenna suppliers have production facilities located in South America.

4.5.3 Postponement

The suggestion regarding postponement relates to the separation of the including parts in the antenna kit to further store the large reflectors at the supply hubs. The remaining products in the antenna kit would either be stored at the supply hub or be ordered when a customer order is received. The items would thus have to be picked and packed at the supply hub for delivery to the customer.

Postponement has been discussed as a good alternative to gain benefits of for example bulk shipment. SCM 2 state that this is a logistically good idea as it is possible to ship more antenna reflectors in a transportation vehicle. Thus, the cost aspect generated from this is highlighted as a benefit. Today, the product number of one antenna contain several separate parts. If applying postponement, it would therefore be necessary to split the package and create one article number for each part included in the package. This also means that a purchasing process needs to be established for each article number.

Postponing the assembly from the supplier would require assembly downstream in the supply chain. This result in the need for a production order for the “assembly” of the antenna kit and preparation of packaging material. SCM 2 add that this assembly is possible to perform at the *EDC* in Sweden. It is however unsure if the other Ericsson supply hubs would be able to assist with these kinds of activities. Further, the postponement requires establishment of a buffer in storage which is stated to space wise not be an issue (SCM 2). SCM 3 explains that in the technical aspect it would not be an issue to split the antenna kit, but questions the value gained from the postponement. Supplier Manager highlight that there needs to be some improvement or earnings for Ericsson to assemble products and thus being a part of the antenna production processing. Supplier Manager further state that building the packaging material for the antennas is not possible to do cheaper in Sweden (if the postponement were to be implemented in the current distribution strategy) than the cost of doing these activities today. Further, utilising postponement will involve the suppliers. Instead of selling an antenna kit they will have to offer the antenna in bits and pieces. This is something that SCM 2 mentions as difficult since the suppliers most likely lose some of their profit margin that now is hidden in the montage and packaging of the kit.

4.5.4 Regionalised supply

The three antenna suppliers have production sites in several location. One alternative is thus to regionalise the supply and source material locally to one market area from the production sites located closest to that market area. Hence, sourcing locally and closer to the customer. It has been mentioned that shipping antennas from a supplier production site that are closely located to the customer would generate large cost, environment and logistical benefits. A prerequisite for this alternative is to secure that the suppliers have enough capacity in these production sites.

The level of advancement of the antennas can be divided into different classes (Supplier Manager). All supplier production sites are not equipped for production of all antenna classes, thus regionalising the supply would require implementation of the desired antenna production in respective supplier factory. According to SCM 2 the production capacity is acceptable in all production sites which makes this alternative attractive, but the production of all variants is not in place today which is in line with the information presented by the Supplier Manager.

An advantage with a regionalised set-up is that the transportation distance can be reduced if the need for bypassing the *EDC* in Sweden is eliminated. SCM 2 emphasise the environmental impact caused by the movement of goods around the world which thereby could be heavily reduced.

4.5.5 Reconstruction of the antenna designs

Today, three of four large antennas are divided in two parts due to restrictions related to the transportation. An alternative brought up is to divide the antenna reflector into even smaller pieces.

As the antenna reflector in the three largest antenna sizes already are divided in two, SCM 3 state that it would probably be possible to divide the antenna reflector in additionally smaller pieces. This would lead to benefits during transportation as the package would be smaller. System Manager Antennas explains that if the reflector is divided into smaller pieces the installation would be more time consuming at the site. This is however not an issue as the current time for installing large antennas is long, an addition in time would therefore not affect the overall installation significantly. The reconstruction to smaller pieces would also affect the price negatively and the packaging material would need to be changed in order to suit the product (System Manager Antennas). Head of SDM emphasize the difficulty of changing the antenna reflector design as Ericsson purchase the suppliers design and is thus not the owner of it. The products are not Ericsson unique, but rather adjusted to specifications that suit the MINI-LINK radios. As all suppliers have their own product number Head of SDM questions the possibility to do assembly of a product design that Ericsson does not have ownership of.

Previously, the antenna kit was divided in several smaller pieces which led to smaller packaging sizes (System Manager Antennas). This solution did however affect the customer in terms of longer installation time and was later changed to the current set up due to customer complaints.

4.6 Presentation of three customer cases

To validate suggestions for changes of antenna distribution, a customer case has been created containing information about transport distance and customer country.

The five market areas of Ericsson are seen in Figure 13. Three out of these five market areas have a significantly higher order volume in terms of large antennas, namely MOAI, MELA and MMEA. To enable a validation, the biggest customer who has ordered large antennas has been identified in each of the three market areas. The distances shown in Table 9 is the linear distance between the *EDC* in Sweden and the customer address as registered in the order in the ERP-system.

Table 9 - Three customer cases.

Customer country	**Distance**
Customer 1	10819 km
Customer 2	5762 km
Customer 3	12213 km

5. Analysis of the empirical findings

The following chapter includes an analysis where the empirical findings are mapped against the theoretical framework. The ingoing parts are an analysis of the large antenna demand, the supply chain performance evaluation followed by an analysis of the current state. Followingly, the requirements of a future distribution are presented where after the different suggestions for improvements will be evaluated and analysed. The chapter is finalised by concretise a flexible distribution strategy and by pointing the direction for future changes. Thereafter, research questions are answered according to the results presented in the empirical findings and the analysis.

5.1 Patterns in the large antenna demand

The demand for large antennas has from many of the interviewees been described as varying between different months. Analysing the real demand during a two-years period, the demand for large antennas are highly varying as seen in Figure 22. When applying an average demand line to the demand data, it is shown that the demand in some rare occasions are close to the average. However, the more frequent situation is that the demand is differing from the average creating difficulties in forecasting. This has been emphasized in the empirical findings as well. However, looking at the demand for a whole year the demand pattern is quite stable from year to year. As seen in Figure 22, one large peak demand was present during both years. Understanding the demand pattern is one of the foundations when creating a supply chain that is well-performing (Bowersox et al., 2013). Hence, the demand patterns of large antennas should be considered when designing the supply chain and the distribution strategy.

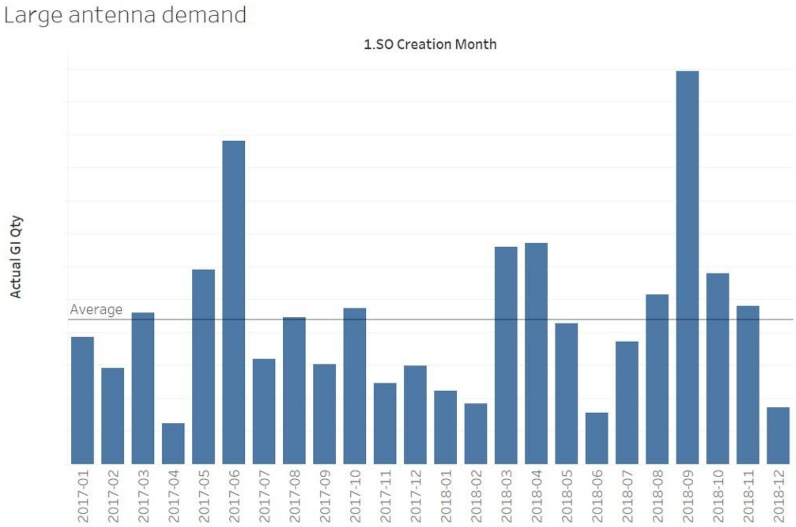

Figure 22 - The large antenna demand showing the average line.

5.2 Supply chain performance evaluation

Measuring the success of a supply chain strategy of a company is done through establishing a set of *KPIs* (Ross, 2015). The three *KPIs* used to internally evaluate the Microwave supply chain end to end supply cost, end to end inventory days and delivery performance according to standard lead time. Followingly, through using and analysing the *KPIs* several actions are initiated for increased control and reduction of the supply chain costs. There are however ambiguities regarding how and if transportation costs are measured throughout the supply chain. The transportation costs occur in several parts of the supply chain (Lovell et al., 2005) and transportation is in addition regarded as a part of the inventory of a supply chain (Ross, 2015). Hence, the transportation costs can be regarded as a part of inventory costs. It can be argued that to successfully evaluate the supply chain performance and thereby the success of the supply chain strategy the measuring of transportation costs is important. As stated by Ates et al. (2010) the identification of cost drivers in the supply chain may give an indication of different supply chain requirements for different products, which creates a basis for how to segment the supply chain. Establishing performance measurements that evaluates the transportation costs of the large antennas is thus one of the crucial steps towards a segmented supply chain. The establishment of performance measurements will in addition give an indication if changes made in the strategy are successful or not.

In several occasions the explicit importance of reducing environmental impact has been raised in the empirical findings. As stated by Ates et al. (2010) both internal and external investments are important for improving environmental performance where the internal initiatives are superior to external initiatives regarding the impact of environmental performance. It could thereby be stated that in order to reach environmental goals and reduce the environmental impact of Ericsson's logistics activities, internal initiatives need to be established such as evaluating and measuring the logistic activities related to the large antennas. In addition, establishing mutual environmental goals and practices together with suppliers is an example of external initiatives that has an impact on environmental performance. As sourcing and information is two of the five cross-functional performance drivers (Chopra, 2003), a high level of collaboration and information sharing in the supply chain is vital for the overall performance. In addition, being an enabler for the success of external environmental initiatives.

5.3 The current supply chain structure for large antennas

The following section analyse the current supply chain of large antennas following the same structure as in the theoretical framework. Hence, considering the activities related to the large antennas in terms of buying, making, storing, moving and selling as presented by Govil and Proth (2002).

5.3.1 The buying of large antennas

Until recently, Ericsson Microwave has purchased antennas from one single supplier. Hence, utilising the concept of single sourcing where the firm's need for a purchasing item is fulfilled from one supplier (Don, 2014). However, Ericsson Microwave has during the last years introduced two new suppliers. The need for a specific purchasing item is thus fulfilled from several suppliers creating a multiple sourcing situation (Don, 2014). Multiple sourcing increases the complexity of the purchasing process (ibid.) This is emphasized by the Supplier Manager who argues that the introduction of two new suppliers for the antenna supply creates a need to have a clear strategy of how to collaborate with the different suppliers, since the demand now is distributed unevenly between the three suppliers.

According to van Weele (2018), the transfer from single sourcing to multiple sourcing can impact a supplier relationship negatively. This is emphasized by the Supplier Manager who states that the introduction of two new suppliers have impacted the relationship with Supplier A and their willingness to collaborate. Single sourcing is preferred if the intention is to create a collaborative relationship (Samir, 2016). The change from single sourcing to multiple sourcing may therefore affect the possibilities to maintain or create a collaborative relationship, which is stated to be needed to engage suppliers in improvements or changes in product development as well as distribution. However, if relying on solely one supplier the dependency position is high, and Ericsson Microwave therefore gets vulnerable, as the risk for disruption of supply increases (Samir, 2016). As interpreted from the interviewees, this is the main reason for introducing two new suppliers to the antenna supplier base as the dependency situation created an unsecure position where the antenna supply was dependent upon on supplier. Van Weele (2018) argues that collaborative relationships can be created in multiple sourcing strategies as well. However, the need for a clear supplier strategy is hence even more important for all actors to know the prerequisites for collaboration. This is the case for Ericsson Microwave where a clear strategy is needed to enable improvements.

The relationship between the three suppliers differ some, even though the Supplier Manager argues that they aim at working similarly with all suppliers. The relationships are coordinated and managed differently which emphasize the need for a clear supplier strategy as highlighted by the Account Manager. With the focus from Ericsson Microwave to reduce the environmental impact, there is a further importance of a close collaboration with all antenna suppliers. Cooperation among supply chain actors has been identified as a qualifier to address sustainability issues, where an early engagement from the supply chain actors in environmental sustainability issues creates benefits (Saunders, o.a., 2015). The different characteristics of the relationships with the antenna supplier might hence give a direction of which supplier to involve in changes in the distribution strategy in the nearest future.

Since the suppliers are delivering antennas with different form, fit and function it can be discussed whether Ericsson have a single sourcing or a multiple sourcing of antennas. The distinction of classifying the sourcing situation as multiple sourcing would have been clearer if the antennas where of the same form, fit and function and hence attracting the same end customers. This type of multiple sourcing would enable a better negotiation situation as Samir (2016) argues that multiple sourcing generates a flexibility to respond to strategic consequences of source failure or the increase of negotiation power in the supplier relationship. At Ericsson, it has been argued that the introduction of the two new suppliers give a position where they can negotiate better even though the form, fit and function differ. According to the Account Manager, the possibility to influence customers are quite high as products with a shorter lead time often have a higher customer value. Despite the classification of multiple sourcing or single sourcing, the administrative costs and fixed costs increases when working with several suppliers (Samir, 2016), which further strengthen the need for a clear supplier strategy. A summation of the disadvantages and advantages of single respective multiple sourcing is presented in Table 10**.**

Table 10 - Single vs multiple sourcing.

	Advantages	**Disadvantages**
Single sourcing	Improve the possibility to engage in long-term relationships resulting in mutual cost reduction (Samir, 2016).	Higher level of risk for disruption of supply (Supplier Manager, 2019; Don, 2014)
	Quality control and material planning (Samir, 2016).	Dependency level increases (Supplier Manager, 2019)
	Increased willingness for risk sharing (Cooper & Lambert, 1997).	Higher purchase price (Samir, 2016).
Multiple sourcing	Lower level of risk for disruption of supply (Samir, 2016).	More difficult to build a long-term relationship (Samir, 2016).
	Better negotiation position regarding price (Supplier Manager, 2019)	Increased administrative work at the buyer's side (Samir, 2016).
		Increased variation in product design and packaging, hence the degree of standardisation (SCM 2)

Cooper and Lambert (1997) argues that collaborative goals and activities among supply chains actors increase the ability to optimise the whole supply chain rather than sub optimising within each actors' activities. For Ericsson Microwave, this imply that collaborative activities with suppliers are needed to succeed and increase the overall supply chain performance. Increasing the collaboration, the willingness to share risks are increasing and hence, the willingness to change and improve increases. As the presence of perfect orders increase (Bowersox et al., 2013) there is an increased pressure on Ericsson Microwave to deliver the right products at the right time where collaboration with the suppliers is necessary.

Utilising the portfolio purchasing model presented in 3.2.1, the characteristics of the antenna can be utilised to explore what strategy to use regarding supplier relationship as the matrix identify critical items and suppliers (Araujo, Gadde, & Dubois, 2016). The matrix consists of two dimensions: profit impact and supply risk. For antennas, the supply risk can be considered high even though Ericsson currently have three suppliers. The three suppliers are delivering antennas in different form, fit and function designs and hence, the antennas from the three suppliers cannot always be equalised according to the Supplier Manager. In addition, some suppliers have had issues delivering according to promises which has had a negative impact on the customer experience. Thus, the supply risk can be argued to be high. The profit impact, or importance of purchasing, could also be seen as high where the antenna is of high importance for the configuration and total performance of the telecommunication network by enabling the collection of microwave signals. These two characteristics position large antennas in the upper right corner among strategic items. Strategic items are characterised by high sourcing difficulty and supply risk that require control in terms of long-term contracts through long-term relationships and partnering with suppliers (Araujo et al., 2016). The characteristics of antennas though create a position in the matrix showing that Ericsson due to the supply risk and high purchasing importance should continue to establish closer relationships with the three suppliers.

5.3.2 The making environments for large antennas

Depending on what the company is making and what the customers need, different manufacturing environments are used. The fluctuating and relatively low demand of large antennas, as well as the high costs for keeping them in stock, have led to not having inventories or buffers of finished antennas. Therefore, the large antennas are purchased when a customer order is received, and no inventories are generally held neither at the supplier nor at Ericsson Microwave. As the demand of the large antennas is hard to dimension it is difficult to handle inventories and the size of the antennas require a lot of storage space which has been noted as unbeneficial. Hence, a manufacturing environment that promotes low inventories can be related to the production of large antennas.

For the large antennas the order penetration point or the decoupling point occurs when an order reaches Ericsson Microwave. Thus, from this point a purchase order is sent to the supplier who produces and sends the products. If the order penetration point is located closer to the customer, orders are fulfilled from inventory (Andries & Gelders, 1995). The *MTS* environment is linked to the ability to forecast accurate demand and used when production lead time are longer than expected lead time from the customer (Kolisch, 2001). The *MTS* environment is therefore partly in line with the requirements for the large antennas as the production lead times often exceed customer expectations but the ability to forecast accurate demand is perceived as hard.

In an *ATO* environment, the assembly of a product is done when a customer request has been received (Kolisch, 2001). In this case, several options are often provided to the standard set of products (ibid). The antennas have been presented as not being customer unique, rather there are several combinations available depending on the attributes and requirements of a network. This can thus be linked to the *ATO* environment as some or several parts could be held in stock and assembly would be initiated when a customer order is received. Hence, it can be argued that an *ATO* environment is more suitable for the antenna characteristics.

As described by Andries & Gelders (1995), having an order penetration point located in the beginning of the process will give low inventories but customer service will be critical. Hence, a balance is needed between the trade-off of having high safety stocks and the ability to provide customer service through short order lead times. With *ATO*, having a decoupling point between *MTO* and *MTS*, could therefore be one way to handle this balance.

5.3.3 The storing of large antennas

The current distribution strategy of the Microwave product portfolio is a centralised distribution strategy with distribution organised around one distribution centre (*EDC* Sweden). As SCM 1 mentions, the distribution strategy of the Microwave Portfolio is created and adapted to products with small sizes through enabling low transportation costs where a greater number of small products can fit in a transportation unit. The large antennas do have other characteristics in terms of weight and volume and thus, the distribution strategy of Microwave supply is not adapted to the characteristics of large antennas creating an unoptimized distribution. As Christopher (2011) argues, the time when "one size fits all" is over and companies needs to analyse their distribution strategy and adapt the distribution channels to the characteristics of the products being distributed. Hence for large products, this enable potentials for cost savings, lead time and environmental impact as the current distribution strategy is not fully considering the large antenna characteristics.

A centralised distribution strategy can bring benefits in terms of minimal safety stocks, reduced inbound transportation costs and a reduction of fixed costs (Ross, 2015). The reduction of fixed cost is applicable for Ericsson Microwave as the cost of warehousing is limited to one warehouse. The inbound transportation cost of large antennas is discussable since products are bought according to *PTO* and hence, bulk shipping and the following reduction of inbound transportation cost is hard to achieve as the demand is not aggregated. However, one situation when the reduction of inbound transportation cost is applicable is when several customer orders can be sent from the supplier to the *EDC*. In addition, the outbound transportation costs increase with a centralised distribution strategy, especially when the source of supply or source of demand is located far from the centralised warehouse (Ross, 2015).

As Ross (2015) argues, when the distance between the point of supply to point of demand increases the lead time increases. Ericsson's centralised strategy is structured around a distribution centre located in the north of Europe. Analysing the geographical spread of the customer base of large antennas it can be stated that the distribution centre is located far away from most of the customers. If including the supplier dimension, the large antennas are transported from suppliers located south of Sweden to the distribution centre where they are consolidated as one shipment and later sent to the customers who often are located south of Sweden as well. Hence, bypassing the distribution centre in Sweden increase the total transportation distance. Generally, the lead time and environmental impact is increasing as the transportation distance is increasing (Ross, 2015). In addition, long transportation lead times generate a higher level of tied-up capital (Chopra, 2003), which further emphasise the importance of a transportation lead time reduction.

An advantage of utilising intermediaries for Ericsson Microwave's products is the ability to consolidate products to customers (Chopra, 2003). This enables one shipment containing all ordered products rather than several shipments containing parts of the ordered products. This advantage is the basis for the distribution strategy of Ericsson. However, SCM 1 argues that the need for complete shipment sometimes can be discussed as several shipments could bring benefits in terms of for example cost reduction. As argued by Chopra and Meindl (2013), global presence brings a situation where taxes and customs parameters need to be taken into consideration. The distribution strategy and the belonging processes at Ericsson Microwave are created to be able to deliver to all countries in the world having the same documentation for all customers (SCM 1).

In addition, an advantage with the current distribution is the experienced control over the flow at Ericsson. Changing from a centralised strategy, a consequence is that involved actors experience a lack of control which hence might impact the willingness to change (Szmelter-Jarosz, 2016). The Control Tower mentions the risk of distributing the responsibility for the material flow among several actors as there is an increased risk that some steps are falling between two processes. SCM 2 further emphasise that there is a lack of resources to control a new set-up. The more handling points in the distribution structure, the more complex the handling becomes (Bowersox et al., 2013).

A summation of the advantages and disadvantages with the current distribution strategy is presented in Table 11.

Table 11 - Advantages and disadvantages with the current distribution strategy of Ericsson.

A Centralized Distribution Strategy	
Advantages	***Disadvantages***
Increased control of material flow (Szmelter-Jarosz, 2016; SC Control Tower).	Increased distance between point of supply to point of demand (Ross, 2015).
Possibility to consolidate products as one shipment (SCM 1).	High transportation cost (Ross, 2015).
Advantageous export/import conditions (SCM 2).	High environmental impact (SCM 1).
Possibility for reduced inbound transportation (Ross, 2015).	Reduced flexibility (Chopra, 2003).
	Higher level of tied-up capital during transportation (Chopra, 2003).
	Distribution strategy not adapted to the product group large antennas (SCM 1)
	Reduced performance when utilising a "one size fits all"-strategy (Christopher, 2011).

5.3.4 The moving of large antennas

The movement of goods has been defined as transportation (Chopra & Meindl, 2013), acting as a physical link between supply and demand (Naim et al., 2006). The outbound transportation planning for Microwave products is based on factors such as country of origin, destination country, flow, weight, volume and mode of transport. The share of respective transport mode for outbound transport of large antennas is presented in 4.3.2.3. It can be stated that regardless of antenna size, sea transportation is most common for transporting antennas. Except from 3,0 m antennas, air transportation is most common after sea transportation. Truck is the least common mode of transport. The results thus differ from the interpretation among employees as the transport mode air is more commonly used than truck. In Ericsson Microwave's case, the need for fast transportation modes is frequently needed to fulfil customer requirements as lead times are prolonged and disturbances appear. Hence implying that the supply chain and the distribution structure itself reduce the possibility to reduce environmental impact and reduce the utilisation of transport modes that bring high emissions.

It can therefore be seen that choosing how to transport goods is affected by several aspects such as environmental and cost aspects (Naim et al., 2006) as well as transport lead time (Skjøtt-Larsen et al., 2007). When operating globally, the trade-off between longer or more costly transit times are addressed (ibid). When using air transportation, the transit times will be costly while surface transport will cause longer transit times and thereby increased tied-up capital. As shown in Table 7 the large antennas are mostly shipped by sea transportation, which together with truck is the first-hand choice of transport mode according to the empirical findings. However, a large share of all antenna sizes is transported by air. The reason for choosing air transportation may vary, but the major benefit with this mode of transport is the ability to reduce transport lead time. However, as seen in Table 3 the emissions generated from air is very much higher compared to the other transport modes. In the empirical findings it is stated that a feature has been established regarding the choice of transport mode meaning that only one person in each market area can approve a change of transport mode, which has been done in an attempt to reduce the usage of air freight. If the shipment is large and costs are high, a business case and approval from this person is thus needed for sending goods with shorter lead time than standard, this includes both change of transport mode as well as express shipment. Changing transportation mode mean that Ericsson is burdened by the costs that follow which affect the order margin, the usage of air freight is thus not a preferred alternative. However, this reasoning is not as clear analysing Table 7.

According to Dekker et al. (2012), the choice of transport mode is somewhat limited as the mode of transport is often decided by the type of product or the distance. The large antennas have been described as difficult to transport due to their size and the design of the antennas has been adjusted to some extent in consideration to the possibilities for transportation, for example the reflector of a 3,7 m antenna is divided in two pieces. The heavy weight of the antennas has also been emphasized as an important factor in terms of transportation and is included as one of the parameters needed for transport booking. Deciding which transport mode to choose is thus affected by several aspects, however considering environmental aspects it is important to reduce the carbon footprint caused by the transportation of goods. As air transport generally release more CO2 than the other transport modes and is costlier, this alternative should be avoided. However, choosing a fast and expensive mode could reduce the inventories held in the supply chain thus reduce costs (Stanton, 2018). A trade-off between speed, cost and environmental impact thus needs to be considered. As the distribution structure affect the emissions from freight transportation, travel distance and fill rate should be considered as they are important parameters for the reduction of emissions (Min & Chung, 2017). Hence, independently of transport mode, aiming at having a shorter travel distance is an important initiative in the environmental aspect. This is further strengthened by the equation presented by Kontovas and Harilaos (2016), given that the two other parameters in the equation are unchanged.

5.3.5 Customer relationships and selling of antennas

It has been stated that most of the direct selling activities at Ericsson Microwave are performed at the local companies. Govil and Proth (2002) state that one of the questions to be answered for solving long-term issues within selling regards how to improve the ability to anticipate customer requirements. As distribution is performed between production and consumption, the challenge of the distribution function is to bridge the gap between demand and supply (Rosenbloom, 1995). Hence, successful distribution is dependent on the level of collaboration between the firm’s marketing and logistics functions (Ellinger, 2000). The collaboration between customers, local companies and Microwave supply has been stated as important for meeting customer requirements. The sales team provides sales leads of potential customer orders, hence contributing to the forecasting of products. The importance of aligning selling, and production is emphasized by Govil and Proth (2002) who states that the sell module can be limited by constraints in the production.

The communication and information sharing between the local companies and Microwave supply is important for both providing information to customers but also the ability for Microwave supply to respond quickly to customer orders and meeting requested lead times. Improving the understanding of roles, tasks and expectations between respective departments has been emphasized as important for improving collaboration. This is in line with Ellinger (2000) who states that the absence of cross-functional collaboration within an organization may result in the inability for the logistics function to deliver according to the promises of the sales force. For Ericsson having an organization containing separate local companies, this cross-functionality gets even more important as well as a standardised way of working with all local companies. Something that can be a challenge when different local companies have different cultures and ways of working as stated by SCM 1. Govil and Proth (2002) further state that answering the question of how to coordinate and share information with other participants in the supply chain, aiming at being effective in the marketplace, is important for solving long-term issues within selling.

Taking actions towards a reduction in environmental impact, the customer interface is highly important to motivate customers to take responsibility for the consumption behaviour and requirements (Zijm et al., 2019). Close relationships enable strong collaborations and hence, the efforts directed toward maintaining and strengthen customer relationships enable collaborative actions towards a more sustainable world. Ericsson aims to reduce their carbon footprint with 35% between 2016 and 2022 and to succeed, it is crucial to involve stakeholders and other actors in the supply chain. As Zijm et al. (2019) argue, companies have a great possibility to positively affect their customers acting with guidance and as role models. Hence, Ericsson Microwave need to involve and inform customers about the environmental impact their products are generating but also the transport alternatives utilised to distribute the products from supplier to customers. With collaboration with customers where Ericsson Microwave is acting as guidance, responsible decisions can be made, taking all stakeholder requirements into consideration whilst generating as low environmental impact as possible. To achieve this, Ericsson Microwave must first be able to offer transportation alternatives with low environmental impact.

5.4 Requirements on the distribution of large antennas

The following section include an analysis of the requirements of the future distribution of large antennas where the areas of supply chain strategy formulation, segmentation and evaluation of the distribution.

5.4.1 Formulation of a supply chain strategy

The first phase of designing a supply chain constitutes of creating a supply chain strategy which aims at specifying the capabilities needed from the supply chain network to support the competitive strategy (Chopra & Meindl, 2013). The competitive strategy can be defined through specifying the customer needs that the supply chain aims to fulfil. Capabilities of supply and demand needs to be understood in order to align the competitive strategy with the supply chain strategy Skjøtt-Larsen et al., 2007). According to Drake (2012), variability is inevitable when managing a supply chain, which can be handled through two different strategies of either having extra inventories or having agile and responsive supply chain operations. The market that Microwave serves is volatile where a customer order can be received with limited or no warning. Even if the projects that the products are used in are large and require a lot of planning, it is emphasized that unpredicted orders are rather frequent. SCM 3 has stated that Ericsson Microwave often acts in favour of the customer, emphasizing that a lot of time is devoted to meeting customer requirements such as requested delivery date or other order specific requests. What is possible to improve is sometimes not thoroughly evaluated which creates a problematic situation, as a lot of time is devoted to finding solutions for a request that might not be possible to satisfy. In addition, lack of communication between departments has been mentioned as a root cause for the time devoted to non-value-added activities. This creates a situation where time is spent on short-sighted efforts to please customers instead of general improvements. Further, the customers often have high requirements on fast handling of orders and expect as short lead times as possible, thus a lot of the power lies with the customer.

Competitive factors can be categorised into either order winner or order enabler. It has been mentioned that the most important thing for winning an order is the ability to deliver faster than the competitors. Price has also been mentioned as an important factor for winning an order, where price is sometimes discussed before lead time. Christopher (2011) state that criteria's for winning an order are more likely service oriented rather than product oriented in today's market place. The competitive factors at Ericsson Microwave are shown in Table 12, where lead time is mentioned several times as an order winner. Further, price is sometimes discussed before lead time thus being an order enabler. In addition, the technical qualification offered by Ericsson is mentioned as important for customers and is therefore classified as an order enabler. As seen in Table 12**,** the lead time is viewed as an order winner which is thus an important part of the competitive strategy for Microwave.

Table 12 - The competitive factors of Ericsson Microwave.

Order winner	Order enabler
Lead time	Price/cost
	Technical qualifications

5.4.2 Segmentation through the consideration of supply and demand characteristics

As presented earlier, the design of a supply chain strategy should support a company's competitive strategy. Since affecting the supply chain strategy, the distribution strategy is affected as well. Aspects such as customer requirements on products, delivery and service preferences impact the shape and design of the supply chain (Skjøtt-Larsen et al., 2007). Highlighting the need for aligning lead time and cost of the products with customer requirements could thus be argued as an important part of the Microwave distribution strategy, as Ross (2015) state that the goal of a supply chain strategy is to enhance characteristics presented as order winners. Reducing lead time has been stated as a goal within the supply chain strategy of Microwave Supply. Segmentation of the product portfolio is thus a focus area within the supply chain strategy at Ericsson Microwave which aims at improving the ability to respond to regional requirements. Waller et al. (2000) state that performing segmentation to differentiate products and services to maintain and create pleased customers, require differentiated supply chains which is part of the ability to adopt to a market-oriented supply chain and thus handle responsiveness. Therefore, it can be argued that segmentation of both products and supply chains are important initiatives at Ericsson Microwave for improving responsiveness and bridging the gap between supply and demand.

Further, to classify the handling of large antennas Rushton et al. (2017) present a model which show that when the supply and demand characteristics for innovative products with long supply lead times are both high, a combination of an agile and lean supply system is preferred. The innovative products are referred to as having unpredictable demand, which requires a more responsive supply chain. Analysing the supply and demand conditions of Ericsson Microwave to the matrix created by Rushton et al. (2017), the result presented in Figure 23 is generated. Firstly, the demand predictability is analysed where several interviewees has highlighted the fluctuating demand of large antennas. For some orders, the demand is predictable to some extent whilst for other orders the demand is unpredictable. This places Ericsson Microwave in a position between predictable and unpredictable, but closer to the unpredictable corner. Regarding the supply lead time dimension in the matrix the lead time for large antennas is characterised as long. These two parameters put Ericsson Microwave in the upper part of the matrix positioned between a predictable and unpredictable demand.

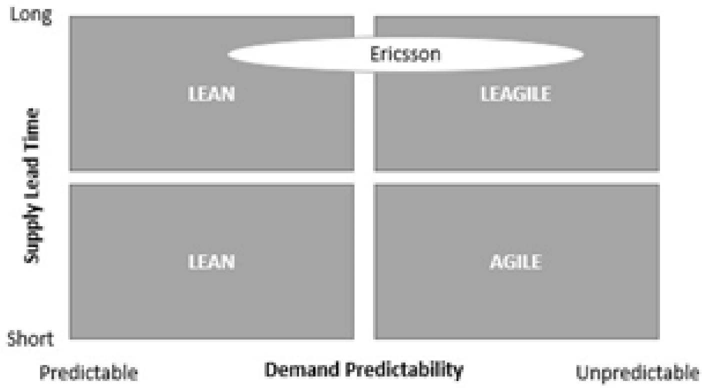

Figure 23 - The positioning of large antennas in the supply/demand matrix.

The position thus place Ericsson Microwave in the leagile section of the model. An agile supply chain is represented by responding to constant changes (Rushton et al., 2017) while the lean dimension refers to the ability to respond to competitive pressure utilising limited resources (Soltan & Mostafa, 2015). The demand predictability for large antennas has been stated as uncertain and for these kinds of products Rushton et al. (2017) propose agile policies to be suitable. However, if the supply lead times in addition are long, leagile policies may be necessary which is seen in the case of the large antennas. This further strengthen the importance of being responsiveness and thus, having a flexible supply chain. The matrix shows that depending on the customer- and supplier behaviour, the requirements on Ericsson Microwave's supply chain differs. Thus, different actions might be needed to fulfil different customer needs.

5.4.3 Continuous evaluation of distribution

It has been emphasized that Ericsson Microwave are sometimes stuck in old structures where the supply chain structure of large antennas is an example which has undergone limited changes to suit the changing market needs. It has also been emphasized that due to cost cuttings there has been a need for prioritisation and limitations regarding working with improvements. Deciding what improvements to work with have been emphasized as a problematic situation at Microwave Supply. Thus, being able to prioritise and put in effort and time into projects and improvements that will provide value is important. Working with certain structures and guidelines for when and how to continue with improvement projects could hence improve the supply chain flexibility and responsiveness to customer requirements.

In order to meet customer requirements, the management of distribution is an important part of the supply chain as it has a direct impact on the customer through being the last link in the supply chain. Chopra (2003) state that depending on how a company design its distribution, customers will be served differently. The basis for a distribution strategy should hence be the customer and the requirements put on Ericsson Microwave from the customers as well as the product characteristics, wherefore customer segmentation could be performed. Based on the competitive strategy, the distribution should prioritise lead time. In a competitive marketplace a distribution strategy needs to be reactive and responsive, operating at low cost (Ladier & Alpan, 2016). Hence, being able to be flexible in the supply chain as the difficulties to win market shares is intense. Thus, the current centralised distribution strategy might bring a risk of working contradictive to the competitive factors. Even if the distribution sometimes is restricted to changes due to legal reasons the agile abilities are limited in the current centralised structure as it is structured as "one size fit all".

5.5 Evaluation of the suggested alternatives

In this section, the suggestions that has been identified in the empirical findings are analysed and compared to the theoretical framework. Thus, the potential of the alternatives is addressed below.

5.5.1 Changing to a direct shipment strategy

Direct shipment of products has been stated to be an interesting alternative in regards of distribution of large antennas. This is one of the two distribution strategies presented in theory, thus representing the alternative without any intermediaries. Direct shipment is defined as shipping goods directly from point of origin to point of destination (Nikolopoulou et al., 2017) which have arised due to the increased importance of customer responsiveness (Bowersox et al., 2013). The direct distribution of large antennas has been discussed in terms of sending the antennas from the three suppliers directly to customers. There is currently an existing process for direct shipment at Ericsson, it is however mostly limited to situations when goods are to be sent directly because of a one-time purchase from a vendor. The process for direct shipment evaluates the shipment in a profitable aspect compared to the standard shipment of goods, for example through a supply hub. Another reason for evaluating the value gained from direct shipment regards the consolidation of products as one shipment, as Ericsson offers complete solutions to customers rather than separate products. The products that constitutes a site or a network are sourced from several different locations, hence the need for consolidation to one shipment. If all products would be sent directly from suppliers, the offered value of delivering a complete solution in one shipment would inevitably be eliminated. This is further supported by Chopra (2003), stating that customer experience may suffer due to several transportations when an order contains products from several points of origin.

Chopra (2003) describe a strategy where inventories are kept at the manufacturer and the information flows from the customer, via a distributor to the manufacturer and the product is transported directly from the manufacturer to the customer. A difference can thus be found as the flow of information presented by Chopra (2003) is directed through a distributor, while in the case presented by SCM 4 the information is passing *EAB*. In the case presented by SCM 4, goods were shipped directly from an Ericsson manufacturing site which simplify the information sharing. Shipping large antennas directly from an external point outside of Ericsson would thereby require establishment of certain processes in collaboration with the suppliers for transferring of information, as external information sharing is more complex than internal. Thus, performing direct shipment require a well-functioning information infrastructure (Chopra, 2003), as order visibility is one of the strategic capabilities Ericsson is aiming at.

5.5.1.1 Legal considerations

Legal requirements of shipping directly from the plant, such as geopolitical restrictions, has been mentioned as the main hinder to direct distribution which needs to be considered before other aspects. This could eliminate the possibility for sending goods from a certain country to a customer located in another country. However, it has also been mentioned that a prerequisite for direct shipment is increased flexibility in the contracts to customers in terms of allowing shipments to be delivered from locations outside of Sweden. Thus, a distinction is identified between the situations when shipments must be transported via Sweden and when it is possible to adapt contracts to allow a more flexible solution for shipments.

5.5.1.2 Impact on transportation

Higher transportation costs are one of the disadvantages with direct shipment (Chopra, 2003; Ross, 2015; Simchi-Levi et al., 2008). Increased costs for packaging and documenting are also mentioned (Ross, 2015). However, the empirical findings reveal that the general perception of introducing direct shipment would reduce costs related to the transportation of the large antennas. SCM 4 state that when eliminating the need for transporting goods through a supply hub and use direct distribution, the transport lead time is often heavily reduced. Thus, it is preferred to save lead time and cost through direct distribution if the shipped products are heavy and there are no legal requirements such as geopolitical restrictions. Table 13 show the estimated reduction in distance (km) when using direct shipment from the supplier production sites instead of shipping goods from the supplier to the customer through *EDC* Sweden. In all cases a reduction of distance is possible, where the shipment from Supplier C to Customer B have the largest potential for reduction. The calculations have been performed by utilizing the equation in Appendix B – Equation for calculating distance reduction.

Table 13 - Reduction of transport distance comparing direct delivery to the current strategy.

	Customer 1	**Customer 2**	**Customer 3**
Supplier A	10%	11%	27%
Supplier B	22%	3%	37%
Supplier C	11%	83%	17%

Simchi-Levi et al. (2008) state that a direct shipment strategy is preferable when firms are delivering large volumes that utilises the full capacity of the transportation vehicle. The increase of transportation costs may occur due to the need for smaller vehicles for transportation of direct shipments (ibid). Ross (2015) argues that the purpose of having a consolidation centre between a domestic warehouse or producer and a foreign market is to reduce transportation cost. In addition, shortening service lead times through shipping products in bulk and split it into individual orders at the consolidation centre. As described, the large antennas are purchased according to customer orders and thereby transported to *EDC* Sweden when the order is ready for shipment. Even if there are occasions when several orders can be shipped simultaneously in inbound transportation, the general perception is that orders are shipped when needed based on customer requirements. Due to the large size of the antennas, the number of antennas that can be transported in a truck is limited. The value of consolidation into one single shipment, in terms of better utilisation of the capacity of the transportation vehicle through adding additional large antennas in both inbound and outbound transportation can thus be questioned. In line with this, Ross (2015) state that direct shipment is often used when having an *MTO* strategy. It could therefore be argued that there would be small changes in terms of utilised capacity of the transport vehicle if the current distribution would be changed to a direct distribution structure. Further, it has been mentioned that the antennas are rarely packed with other material as additional pallets do rarely fit in the remaining load space. An exception can be found when an order contains a few numbers of large antennas, such as one or two antennas, this is however not very common. Thus, as presented by Simchi-Levi et al. (2008) the large volumes and "full" capacity of the transportation vehicle argues for direct shipment of large antennas. This does also shed a light on the unnecessary transport to *EDC* Sweden, as it hardly adds any value in terms of consolidation for better utilisation of capacity. The argument presented by Ross (2015) stating that increased transportation costs can be directed to the usage of smaller vehicles would thereby not affect the transportation of large antennas. Continuing, Ross (2015) argues that direct shipment enables less products in the distribution channel as there is no need for warehousing or shipment consolidation. In addition, Simchi-Levi et al. (2008) argue that direct shipment bring advantages in terms of cost reduction as the distribution centre costs are avoided when the finished products are stored at the manufacturer before shipment to the customer. It could therefore be argued that direct shipment would reduce costs related to the handling of antennas at the *EDC* Sweden and the risk of having tied-up capital at the distribution centre would be eliminated.

5.5.1.3 Effects of direct delivery

It has been emphasised that the current distribution structure enables consolidation into one shipment and control (SCM 2) but contributes to higher costs and environmental impact than needed. Chopra (2003) connects direct distribution to the advantages of a centralised approach to inventories. As direct shipment would remove all intermediaries, storing at one location would enable a higher level of product availability. This would however not be applicable for the large antennas due to the absence of inventories and the need for shipments from three different suppliers. Thus, direct shipment of large antennas would not affect the availability of products. It has however been mentioned that direct shipment enables lead time reduction (Simchi-Levi et al., 2008; SCM 4). It can thereby be discussed that improving time to customer can be done through reducing lead time instead of having a high level of product availability through centralised inventories. However, Chopra (2003) state that there should be few sourcing locations for direct shipping to be effective, hence there is a need to investigate the appropriate number of sourcing locations. Chopra (2003) further mentions that order tracking becomes harder to implement with direct shipment since it often requires integration of all actor's information systems. Traceability of the shipments has been mentioned in the empirical findings as a drawback regarding direct shipments. To handle this, among other challenges of direct shipment, the perception at Microwave supply is that additional support of IT-systems is needed. In addition, the distribution of responsibilities arises when performing direct delivery as the start point of the outbound shipments is moved from Ericsson to the suppliers. Questions regarding how to ensure that customer requirements are met thus needs to be addressed.

As seen in Table 13 the transport distance would decrease with direct shipment, hence argue for decreased transport costs. The environmental impact of emissions could also be decreased due to the reduced transport distances. The reduction of CO2 emissions has further been stated as a benefit with direct shipments in the empirical findings. The emphasis on reducing unnecessary transports between the suppliers and the distribution centre in Sweden has been highlighted several times, arguing for the benefit of direct shipments. As the large antennas often require the full loading capacity there is hardly no value to be gained from consolidation into one shipment. Thus, direct shipment would simply lead to reduced transport distance which thereby adds to a positive environmental impact.

5.5.1.4 Summation of direct delivery

Table 14 summarise the advantages and disadvantages of direct delivery.

Table 14 - Advantages and disadvantages of direct delivery.

Advantages	Disadvantages
Reduced lead time (Simchi-Levi et al., 2008).	Customer experience may suffer (Chopra, 2003) since two shipments are required.
Enables less products in the distribution channel (Ross, 2015).	Higher transport costs (Chopra, 2003; Ross, 2015; Simchi-Levi et al., 2008).
Cost reduction due to avoiding distribution centre costs (Simchi-Levi et al., 2008).	Requirements of a well-functioning information infrastructure (Chopra, 2003). Lack of current system support for direct shipment (SMC 2).
Reduced transport distance (Table 13).	Order tracking is harder to implement (Chopra, 2003).
Reduced CO2 emissions (Workshop).	Traceability (Workshop).
	Increased demand of resources to control the transportation flow (SCM 2).
	Legal aspects (SCM 4)

5.5.2 Changing to an expansion of the supply hub utilisation

The alternative to expand the supply hub strategy refers to the sending of large antennas from the supplier to the supply hub closest to the customer. If an expansion of the supply hub utilisation would occur, the suggestion for large antenna distribution include two alternatives: either the supply hubs within the supply hub network of Ericsson are utilised, or new supply hubs are built to suit the requirements of Microwave Supply. Distribution structures including warehouses enable the addition of activities related to consolidation, storing, easier assembling and packaging (Bowersox et al., 2013). Hence, the capacity for flexibility is large and is thus affecting the ability of responsiveness in the supply chain. When having warehouses located in a strategic position, the ability to respond to different customer requirements is high. Hence, for Ericsson the flexibility achieved from a decentralised supply hub structure generate a better position to faster respond to customer demand and meet the customer requirements. Utilisation of several supply hubs around the world would therefore bring the possibility to implement activities related to postponement which will be addressed in section 5.5.3. The alternative would also bring possibilities related to regionalised supply where customer demands can be fulfilled by suppliers located in the closest area, see 5.5.4.

An advantage if comparing the utilisation of hubs with direct delivery is the ability to consolidate products into one shipment. If a regional supply hub would be utilised, the products that need to be sent through the supply hub in Sweden could be consolidated with the large antennas at the regional supply hub. Thereafter, products are sent to final point of delivery. This alternative warehouse-to-warehouse flow may generate more handling points which often increase the distribution cost and distribution lead time (Simchi-Levi et al., 2008), depending on what the alternative is compared to. It will however fulfil the requirements of customers who demand one shipment whilst reducing the total transportation distance for the large antennas. However, having different distribution structures for large antennas compared to the rest of the product portfolio increase the complexity regarding the consolidation. Changing the distribution structure for all the products in the product portfolio would be a big challenge and hence, consolidation of the order would be a challenge. The risk of lack of control is increasing and thereby the needed resources to handle this coordination of different material flows is increasing. Microwave Supply have a well-established process and knowledge of how to distribute products through supply hubs. Thus, the modification of this supply hub strategy is not as large as an implementation of a direct delivery structure which thereby is an aspect speaking in favour for a decentralised distribution structure.

5.5.2.1 Impact on transportation distance

Analysing the geographical spread of large antenna demand, another aspect in favour of a decentralised hub structure is identified. The supply hub that fulfil customer demand is currently situated in Sweden, a location that is far from optimal when analysing customer demand. Having the supply hub at close distance to the supplier generates a comparatively low inbound transportation cost. The outbound transportation distance, thus cost, are on the other hand higher since most large antenna customers are located far from Sweden.

If utilising the customer case presented in 4.6, the distances saved by sending the large antennas through the nearest supply hub are presented in percentage in Table 15. Calculations show that in all cases, the difference between the two alternatives are positive i.e. the current distribution structure generate a longer transportation distance. This imply that there are potentials for savings regarding both lead time, transportation cost and environmental impact utilising a supply hub closer to the customer. This is accurate regardless if current supply hubs are utilised or if new supply hubs were to be introduced to the supply chain. The calculations have been performed by utilizing the equation in Appendix B – Equation for calculating distance reduction.

Table 15 - Reduction of transport distance comparing supply hub utilisation to the current strategy.

	Customer 1	**Customer 2**	**Customer 3**
Supplier A	10%	10%	15%
Supplier B	22%	3%	21%
Supplier C	5%	55%	1%

The decision regarding number of facilities, location and size influence the overall supply chain performance and affect lead time, transportation costs, safety stock levels and service level (Simchi-Levi et al., 2008). Shorter transportation distances allow companies to be more responsive if an appropriate transport mode is utilised (Chopra & Meindl, 2013). The decision to expand the supply hub network and utilize regional supply hubs would affect Ericsson Microwave's lead time positively since the transportation distance would decrease. Chopra and Meindl (2013) argue that for products with varying demand across regions, flexible facilities or smaller, localised facilities and warehouses are beneficial. As seen in the empirical findings, the large antenna demand is varying between the different market areas. Hence, the fluctuating demand of large antennas would be met more beneficial with regionalised or local facilities compared to the centralised structure of today.

5.5.2.2 Impact on distribution cost

The transportation cost is directly related to the number of warehouses (Simchi-Levi et al., 2008). With an increased number of warehouses, the inbound transportation usually increases since a smaller volume of products are distributed to several warehouses hence reducing the possibility for quantity discounts (ibid). However, as large antennas are bought according to *PTO* the inbound shipments are usually containing only one shipment. The outbound transportations costs are however affected positively (ibid), since transportation distance between the warehouse and the point of final delivery is reduced. Hence, there is an important trade-off between the negative effect on inbound transportation and the positive effect on the outbound transportation. In the customer case presented in 4.6, the inbound transportation distance increased in eight out of nine cases. This increase was generated since the distance between the supplier and the supply hub naturally increased when distributing the antennas through the supply hub nearest the customer. The outbound transportation decreased heavily since the point of final delivery was closer to the supply hub.

The transportation cost is based on the transportation distance which therefore would imply that the transportation cost ideally will be reduced. However, the transportation cost is also dependent of the transport mode used. To eliminate the presence of express shipments that are occurring today, the planning throughout the process needs to be more robust for changes. With a more responsive distribution structure, the need for express shipments can be reduced. In addition, the fill rate in the transportation units is affecting the transportation cost. Simchi-Levi et al. (2008) argues that the fill rate usually decreases in the case when smaller products are sent to a greater amount warehouse. Regarding the distribution of antennas, the fill rate reduction is not applicable since the differences in terms of fill rate between sending goods to a centralised supply hub compared to decentralised supply hubs may be small.

In addition, Bowersox et al. (2013) argues that facility costs increase as the number of warehouses increases. As the most ideal alternative is to utilise the current supply hubs, the cost for expanding the supply hub responsibilities to include Microwave products is thereby neglected. Microwave Supply is not currently carrying the cost for any supply hub apart from the Swedish supply hub. An expansion of the supply hub responsibilities would though include an increase of supply hub costs as Microwave Supply would have to carry some of the facility costs for the concerned supply hubs.

Highly related to the lead time and transportation distance, the environmental impact generated by the utilisation of additional supply hubs could be reduced. Since the transportation distance is reduced, the negative effect on the environment is reduced. Reduced consumption of transportation reduces the environmental footprint of actors thus helping to avoid damaging of ecosystems (Zijm et al., 2019). In addition, consolidation often enable packing of several products into one transportation unit which reduce the total amount of transportation units needed. However, as the risk for damage is high the large antennas are not packed with other products. Hence, this will not have an effect on the environmental impact.

Generally, the lower the number of warehouses the lower the stock level is in the supply chain (Simchi-Levi et al., 2008). Since large antennas are bought according to *PTO*, products are not supposed to be stored at the supply hub. However, if a decision is taken to keep antennas in stock or to introduce postponement in the distribution structure the stock level is an issue that needs to be considered.

5.5.2.3 Legal considerations

Despite the positive aspects of utilising a decentralised distribution strategy, there is a need to investigate the legal and trading aspects. Depending on the restrictions, Ericsson may have to consider locating a supply hub in countries more appropriate regarding the legal and trading aspects. This has been emphasized by Ericsson Microwave as being one of the aspects speaking against the supply hub utilisation during the study as well. Disadvantages brought up by the interviewees are related to the juridical aspect of the change. The Supplier Manager argues that a first step to change is to gather a cross-functional team containing representatives from different departments of the company such as the juridical and financial department. The two different contract types (*EAB*-contract and *LC*-contract) are creating hinders for some alternatives and hence, the Supplier Manager argues that a greater flexibility in the contracts is needed.

5.5.2.4 Summation

Table 16 is presenting a summation of the advantages and disadvantages of the utilisation of supply hubs.

Table 16 - Advantages and disadvantages of supply hub utilisation.

Advantages	Disadvantages
Closeness to customers (Table 15).	Increased amount of handling points (Simchi-Levi et al., 2008).
Well-established processes of distributing through supply hubs (SCM 4, Head of Hub Operations).	Increased complexity to operate consolidation of material (Head of Hub Operations).
Maintained control over the distribution flow (Control Tower).	Pressure on change management (Szmelter-Jarosz, 2016).
Possibility to consolidate into one shipment (SCM 2, SCM 4, Head of Hub Operations).	Require a thorough investigation of legal and trading issues (Supplier Manager).
Increased flexibility (Chopra & Meindl, 2013).	
Possibility to perform value-added activities (Bowersox et al., 2013).	

5.5.3 Changing to a postponement strategy

The concept of postponement is a derivative from mass customization where inventories are introduced to the supply chain to further implement delayed deliveries in different places of the supply chain (Szmelter-Jarosz, 2016). Postponement can be introduced in combination with an agile strategy (Rushton et al., 2017), to cope with unpredictable demand and long supplier lead times (Purvis, Gosling, & Naim, 2014), which is the characteristics of the demand and supply relation for large antennas. To successfully implement postponement, a reduction of demand uncertainty in terms of ordered volume is a requirement (Szmelter-Jarosz, 2016). Hence, increasing the customer focus. In the case of Ericsson Microwave, the demand uncertainty has its origin in the business environment where the frequency permit is approved late and hence, impacting the antenna order. Hence, the foreseeability is hard to improve in this type of environment. However, there are other concepts in the postponement strategy that may be utilised regardless of the level of demand uncertainty. Specially to achieve the benefits of flexibility that postponement brings (Waller et al., 2000).

The alternative to be adapted by Ericsson Microwave involve the purchasing of the antenna reflectors in larger volumes as *MTS* whilst buying the remaining parts when the antenna demand is generated from customers. The material would further be consolidated into one shipment and packed at a supply hub. Purchasing the reflectors in bulk enable transportation in a more effective way increasing the fill rate and reducing transportation costs. However, keeping the large antennas in stock generate tied-up capital that according to the Supplier Manager is difficult to argue for as there will be arguments regarding who will pay for this tied-up capital.

How and when a product is assembled affect the need for transportation. Goods can as an example be imported as finished products or being assembled in local markets where they are sold (Dekker et al., 2012). Transporting large quantities and later repack these into smaller packages locally is an example of how repackaging can reduce transportation demands. The characteristics and packing of large antennas are today affecting the fill rate negatively as large antennas cannot be placed on top of each other or too close to each other (SCM 2). It has however been argued that if the antenna packaging were arranged differently where the reflectors were stacked on each other and the other materials were packed separated from the reflector in other packaging, a positive effect on the fill rate could be achieved. This would further affect the transportation demand as fewer transportation units would be needed. In addition, production of larger volumes enables the utilisation of economies of scale since the production batches increases thus reducing the manufacturing cost (Jonsson & Mattsson, 2009). Thus, Ericsson Microwave could be able to benefit from this cost reduction created at the supplier and in addition, position Ericsson Microwave in a better negotiation situation.

Postponement is powerful in supply chains that are operating on a global scale where inventory positioning, distribution structure and facilitates are critical factors to achieve cost reductions and creation of customer value (Cheng et al, 2010) The success of a postponement strategy depends on the variability in demand (Rushton et al., 2017). Figure 24 show the demand of the different antenna sizes showing that the demand is highest for 1.8 antennas whilst the lowest demand is related to the 3.7 antennas.

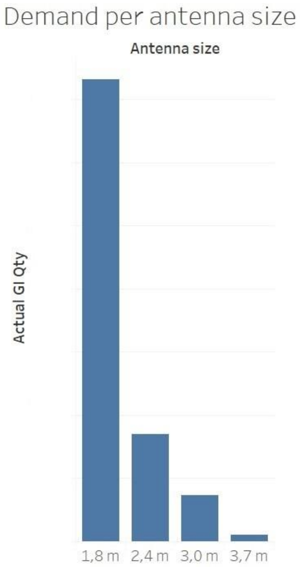

Figure 24 - Illustration of the demand of the four different antenna sizes.

The two characteristics that are varying between the different antenna orders are the antenna reflector size and the frequency-specific product. Figure 25 show how the demand for different frequencies differ which illustrate that the demand for 7/8 GHZ is the higher followed by the demand for 6 GHz products. Thereafter the demand for the other frequencies are distributed quite evenly.

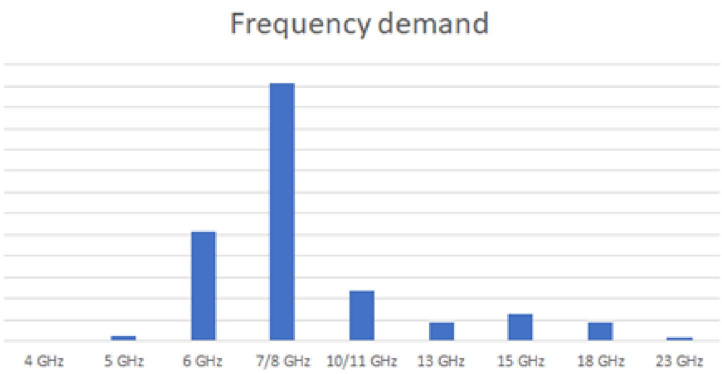

Figure 25 - Illustration of the demand of the different frequencies for large.

A postponement strategy creates a delaying of final assembly, or in Ericsson Microwave´s case the finalisation of the antenna order by packaging the right reflector with the right accessories. As there is no testing of the products before being sent to Ericsson Microwave, the final assembly should be possible to perform at another location (SCM 1). Thus, not having any impact on the product quality which is an aspect speaking in favour of a postponement implementation. The final assembly would then have to be performed at the *EDC* in Sweden, or in other supply hubs if another distribution structure would be utilised, or at the customer site. If taking place at Ericsson, it creates a need for resources as well as competences to perform this activity. Hence, a trade-off is generated between the savings in transportation costs and the introduced cost for finalising the antenna order as well as the inventory cost. In addition, performing the final kitting of antennas in-house creates an activity related to the building of packaging equipment which thereby is added to the scope of responsibility. This activity is according to the Supplier Manager hard to perform more cost-efficient in a country like Sweden where the wage level is high compared to the cost for performing this activity in a low-wage country. Hence, being an aspect of this alternative that is speaking against an implementation of a postponement concept if being implemented in the current distribution strategy.

An implementation of postponement is associated with problems related to the engagement from all actors in the chain (Szmelter-Jarosz, 2016). The implementation is impacting more actors apart from the initiating company and hence, the success of engaging all actors is critical (ibid). Head of SDM emphasize the difficulty to persuade the suppliers to engage in this set-up as some of the margin of the suppliers is in the assembly of the antenna kit. The increased complexity and involvement among actors put pressure on an efficient information flow between the actors. The information flow is being upraised as an important aspect of implementation of a postponement strategy (ibid), where a high level of collaboration and visibility throughout the supply chain is key to succeed (Matthews & Syed, 2004).

If splitting the purchasing of the current antenna kit into several parts, the administrative work could increase where instead of ordering one antenna kit an ordering of all the included parts would be necessary. From Ericsson, this has been addressed as a disadvantage as being an unreasonable increase of the purchasing administrative activities. To cope with this, an alternative is to differentiate the antenna reflector from the remaining accessories to create two new article numbers instead of six article numbers. As the goal of postponement is to maintain products in a noncommitted status as long as possible, arrangements that include delaying of the customization reduce the incidence of manufacturing the wrong products compared to customer order (Bowersox et al., 2013). Several interviewees have expressed the issue of order cancellations which creates inventories of large antennas that are order specific. An advantage with the separation is that the reflectors themselves are not frequency specific and thereby not order specific. Instead, the frequency specific parts are included in the kit with accessories. Due to the flexibility that postponement brings (Bowersox et al., 2013), the consequences of customer cancellations would be heavily reduced due to the separation of the reflector from accessories. Products that have been reserved for an order that has been cancelled can simply be restored at the inventory and thereafter be reused for other orders with other configurations. Hence, achieving a reduction in lost sales as Ferreira et al. (2015) present to be another advantage. In addition, products that are being semi-finished has a lower value compared to finalised products (Chopra & Meindl, 2013), hence reducing the tied-up capital created from the storing of inventories. However, if introducing inventory to the supply chain, inventory management must be addressed (Jonsson & Mattsson, 2009). Hence, if implementing a postponement strategy and introduce stocking of reflectors, Ericsson Microwave would have to address inventory management and hence decide what safety stocks and buffer levels to introduce analysing the demand for large antennas.

Table 17 presents a summation of the advantages and disadvantages of a postponement strategy.

Table 17 - Advantages and disadvantages of a postponement implementation.

Advantages	**Disadvantages**
Increased flexibility (Bowersox et al., 2013).	Introduction of inventory (Szmelter-Jarosz, 2016).
Fill rate in inbound logistics (SCM 2).	Required resources to manage the final assembly at the supply hubs (Supplier Manager).
Improved response time as reflectors are kept in stock (Workshop).	More expensive packaging of the antenna order (Supplier Manager).
Reduction of transportation cost (SCM 2).	Increased administrative tasks (SCM 1).
Reduction of lost sales (Ferreira et al., 2015).	Difficulties to reduce demand uncertainty (Szmelter-Jarosz, 2016).
Better possibility to handle customer cancellations (Workshop).	

5.5.4 Changing to a regionalised supply of large antennas

The antennas that are currently shipped to *EDC* Sweden for consolidation with other products are sent from three different supplier production facilities. In the empirical findings it has however been stated that all three suppliers have production facilities in several locations, and possibilities for establishing production of large antennas in these locations are possible. Rushton et al. (2017) argues that sourcing decisions affect and influence the supply chain design where for example distant sourcing requires different supply chain structures than goods sourced locally. With globalisation, products travel longer distances hence leading to larger emissions from freight transportation (Christopher, 2011). A reduction of distance would thus contribute to a reduction of emissions. A regionalised supply of large antennas does however require production capacity in respective location, where the suppliers would need to handle fluctuating demand as well as increased product variety in the different production locations. However, if segmentation of the supply chains in regard to the market area would be possible the demand can be forecasted on a market area level. According to Rushton et al. (2017) Predictable demand should be met by sourcing globally whilst unpredictable demand instead should be met using local suppliers to gain flexibility benefits and lead time reduction.

Regionalised supply is possible to implement both for direct delivery and a supply hub utilisation. However, it is stated that a supply hub needs to be located in the same country as the production site due to trading issues (Supplier Manager). The need for using the supply hubs could however be investigated further. Alternatives that are not limited to a distribution strategy that include the use of the supply hubs can bring several benefits as presented in 5.5.1 of direct shipment. Hence, distributing products from the supplier's regional production facilities can be investigated in the perspective of a direct shipment strategy and a strategy with intermediary storage points, such as the Ericsson supply hubs. The savings in transportation distance as shown in Table 13 and Table 15 would hence be further increased as the inbound transportation distance would decrease with a regionalised supply.

Analysing the demand variety of the antenna sizes presented in section 4.3.1, the demand for antennas with a diameter of 1,8 m is predominantly largest in MMEA. There are both Ericsson supply hubs and supplier production facilities located closer to customers in this market area compared to *EDC* Sweden. Thus, transporting these antennas to the *EDC* Sweden can be questioned as the largest demand of these products is found in a market area which is located considerably far from *EDC* Sweden. This is further emphasized by the Supplier Manager who states that shipping large antennas from supplier production sites located closer to customers instead of directing all shipments through *EDC* Sweden can have large cost, environmental and logistic benefits. Through enabling the supply of large antennas from regional production sites, the reduction of transport distance could be an important argument in the environmental aspect. The market area MOAI has the second largest demand of 1,8 m antennas. This is a great example of where regionalised supply could reduce transport distance, since antenna suppliers are located in Asia. Hence, the 1,8 m antennas could be produced and transported to customers in the market area MOAI from these production sites. It is however important to mention that legal requirements and geopolitical restrictions could affect the flexibility of changes to the current distribution structure where goods are sent via *EDC* Sweden.

Table 18 show a summation of the advantages and disadvantages of the regionalised supply.

Table 18 - Advantages and disadvantages with regionalised supply.

Advantages	Disadvantages
Reduce environmental impact (Zijm et al., 2019)	Need for production capacity in several locations (SCM 2)
Cost benefits (Supplier Manager)	Increased inventory cost (Workshop)
Shorter transport lead time (Workshop)	Increased product variety for suppliers (Workshop)
	Fluctuating demand (Workshop)

5.5.5 Changing the antenna construction to include smaller reflector pieces

A product's manufacturing and logistics cost is largely determined by its design (Ernst & Kamrad, 2000). Further, product design is often adapted for manufacturability whilst little considerations is taken to transportability. Therefore, Ernst and Kamprad (2000) suggest that products should be designed for efficient supply chain handling more so than design for only manufacturability. Regarding the large antennas, one of the antenna sizes is transported as one single piece whilst for three of the large antenna sizes, the antenna reflector is divided in two pieces. This division has been performed due to space restrictions during the transportation (System Manager Antennas), where the large antenna size (2.4-3.7 m in diameter) otherwise would have been difficult to handle. Hence, the product design has been adapted to enable an easier handling as in line with Ernst and Kamprad (2000) who suggest that products should be designed for efficient supply chain handling more so than design for only manufacturability. Despite the division in two pieces, empirical findings show that the characteristics of the large antennas still create an inefficient transportation and handling of the products. The current product construction creates a situation where transportation unit space is unutilised since the construction is not fully adopted for the transportation. It has been stated that when transporting the large antennas, there are a lot of space in the transportation unit that is unutilised, yet impossible to use due to the risk of damaging the large antennas. Hence, the product is not designed to optimally utilise the transportation unit space which enable identification of benefits related to dividing the antenna reflector into several, smaller pieces. This would however require an increased collaboration with the suppliers in the product development process (Eidelwein, Piran, Lacerda, Dresch, & Rodriques, 2018).

Firstly, an optimisation of the large antenna dimension indicates that the unutilised space in the transportation unit can be reduced and thereby reduce the number of transportation vehicles needed. If analysing the dimensions of a 3.0 m antenna, the length is 3.40 m, the width is 1.17 m and the height is 1.93m. Thus, the number of antennas that is possible to load in a 20-foot container is limited to two antennas which increase the demand for transportation vehicles. This demand is further impacting the transportation cost and environmental impact. Thereby, an optimisation of large antennas can have a positive effect on the environmental impact since the fill rate increase and thereby the needed number of vehicles is reduced. In addition, since the needed number of transportation vehicles decrease the total transportation distance would decrease. This generates a positive effect on the transportation cost since the transportation cost is dependent upon the number of vehicles needed to transport the products as well as the distance travelled to transport the products.

With smaller antenna reflector pieces, the packaging dimensions can be reduced. SCM 2 argues that the actors that are handling the antennas throughout the logistical activities are experiencing more difficulties with the handling of the large antennas the larger the size becomes. An example brought up is the difficulty to load and unload the large antennas where some of the antennas need to be loaded side-wise which require special equipment. Thereby, a new dimensioning of the antennas and corresponding packaging would eliminate the requirement of special equipment and in addition potentially rationalise the large antenna handling.

If a further division of the antenna reflector was enabled, the length of the packaging would decrease since the length dimension is divided in two. The height would be unmodified since the height today is equal to the radius which would be the case even if the antennas would be divided in four pieces. The width would however increase since four antenna pieces would be loaded behind each other instead of the current state where two antenna pieces is placed behind each other. However, it is assumed that an optimisation of the packing in the packaging material can be made hence reducing the width with 20 %. With an analysis of the optimal packaging dimensions would be performed, there might be savings generated from the minimisation of the reflector pieces as seen in Table 19.

Table 19 - Calculation of volume savings if reconstructing the antenna design.

	Current Dimensions	**Dimensions for 4 pieces**	**Change**
Height	1.93	1.93	0
Length	3.404	1.704	- 50%
Width	1.167	1.867	+ 60%
Volume	7.673	6.14	- 20%

The division of antenna reflectors into smaller pieces demand an involvement and engagement from the suppliers. To succeed with this, the relationship with the supplier is of importance. The relationship initiated with a certain supplier is dependent on the sourcing strategy of the firm where the relationship can be either partnership or arm's lengths (van Weele, 2018). Hence, the sourcing strategy of Ericsson is important if a change in the antenna construction would be implemented. As the sourcing strategy recently has changed, a suggestion of this kind could be difficult to implement. Van Weele (2018) argues that for long-term changes aimed at decreasing the total cost in the supply chain, partnership or collaborative relationships are needed. This implies that if Ericsson Microwave would invest in this alternative, a closer relationship would be required to create a situation where the suppliers think it is worth it. Another alternative is that the change is of a kind that would benefit all customers of the suppliers, being a change that is required from all customers. Regardless of what level of change, the supplier oversees the design (Head of SDM) which require the change to be fully accepted from the supplier.

Further, the System Manager Antennas explains that a further division of the antenna reflector can have negative impact on the customer experience since influencing the time needed for installation. For a contract where solely the products are delivered, the increased installation time will have a direct impact on the customer experience since the customer in this contract is responsible for the installation. In other contracts, the change would affect Ericsson as Ericsson themselves are responsible for the installation and hence are affected by the increased installation time. Hence, this rise in required time will not influence the customer experience as much. However, having the antenna reflector divided in four pieces may require other competences for the installation.

A summation of the advantages and disadvantages of this alternative is presented in Table 20.

Table 20 - Advantages and disadvantages of a reconstruction of the antenna design.

Advantages	Disadvantages
Higher fill rate (Ernst & Kamrad, 2000).	Increased installation time (System Manager Antennas)
Reduction of transportation vehicles (Workshop).	Risk for quality reduction (Supplier Manager)
Reduction of transportation distance (Workshop).	Requires supplier involvement (Supplier Manager; Ernst & Kamrad, 2000).
Easier handling (SCM 3)	Ericsson is not in charge of the design (Head of SDM)
Antenna design adapted to the transportability (Ernst & Kamrad, 2000).	

5.6 Comparison of the different alternatives

To compare and evaluate the different alternatives brought up in the thesis, a summation has been created in Table 21. The table evaluate the alternatives based on the parameters brought up in the aim of the thesis. All parameters will we analysed below.

Table 21 - Evaluation of the five alternatives in regards of distribution cost, distribution lead time and environmental impact.

	Distribution cost	Distribution lead time	Environmental impact
Direct delivery	Reduced since the transportation distance is reduced. However, an increase of administrative cost may appear.	Reduced as inbound transportation lead time is eliminated, and outbound transportation lead time is reduced.	Reduced since transportation distance decreases.
Hub utilisation	Varying result depending on the level of increased warehousing cost and reduction of transportation cost.	Reduced as the outbound transportation lead time is reduced. Can though be negatively affected if consolidation is required.	Reduced since the transportation distance decreases and consolidation of shipments are possible.
Postponement	Reduced inbound transportation cost, increased warehousing cost and reduced lost in sales since enabling better respond to customer order cancellations.	Reduced distribution lead time as antenna reflectors are kept in stock.	Potential for reduction, if it is possible to ship bulk volumes.
Regionalised supply	Reduced due to reduction in transportation distance. However, increased costs related to purchasing may occur.	Heavily reduced as the inbound transportation lead time is reduced as well as the outbound transportation lead time.	Heavily reduced as both inbound and outbound transportation distance decreases.
Antennas in smaller pieces	Possibility for reduction as fewer transportation vehicles are needed.	Negligible change generated from an easier supply hub handling.	Possibility for reduction as new dimensions can generate a lower demand of transportation.

5.6.1 Distribution cost

Conceptually analysing the distribution cost of the different alternatives brought up in the thesis, there are pros and cons with all alternatives. Both the expansion of the hub alternative and the postponement alternative would have a negative effect on the warehousing cost since Ericsson Microwave would have to carry the cost of more warehouses and in addition, allocate resources for the activities that would be introduced to the warehouses. Hence increasing the resources needed to perform these activities. However, both these alternatives will have a positive effect on the transportation cost where postponement have the potential to reduce inbound transportation cost. The hub alternative would also have a positive effect on the transportation cost as the average distribution distance can be reduced which is a positive effect in the cost aspect.

For direct delivery, the warehousing cost is eliminated for large antennas since the products are being sent directly from the supplier to the point of delivery. As the transportation distance in reduced, there is potential to reduce the transportation cost as well. However, as identified in the empirical findings the direct delivery alternative would generate more administrative costs since traceability and coordination of the shipment would be of greater importance. In addition, for each order an analysis of the transportation flow must be performed which consumes resources. Hence, increasing the administrative costs.

If having the possibility to implement a regionalised supply strategy, the distribution cost would be affected positively as the transportation distance is reduced. However, as for the direct delivery alternative the administrative costs are assumed to increase since the sourcing becomes more complex as the customer must be allocated to the closest supplier. In addition, the potential for cost savings generated from a regionalised supply depends on the choice of having a direct delivery solution or having a hub solution.

Finally, the alternative to construct the antenna reflector in smaller pieces can generate a cost saving created from the minimised demand for transportation vehicles as the transportation unit have the potential to be loaded more optimally. This alternative also has the potential to reduce the time needed for both handling and packaging the large antennas which reduce the resources needed to handle the large antennas. Thus, having a positive effect on the distribution cost.

To summarise, the analysis of the five alternatives brought up in the thesis show that conceptually, all alternatives have potential to generate cost savings related to the distribution of all large antennas. However, Chopra and Meindl (2013) argues that it is important to analyse the alternatives thoroughly as sub-optimisations may occur. A reduction of one cost may create an increase in another cost parameter hence generating summarised saving of zero.

5.6.2 Distribution lead time

The design of the distribution is highly affecting the lead time (Chopra and Meindl, 2013; Christopher, 2011). An introduction of direct delivery and/or a decentralised hub solution are both alternatives with potential for distribution lead time reduction, as Bowersox et al. (2013) argues that a centralised warehouse often increases distribution lead time. If comparing the two alternatives of direct delivery and an expansion of the hub utilisation, the direct delivery can perform a higher lead time reduction as large antennas are shipped directly from the supplier to the point of delivery without any intermediate stops. If a regional supply hub would be utilised, the distribution lead time is assumed to be higher since partly the distance increases and partly since additional touch-points generate an increase in lead time as described by Simchi-Levi et al. (2008).

A further reduction in lead time can be generated by utilising the concept of regionalised supply, both in direct delivery and a supply hub utilisation as the large antennas are sourced locally rather than globally. As Zijm et al. (2019) states, the trend is moving to sourcing locally if possible and globally if needed which would have a positive effect on the lead time.

The concept of postponement does also have the potential to reduce the total lead time as the large antennas would be kept in stock which would heavily reduce the total lead time as the response time would be reduced. Similarly, *ATO* would have a positive effect on the production lead time which hence could be a step towards being able to decrease response time. However, the supply hub handling lead time have a risk of being increased as an activity related to the kitting and packaging of the antennas must be added to the responsibilities of the supply hubs.

The one alternative that would not influence the distribution lead time is if solely constructing the antenna reflector in smaller pieces. Smaller products are easier to handle and transport (Ernst & Kamrad, 2000), but are not able to reduce the lead time and hence, this alternative is not to suggest if a lead time reduction is of higher importance.

To summarise, four out of five alternatives have the potential to reduce the distribution lead time as contributing to significant changes in the distribution structure. The alternative with most potential to reduce the distribution lead time is direct delivery though being able to heavily reduce the transportation distance when eliminating the bypassing through a supply hub and thereby the number of touch-points in the distribution. The reduction is the greatest if regionalised supply can be implemented in addition to the direct delivery. With direct shipment, the large antennas are not consolidated which is an activity that increases the distribution lead time.

5.6.3 Environmental impact

All alternatives brought up in the study has a potential to reduce the environmental impact of the distribution of large antennas. The environmental impact is influenced by among other things the transportation distance, the fill rate, the number of vehicles needed, and the transport mode used. The equation in 3.2.3 show that the amount of emissions is based on the volumes, the average distance and an absolute term for the CO_2-emissions. All the alternatives have a positive effect on at least one of these parameters and therefore, all alternatives have the potential to reduce the emissions.

Analysing the alternatives with the potential to reduce the transportation distance, the direct delivery and the expansion of the hub utilisation are highly capable to perform a reduction of transportation distance as eliminating the bypassing at the supply hub in Sweden. Comparing the two alternatives, the direct delivery heavily reduces the transportation distance but creates a situation where two shipments are needed to fulfil the customer order: one for the large antennas and one for the rest of the products in the order. The hub utilisation alternative has the potential to create two inbound shipments to the nearest supply hub where all products would be consolidated to one shipment. Hence, having solely one outbound transportation to the customer which have a positive effect on the environmental impact. If the alternative of regionalised supply would be implemented, the environmental impact could further be heavily reduced as the large antennas would not have to travel around the globe to reach the final point of delivery. Instead, the large antennas would be supplied locally and thereby sent to the customer either directly or by the nearest hub. Thus, reducing the transportation distance. Björklund (2012) argues that environmental benefits can be gained in a decentralised logistic system as the most suitable transport mode for every node in the network can be used, in contrast to a centralised system where this might not be possible. Hence, the regionalised supply can have a positive effect on the utilisation of transport mode where air could be eliminated since the distance to customers is reduced.

The postponement and the alternative including a new construction of the antenna reflector have potential to reduce the environmental impact by influencing the fill rate of the transportation vehicles. Having the antennas divided in smaller pieces enable more large antennas to be loaded into one transportation vehicle, which partly have a positive effect on the fill rate and thereby partly influence the amount of transportation vehicles that are needed for the distribution of large antennas. Implementing a postponement strategy would enable the large antenna reflectors to be sent in bulk which also have a positive effect on the fill rate as well as the amount of transportations needed.

To summarise, all alternatives brought up in the study have the potential to have a positive effect on the environmental impact by reducing the emissions sourced from large antenna distribution. Despite the analysis, there are some difficulties to rank the alternatives since different parameters of the emissions are reduced and thereby difficult to compare. However, Simchi-Levi et al. (2008) argues that the transportation distance is the highest in a centralised distribution strategy. Hence, implying that the emissions are the highest if utilising a centralised distribution strategy which is the current distribution strategy of Ericsson Microwave.

5.7 Concretise a flexible distribution strategy

Supply chain flexibility is said to be one of the success factors to adapt and respond to quick changes in customer demand (Chatzikontidou, Longinidis, Tsiakis, & Georgiadis, 2017). Flexibility can be introduced in several ways where flexibility in the contracting with customers has been mentioned as an important part of improvement of the large antenna distribution. Developing different alternatives for distributing antennas is further an alternative for increasing the flexibility of the distribution strategy. Hence, creating a mix of distribution channels. This enable having a strategy where an organisation can determine what distribution solution that best meets the customer need (Partida, 2017). Through analysing the customer requirement in terms of distribution lead time, acceptable number of shipments and distribution cost the most advantageous distribution structure can be utilised. As Ericsson additionally want to reduce the environmental impact from their distribution, this is a parameter that needs to be included when determining what distribution structure to offer the customer.

The identified alternatives can be categorised as changes in distribution channel and general suggestions. Direct delivery and supply hub utilisation are changes related to distribution channels whilst the other three suggestions are general suggestions to improve the distribution of large antennas. If analysing the distribution channel changes, Figure 26 show situations when one alternative is more preferable than the other. As seen, the direct delivery should be utilised when the antenna order volume is high since these shipments generate high transportation costs and environmental impact. Hence, the transportation distance needs to be as low as possible. Further, when the customer requires a fast delivery or when the closest supply hub is located far away from the antenna supplier and a bypassing through the supply hub significantly would increase the transportation distance. The utilisation of the supply hub would instead be suitable for distribution when consolidation with remaining products in an order is required or when there are obvious legal, or trading advantages brought from utilising a supply hub. In addition, when the supplier is located close to the supply hub the savings in transportation distance are negligible.

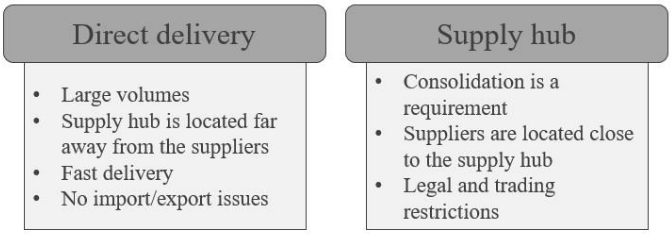

Figure 26 - Application of direct delivery and supply hub utilisation.

The flexibility introduced enables Ericsson to proceed with the initiatives to segment the supply chains regarding the five market areas. With a continuous analysis of the segments and the corresponding antenna demands, proactive actions can be taken to plan the regionalised supply and encounter the production capacity of certain antenna sizes and frequencies. In addition, as changes appear faster and faster the need for adaptability and responsiveness is crucial (Rushton et al., 2017). Thus, pointing the direction for Ericsson to stay ahead and invest in the distribution of tomorrow. Both regarding technological development as well as development of the distribution structures itself.

5.8 Pointing the direction for changes

The suggestions identified in the study has further been divided as seen in Figure 27. The categorisation and division were made to identify what alternatives that are possible to combine with each other since some of the alternatives are dependent upon another change.

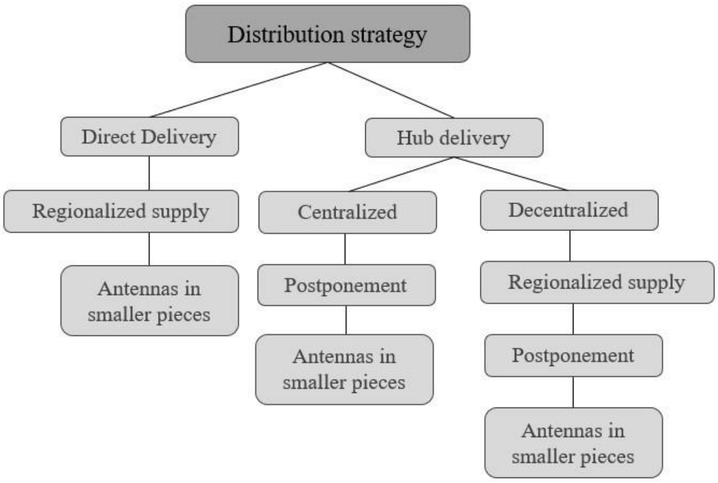

Figure 27 - Illustration showing the possible combinations of the distribution alternatives.

Hence, a first categorisation has been made separating direct delivery from distribution through hubs. The other alternatives that have been identified are suitable for only one of these whilst other alternatives might be suitable in both categories. Accordingly, for direct delivery it would not be possible to apply a postponement strategy since this suggestion has been introduced in combination with the usage of hubs. In addition, direct delivery is often used together with *MTO* (Ross, 2015) hence, in absence of inventories. However, developing a strategy for direct delivery enables the possibilities to further investigate the potentials with regionalised supply. In addition, investigating the potential to redesign the antennas and hence produce the antennas in smaller pieces is interesting in regards of direct distribution.

The hub delivery can further be broken down to a centralised hub strategy and a decentralised hub strategy (Ross, 2015). For a centralised hub, the alternative of regionalised supply is not applicable since the products must travel to a centralised distribution centre hence eliminating the benefits of using suppliers located closer to customers. However, the alternative of postponement is possible since final assembly can be performed in a centralised hub. In addition, the alternative of having antennas in smaller pieces also fit in the centralised hub strategy as this is a change that is performed at the supplier and does thus not affect the distribution strategy.

If using a decentralised hub distribution, the alternatives increase. Having intermediary warehouses enable the possibility to perform value-added activities (Bowersox et al., 2013). Therefore, if implementing a decentralised hub distribution there would be possibilities to supply the customers with large antennas locally instead of centrally. As mentioned, the suppliers have production sites in several countries around the world which imply that large antennas can be sourced from a closer location. Further, the concept of postponement would be possible to implement as the large antenna reflectors could be stored regionally to be further kitted with the remaining accessories when a customer order is received. In line with Szmelter-Jarosz (2016), a postponement strategy demands a site to perform the additional activities at. Finally, the decentralised distribution strategy would further enable the solution of constructing the antenna reflector in smaller pieces since this change do not affect the distribution strategy more than generating a positive effect on the fill rate as well as the handling of the large antennas.

Regardless of which strategy to use, either to keep the current strategy or adopt another strategy, the possibilities to implement the suggestions for changes brought up in the thesis are affected. As shown in Figure 27, the decentralised alternative of hub delivery enables implementation of the largest number of changes analysed in the thesis. However, to be able to respond to changing customer requirements and business environments, flexibility is of importance (Rushton et al., 2017) which therefore speak in favour of evaluating the implementation of several different alternatives.

5.9 Summarising the research questions

In the following section, the results of the thesis are summarised by answering the research questions.

- *How is the current supply chain of large antennas designed?*

The current supply chain structure of large antennas is defined as centralised. The actors involved in the antenna supply chain is the department of Microwave supply at Ericsson, antenna suppliers, *3PL* providers, *EDC* Sweden and local companies. The antennas are sourced from three different suppliers located in different geographical locations. Only when a customer order is received, the antennas are produced and sent from the suppliers to *EDC* Sweden and further shipped to the final point of destination which is either the end customer, local warehouse or project warehouse. Where the final point of delivery is located depends on the contracting between either *EAB* and the customer or the local company and the customer. This is the common supply chain strategy for all incoming orders of large antennas, aside from a handful exceptions. Due to costs reasons and need for storage space, Ericsson do not currently keep the large antennas in stock.

The antennas are part of an order constituting of several products needed for a complete installation of a site or network, where all products today are delivered as a complete order to the customers. In some cases, legal restrictions require complete shipment of orders which on one hand require consolidation and on the other hand require that goods are shipped from entities which are legally approved as *EAB*. Thereby, when evaluating the antenna supply chain, the total Microwave supply chain needs to be taken in consideration. From *EDC* Sweden goods are transported by truck, either directly to the customer or a change of transport mode is done before the goods reach the final point of delivery. The default mode is boat or truck and a certain approval is required if changes regarding transportation mode is needed. The local companies are responsible for selling activities and the direct contact with customer, hence the flow of information from customer and Microwave supply is directed through the local companies.

- *What key issues can be identified in the current distribution of large antennas?*

The distribution structure of the large antennas has been adjusted in line with the distribution structure of radios. Thus, the distribution structure does not consider the product characteristics of the large antennas.

As the distribution of large antennas is restricted to a centralised structure, the distribution flexibility is considered low which eliminates the possibilities for evaluating best practice solutions in line with customer requirements. Limiting itself to a centralised structure thus excluding other structures that might have desirable advantages.

The competitive factors for Microwave orders have been identified, revealing that one of the most important factors is lead time which is classified as an order winner. As the lead time from order to delivery is expressed as longer than customer requirements, the total lead time for large antennas is identified as an additional issue of the current distribution structure. Thus, the distribution is not focusing on the competitive factor for Microwave products.

The distribution structure of large antennas is also described as costly, having a negative impact on the environment through unnecessary transportation. Cost and technical specifications have been classified as order enablers. Two of the three competitive factors identified, cost and lead time, are linked to the defined issues of the current supply chain structure of large antennas. As the large antennas are sourced from three different suppliers, it adds to the complexity of aligning information from several nodes in the supply chain.

The preferred modes of transportation for large antennas have been defined as boat or truck, while it has been identified that air transportation is frequently used. This choice of transportation mode impacts the distribution cost and environmental impact negatively which limits Ericsson Microwave to reach the goals of a reduced distribution cost and environmental impact. In addition, limited analysis of transportation costs has been identified which limits the possibilities for evaluating the distribution strategy, hence adding to the defined issues.

Information sharing between local companies and the department of Microwave supply has been identified as crucial for forecasting and efficient handling of customer orders. As the demand for large antennas is varying, the forecasting process increases in importance to respond to the fluctuating demand. However, sharing a mutual understanding of the different functions sometimes fails which lead to difficulties in working efficiently and working towards meeting customer requirements. Communication has thus been identified as an issue related to orders of the large antennas.

- *What alternative distribution strategies can be identified for large antennas?*

Considering the different issues identified in the second research question, a set of additional alternatives for distributing large antennas are identified. In the context of rapid change and fluctuating demand, distribution and its flexibility are expected to be increasingly important to satisfy customer demand. The identified solutions are direct delivery, expanded utilisation of supply hubs, postponement, regionalised supply and constructing the antenna reflector with an increasing number of divided pieces.

The identified distribution structures can be divided into direct delivery, centralised and decentralised, and thereby evaluated in regards of their respective effect on costs, environmental impact and contribution to changes of lead time. Depending on how the distribution structures are combined and/or limited against each other, different effects of the investigated parameters are generated. It can however be stated that regionalised supply in combination with direct delivery or/and regional supply hubs is preferred in the environmental aspect and cost aspect due to the closeness to customers. If regionalised supply is not possible, direct delivery is preferred in the cost aspect as having a positive effect on lead time through contributing to reduced travel distance and reduced points of handling. Postponement and the reconstruction of antennas have both a positive cost aspect through rationalising the transportation by enabling bulk shipping and shipments with an increased number of antennas in one transportation vehicle. The environmental aspect only is changed in the postponement strategy. However, these latter alternatives involve a high-level engagement with the suppliers as the suppliers are responsible for the antenna design. Hence, being a more long-term suggestion of change. Regarding the distribution lead time, the alternative with the highest potential is the regionalised supply in combination with a direct delivery alternative.

Flexible supply chains, in terms of agile and responsive operations, are important for attracting customers and deliver superior customer experience. Hence being able to adjust the centralised structure to better meet customer requirements should be a priority. This will require a custom-specific analysis of what distribution structure that best fit the customer requirements, an analysis that will help generate a segmented supply chain. However, the possibilities for having an impact on customer requirements through communicating and offering environmental alternatives are important initiatives for a reduced environmental impact.

6. Discussion

The discussion chapter presents the contribution of the study concerning both academic contribution as well as the contribution towards the focus company. Further, a critical review of the study and its results is conducted where potential sources of error are presented. Followingly, the generalisation of the study is presented where after a discussion about identified interesting topics are presented.

6.1 Contribution of the study

Supply chain design and distribution strategies are two well-known subjects that have been thoroughly studied in research. As the study is based on accepted theories, the study itself cannot be argued to contribute to these concepts. However, as the theories have been adapted towards a specific product type, the identified alternatives for distribution improvements can be argued to generate some academic contribution as the improvements are general for large-size products. Further, the study contains a compiled literature summary in regards of supply chain design, distribution strategies and supply chain performance. Hence, functioning as a source of fundamental knowledge.

This study can serve as a foundation for the future work of improving the distribution strategy of large antennas for Ericsson Microwave as presenting alternatives for improvement of distribution performance. Hence, Ericsson could have use for the findings and conclusions by gaining increased knowledge about the presented suggestions for improvement and the advantages and disadvantages with these suggestions. Furthermore, the study provides an overall current state map and highlights the main issues with the distribution strategy. Thus, being interesting for both the department of Microwave Supply as well as other departments not being a direct part of the supply chain.

6.2 Evaluating the used method

The presented findings have considered both theoretical and empirical information and by performing an analysis of theoretical and empirical sources, similar challenges and suggestions for improvements have been identified. Multiple empirical sources from interviews, workshops, team meetings and quantitative data strengthen the reasoning and contribute to the fulfilment of the purpose of the study. In addition, interviews were conducted at various functions related to the Microwave supply chain spanning from the Key Account Manager to Inbound Supplier Manager. Further, the theoretical framework is based on a mix of accepted supply chain theory and concepts and more recent publications regarding i.e. green logistics and supply chain flexibility.

6.2.1 Evaluating the research strategy

The data collection methods used in this study generates certain challenges that need to be addressed. As stated, the usage of both qualitative and quantitative strategies for data collection increase the validity and generalisability of the result of a study (Easterby-Smith et al., 2015). The quantitative data collected in the thesis was done to strengthen the reasoning of the improvement possibilities and to substantiate information received from the interviews. The data relates specifically to the large antennas where data such as mode of transport, geographical spread and fluctuating demand was useful in the analysis of both the current state and potential changes, hence positively adding to the validity of reasonings and results of the thesis. The potentials for distance reduction regarding the distribution alternatives direct delivery and expansion of the supply hub utilisation are quantitatively analysed in the study. However, the transportation distance reductions are based on the linear distances between two measuring points. Hence, the probability that these reductions are accurate are low as the transportation of the large antennas is dependent upon the transportation infrastructure. However, the distance reduction shows the concept and emphasise potential savings. In addition, the strategy of regionalised supply was not quantitatively measured due to assumptions drawn from both the reduction of transport distance of the two other alternatives and that through situating the production closer to customers will reduce inbound transportation. Hence, these assumptions would need further investigation in terms of dividing customers in suitable regions where the transport distance actually is decreased.

Another limitation with the study is the interviews conducted at Ericsson. According to Bryman and Bell (2015) the snowball method is preferable when knowledge and contact network is restricted. The snowball method proved to be valuable for finding interviewees, however it is not possible to rule out the risk that valuable information is excluded due to the restrictions that comes with sourcing interviewees within a certain network. In addition, efforts were made to select and contact interviewees working in the area of supply chain but still, some of the selected interviewees were not possible to reach which might have led to missing some important insights. Regarding the interviews that were conducted, there might be contradictions among the answers from the interviewees. Information has thus been investigated further to strengthen the validity.

The results from this study should mainly be seen as of a conceptual nature where in-depth investigation and case-specific calculations for each distribution alternative are necessary before being able to draw any reasonable general economic conclusions. The limited number of interviewees may lead to biased answered. Further, the case observed in this study is lacking a cost perspective due to limitations in terms of sources and is hence, based upon assumptions.

The conclusions are dependent upon the circumstances of the industry and the studied company's current situation, which means that in other circumstances the conclusion might differ. As research question 1 and 2 are the foundation for research question 3, the answer is related to the development of the business today. If the circumstances in the business environment changes, the results will differ as the requirements for winning an order change. The competitive factors identified in the study changes with the circumstances and hence, the results will differ.

6.2.2 Including the perspective of other actors than Ericsson

Areas that has not been explored and constitute several uncertainties needs to be critically evaluated before any decision regarding distribution strategy may be taken. This study stresses the importance of collaborating with the actors in the supply chain, although the study exclusively focus on the perspective of Ericsson. Through creating collaborative goals and activities with other actors it is possible to optimise the result of the whole supply chain, rather than sub optimisation in each separate organisation (Cooper & Lambert, 1997). Thus, the perspective of additional actors such as the suppliers could be an area for further investigation to draw conclusions about a future distribution strategy. In addition, external initiatives are important for improving environmental performance (Ates et al., 2010), hence addressing the importance of involving suppliers among others in the quest for a successful environmental strategy. Further, the study stresses the importance of considering the legal and geopolitical aspects of global supply chains. Mainly as these aspects are largely influencing how distribution may be structured. Thus, further investigation needs to be made to gain knowledge about the legal and geopolitical restrictions and share information throughout the company.

6.3 Generalisation of the results

The findings in this study have been generated for the specific product group, large antennas, at the studied company, *EAB*. This imply that the results and conclusions cannot be applicable onto other product groups without further investigation. However, the design alternatives may be useful for products with the same characteristics as the large antennas, namely large-size products with fluctuating demand and long supply lead time. Further, as the findings have been generated for the studied company Ericsson, the findings cannot be directly applicable onto other originations or industries. The findings may however be useful for other actors in the telecommunication industry or in other industries where the offering to customers are large systems, consisting of several different products.

Thus, the findings cannot be said to be generalised as it is dependent upon the circumstances of the company. However, the method used in the thesis can be applied by other companies. In addition, some of the concluding findings in the thesis might be usable for other companies. The success factor of flexibility is relevant for other companies present in a context with rapid change and fluctuating demand, aiming at meeting customer requirements.

6.4 Evaluation of the results

The distribution of large antennas has been discussed mainly in two different aspects, through a centralised structure or a decentralised structure, where both positive and negative aspects of the solutions can be found. Regardless of what choice that is made, distribution is inevitably an important part of the customer experience through representing the link between the producer and the customer, thus bridging the gap between supply and demand (Rosenbloom, 1995). It has been found that as distribution constitutes the last part of the supply chain, it is often affected when companies face material shortage or have difficulties in delivering according to customer requirements. Hence, actions such as choosing a faster transport mode may be introduced to reduce the impact of the customer experience.

In the introductory part of the study it was stated that the emissions and the environmental impact was a main concern for Ericsson Microwave, as well as the desire of improving the ability to deliver the large antennas at a reduced distribution lead time, however with the cost and environmental aspects in mind. Hence, the choice of transport mode could not be limited to air which provide high speed, as this mode is correlated to high costs (Drake, 2011) and high CO_2 emissions (Dekker et al., 2012). In addition, it is argued that the "one size fits all" strategy of transportation lead to increased costs as well as inability to fulfil customer expectation (Naim et al., 2006). Thereby, offering several alternatives of transportation is of importance. In addition, suggesting an introduction of inventory would neither be enough nor applicable as a single solution because the empirical results informed that the antennas are costly to store, and they require a lot of storage space. Hence, solely giving a recommendation to introduce inventories would neglect the cost parameter since keeping inventories generate costs related to warehouse buildings and tied-up capital (Stanton, 2018).

As the supply chain of antennas has a global presence, it causes long travel distances which in addition contribute to larger emissions from freight transportation (Min & Chung, 2017). Evaluating the results in the thesis, the cost aspects as well as lead time and distance were considered, leading to several different alternatives to be further evaluated. As all alternatives reveal potentials for reduced transport distance, Ericsson Microwave may reach profitable gaining if implementing the changes. Thus, going ahead with the presented findings, continuous evaluation and optimising the transportation of large antennas is recommended as transportation is often one of the largest costs in logistics (Bowersox et al., 2013). As mentioned, several aspects do however need to be taken into consideration to fully support the argument for reduced costs.

Analysing and evaluating new suggestions for the distribution of large antennas has in addition proven to contribute to the reduction of environmental impact in terms of CO_2 emissions. The impact is partly evaluated in terms of how the distribution structure is designed which affect emissions (Min & Chung, 2017) but also in terms of which mode of transport that is used. Due to the increased importance of addressing environmental impact, keeping this in mind when designing an appropriate distribution for large antennas can be regarded as vital for Ericsson Microwave.

Sustainability can however be interpreted in different ways, where arguments can be directed towards a contradiction between environmental impact and cost. Some argue that actions towards greener logistics is costly and require investments that companies are not ready to enter if impacting the economic profitability. Hence, companies must come to the recognition that actions towards a more sustainable business bring sacrifices in economic profitability. However, it has also been emphasised that costs may be reduced when the environmental impact of logistics is reduced (McKinnon et al., 2015) thus arguing in favour of the focus on environmental impact. As an example, the regionalised supply presented in the solutions may provide benefits in both parameters due to the closeness to customers and hence decreased transportation lead time.

Further it has been emphasised that the best possible solution for distributing large antennas will probably require flexibility in terms of offering several different solutions to customers. In the near future it would not be possible to fully reject the current centralised structure in favour for the solutions presented in the thesis. This due to laws and geopolitical restrictions requiring consolidated shipments and limitations regarding shipments from certain countries as some examples. Thus, the upcoming work of designing the distribution design of large antennas will thus need to consider several solutions simultaneously. In a competitive market place, as stated by Ladier & Alpan (2016), the distribution strategy has to be responsive and fast while operating at low cost.

6.5 Recommendation for future actions

Based on this thesis, there are several actions that may be initiated to improve the current distribution of large antennas. The actions are summarized in Figure 28 and should not be addressed as isolated actions but rather complement each other to move forward with the creation of an improved distribution strategy.

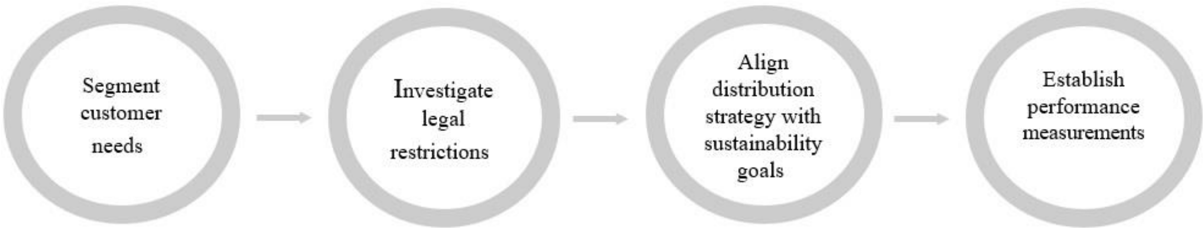

Figure 28 - Recommended areas for future actions.

It is evident that there are many different factors influencing the success of the distribution of large antennas. For Ericsson to succeed with a new distribution strategy, the company needs to aim at increasing the flexibility of the supply chain. From contracting to delivery. As the changing of a distribution strategy is a complex project, pilot projects with collaborative customers can be utilised to gain experience and insights from such collaborations.

In the next step forward, it is important for Ericsson Microwave to fully understand the need of the customers and use it as a starting point for their continuous work of forming a suitable distribution strategy. It may be argued that doing so will give Ericsson Microwave a strong competitive advantage through offering differentiated services, in terms of efficient distribution, required by customers. Segmenting customers according to their specific needs may be a first step of changing the distribution strategy. As the market areas MMEA, MOAI and MELA have the largest demand for large antennas, the distribution to customers in these markets should preferably be investigated first. The 1,8 m antenna sizes have the largest demand in all these market areas, thus a first step could be to focus on this specific group of products. In addition, the 1,8 m antennas represent the second largest group that is most frequently sent by air. The large volumes and the high usage of air transportation does further argue for prioritizing this group of antennas. Considering the reduced transport distance presented in the thesis, the cost aspect may also be affected by segmenting products and find the most suitable distribution for each category. In turn prices may be reduced hence adding to the competitive advantage for Ericsson Microwave.

Being present in a global market bring responsibilities regarding legal and trading aspects. The main restrictions regarding determining which distribution structure that is most suitable are tied to laws and regulations that simply cannot be neither neglected nor changed. For future actions, these restrictions should however not overshadow the potential improvements but rather being investigated in parallel with the suggested distribution alternatives. Due to the lack of resources, the study has excluded deeper analysis regarding these issues. Hence, a thorough investigation of these restrictions needs to be evaluated in collaboration with other departments such as legal and trading in order to move forward with any of the presented distribution designs. Similarly, a more thorough identification of the costs that might occur when changing distribution structure needs to be evaluated in relation to the benefits gained.

Further, as the environmental footprint is increasingly important a thorough investigation and disintegration of environmental impact throughout the current supply chain needs to be performed. Thus, creating guidelines to give direction towards what distribution design and performance measurements to use to reach the sustainability goal.

To finalise, you cannot control what you do not measure. To succeed with the presented results, it is emphasised that suitable measurements need to be evaluated and established. Having a strategy may not be enough for reaching real performance if the progresses are not possible to follow up. Hence, in line with developing different alternatives for distribution of large antennas, a set of KPIs should be implemented and followed up on a regular basis. In this way it will be possible for Ericsson Microwave to evaluate its performance towards wanted position and in turn evaluate their distribution strategy to always being on top of their business.

7. Conclusion

Distribution refers to bridging the gap between production and consumption (Rosenbloom, 1995). Thus, being a crucial part of the fulfilment of customer demand. This study has fulfilled the purpose of aiding Ericsson in exploring different suggestions for changes of the distribution of large antennas to cope with the increasing requirements. The aim of the thesis was to find suggestions for changes of the current distribution of large antennas to reduce lead time, cost and environmental impact. To do so, the current supply chain of large antennas has been mapped to identify the involved actors and activities, and to learn about the environment where the large antennas are sold, as summarised in 5.9. The mapping and illustration of the supply chain help to answer the first research question*: "How is the current supply chain of large antennas designed?".* When analysing the supply chain, it became apparent that the current supply chain was designed for small-sized products with short life cycles and low transportation costs. Product characteristics that are not representative for the characteristics of large antennas.

To provide suggestions for changes, issues and challenges in the current distribution or large antennas were identified. Thus, answering to the second research question *"What key issues can be identified in the current distribution of large antennas?".* These issues are summarised in section 5.9 and include the lack of flexibility in the distribution. Further, as the large antennas are consolidated in a centralised distribution centre located far from the customer the distribution is costly, time-consuming and have an environmental impact larger than needed.

With the basis of the current supply chain of large antennas and the experienced issues, the third research question "*What alternative distribution strategies can be identified for large antennas?"* could be undertaken. Five different alternatives were identified as having potential for improving the distribution: direct delivery, expanded utilisation of supply hub, postponement, regionalised supply and reconstruction of the antenna design. By comparing the alternatives in relation to the demand and supply characteristics of the large antennas, it became obvious that a flexibility in the distribution is needed to cope with the varying customer demands as telecommunication network orders are customer unique. Thus, to distribute the large antennas with a reduction of distribution cost, lead time and environmental impact, different solutions are needed as the potential of the alternatives are alternating between different customer cases. Thus, the era of "one size fits all" is gone and companies are required to create the ability to adapt to rapid changes. Redesigning the distribution strategy of large antennas will gain benefits for Ericsson Microwave related to an increased ability to meet differing customer demands apart from the reduction in distribution cost, distribution lead time and environmental impact.

The study concludes that distribution is an increasingly important function to stay competitive in a global supply chain and that the performance of the distribution needs to be frequently assessed to stay alert and find potential for improvements. Thus, the study provides recommendations to measure the performance but more important to analyse the performance measurements to detect areas of improvement. Further, that information sharing is crucial to improve the collaboration between different actors. Ericsson Microwave should followingly invest in understanding the customer needs to enable a customer segmentation functioning as a guidance regarding distribution strategy adaption and flexibility.

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Appendix A – Interview template

The general interview template that was used during the study is presented below. The general interview template was used to understand the context the antennas are ordered in and further to identify the activities and actors involved in the antenna supply chain and distribution. As some interviewees has expertise knowledge about different parts of the investigation area, more specific questions related to the interviewee's role were asked in addition to the general template questions.

General questions

- Tell us about your role at Ericsson
- What relation do you have to the antenna supply chain?
- How would you describe the supply chain of antennas from order to delivery?
- How would you describe the overall supply chain strategy?
    - What goals are the supply chain aiming at to reach?
- What do you think is the main reason for customers to choose Ericsson?
    - Lead time/service level/quality/cost
- Which actors are involved in the supply chain?
- What activities do they perform?
- What are the biggest and the most frequent challenges you are facing regarding the supply chain today?
- What external factors are impacting the material flow?
    - Which are possible to change?
    - Which are impossible to change?
- How often do customers require complete shipments of the order?
- What differences are there between an EAB-contract and a LC-contract?
- How would you describe the order flow?
- How would you describe the orders?
    - Customised vs standardised?
- What changes do you think would be possible to implement regarding the distribution of large antennas?

Appendix B – Equation for calculating distance reduction

The potentials for distance reduction have been calculated utilizing the following equation:

$$Distance\ reduction = \frac{Distance\ X - Distance\ Y}{Distance\ Y}$$

Distance X = The linear distance between supplier and customer utilizing the new distribution design

Distance Y = The linear distance between supplier and customer utilizing the current distribution design