Master’s degree thesis

LOG950 Logistics

Warehouse location for Rolls-Royce´s production centers at Sunnmøre: A case study

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Preface

This master thesis concludes our two years at Molde University College – Specialized University in Logistics. The thesis presents the academic work that has been done during this last semester. The work period has lasted from December 2018 to May 2019, where we have accomplished to finish an MSc degree in Logistics. The work of the thesis has been very educational, where we have learned much through the writing.

We would like to thank our dearest supervisor Arild Hoff for supervising us throughout this semester. The process of writing the thesis has been difficult at times. We appreciate the good guidance through the process of writing the thesis. The supervising has been very helpful.

We would also thank the Spares division at Rolls-Royce Marine Ulsteinvik for giving us the opportunity to write for them. We would especially thank Ida Mari and Bjørn Inge for an outstanding contact, and for always responding quickly to questions we had. We are grateful for all the data we have received, in addition to that we got to perform interviews with relevant customers. We would like to thank the interviewees who took the time for an interview. Their statements were valuable of conducting this thesis.

Lastly, we would like to thank our family and friends for their unconditional support and understanding through the work of this thesis. We are also grateful for our classmates, where we have encouraged each other through this master degree.

Karoline Hjelme Haukeland and Julie Vik
Molde, Norway
May 2019

Abstract

This master thesis investigates warehouse location for Rolls-Royce´s production centers at Sunnmøre. Rolls-Royce have restructured their distribution network towards a centralized system, where they use a global distribution center (GDC) in Helmond. The GDC distribute spare parts to customers in addition to sending items to the production centers when needed. Before centralizing to Helmond, the production centers operated and distributed the spare parts from their own local warehouses. Given that most of the customers of Rolls-Royce are located in the maritime cluster in Møre and Romsdal, we will examine relevant customer opinions about the current situation. In addition, we will investigate how the centralization of the warehouse has affected them.

Both a qualitative and a quantitative approach have been used in order to answer the research questions. There has been conducted interviews with key customers. In addition, we have analyzed internal data reports to review how a selection of distribution activities has developed since the centralization occurred in 2011. The development can give further indication if it is desirable to locate a warehouse at Sunnmøre as a supplement to the current GDC in Helmond. Further, we performed a facility location analysis in order to find out where Rolls-Royce could locate a potential warehouse at Sunnmøre. Factors such as transportation costs, establishment costs and demand were used as measurements in the model. Other important factors such as availability of qualified staff, proximity to airports and goods traffic flow etc. are discussed theoretically.

We have also had continuous dialogue with Rolls-Royce´s spares division in Ulsteinvik during the writing process. By comparing the results from the analyses, Rolls-Royce could further consider to establish a common warehouse for all of the production centers at Sunnmøre.

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List of Abbreviations

BGV	Brattvåg
GDC	Global Distribution Center
HLM	Helmond
LGV	Longva
PC	Production Center
RR	Rolls-Royce
SOT-DAYS	Safety time in days
ULS	Ulsteinvik

1.0 Introduction

Centralization of inventories is a trend, where many companies have chosen to rationalize production into fewer locations. Because of consolidating inventory, organizations have steadily closed national warehouses and moved them into regional distribution centers. This is in order to serve a much wider geographical area and reduce total inventory requirements (Christopher 2016). Companies can achieve economies of scale by centralizing warehouses and distribution centers (Nahmias 2009). Rolls-Royce have also restructured their distribution network towards a centralized system, where the spare parts are distributed through a global distribution center in Helmond, Netherland. Before the centralization, the production centers at Sunnmøre distributed and stored the spare parts themselves at their local warehouses. A centralized system will, however, normally increase the transportation costs in that products have to move over greater distances. In addition, centralization would typically lead to higher cost in airfreight to ensure short lead-times to the customer (Christopher 2016). Due to the fact that Rolls-Royce have centralized the spare parts warehouse to Helmond, the distance to the customers located at Møre and Romsdal has increased.

Even though companies see the benefits of centralization, some companies have seen the advantages of locating near the customers or the point of production where managing and controlling occur centrally (Christopher 2016). Rolls-Royce Ulsteinvik have speculated if it would be beneficial to locate a warehouse at Sunnmøre. The warehouse will then be located near the major production centers and will also be close to the customers in a strong maritime cluster. Locating a warehouse is one of the most important strategic decisions a company does and it is essential to locate the warehouse at the most cost-effective geographic location (Richards 2017).

By performing interviews, reviewed internal data reports and conducting a simple optimization model, we can get an overview of the current situation and suggest where a potential warehouse could be located.

1.1 Company Overview

During the writing of the thesis, Rolls-Royce Commercial Marine have become a part of the Kongsberg Group. They were formally taken over by Kongsberg on April 1, 2019. However, this thesis will focus on Rolls-Royce since they became a part of Kongsberg Group after the writing process had started.

Rolls-Royce Holdings Plc is a British owned international concern that operates in over 50 countries to produce and develop technical solutions in several divisions (Rolls-Royce 2018). The company is divided in five business divisions involving Civil Aerospace, Defence Aerospace, Power system, Nuclear and Marine (Rolls-Royce 2017). Rolls-Royce have facilities in several countries and is a global business, which deliver world leading products. They offers first rate after sales services, covering mechanical overhauls in addition to spare part distribution (Yusuf, Gunasekaran, and Abthorpe 2004). In this thesis we will focus on the marine division.

Rolls-Royce Marine are one of the largest suppliers of marine products, systems and technology (NorwayExports 2018). As Rolls-Royce Marine are a part of the Norwegian maritime industry, the marine division provides manufacturing and services propulsion and handling solutions for maritime markets in merchant, offshore and naval. The products delivered are varying from standardized to complex solutions (Rolls-Royce 2017).

Rolls-Royce Commercial Marine are highly represented in Scandinavia and has a total of 3600 employees, where 1600 employees are working in Norway (Stensvold 2018a). The marine business has its largest engineering and technology unit located in Norway spread out across ten locations (Rolls-Royce 2018). The majority of the sites in Norway are located at Sunnmøre, in Ålesund, Ulsteinvik, Hjørungavåg, Brattvåg and Longva.

In this thesis the main focus will be upon the production centers in Ulsteinvik, Brattvåg and Longva. These sites are the ones that are connected to the distribution network with the global distribution center (GDC) in Helmond. The production and service division at the site in Hjørungavåg has been closed down and moved to Brattvåg. The site still operates the administrative related to the production and service that before was conducted in Hjørungavåg. There is however, a warehouse at the site that can be used. The site in Ålesund is the main administrative headquarter. This site does not have a production division nor a service division, and therefore they have no usage of any warehouse.

Figure 1-Overview over the production centers at Sunnmøre (maps.google)

1.1.1 Rolls-Royce`s Supply Chain

Rolls-Royce´s distribution network consists of the production centers and the global distribution center (GDC) in Helmond. The company are producing and designing fully integrated ship equipment for the end-customer. Rolls-Royce have been divided into different divisions, where each production center are producing and providing services on different parts of the final integrated system.

The Production Centers

All the production centers are located at Sunnmøre in the county Møre and Romsdal, which is located in the north of the west-coast of Norway.

Rolls-Royce Marine Propulsion-Ulsteinvik

Rolls-Royce Marine Propulsion are located in Ulsteinvik which lays south in the Sunnmøre district. The production center is producing and providing services within the propulsion systems. This involves Azimuth thrusters, propellers and tunnel thrusters etc.

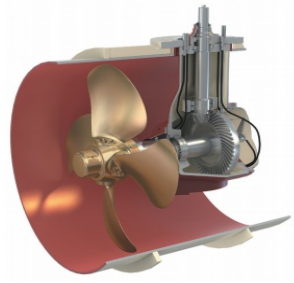


Figure 2-Standard tunnel thruster

Rolls-Royce Marine Deck Machinery and Steering Gear-Brattvåg

The production center in Brattvåg is located north of Ålesund on the mainland. Brattvåg produce and perform services on deck machinery and steering gear. Deck machinery involves winches and cranes etc. In the steering gear division, they produce reduction gear, rudders, etc.

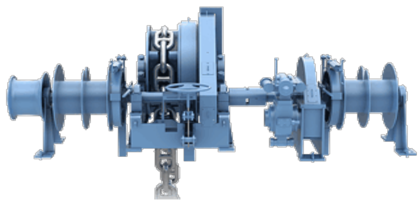


Figure 3-Hydraulic winch

Rolls-Royce Marine Automation-Longva

Rolls-Royce Marine Automation are located on Flemsøya, which is an island outside Ålesund. The Longva division are manufacturing automation and control systems. This involves integrated bridge systems, common control platform etc.

Figure 4-Integrated brigde system

1.1.2 The Global Distribution Center (GDC) in Helmond

Rolls-Royce established their Global Distribution Network in 2011, where the global distribution centers (GDCs) were located in Netherland, Houston and Singapore (Rolls-Royce 2014) (Rolls-Royce 2019). The main global distribution center (GDC) was located in Helmond, Netherland. The establishing of the network was to simplify the ordering process for their regional service centers, and also be able to provide better customer support service (Rolls-

Royce 2019). Since it is the regional service centers that are using the GDC, it is mainly spare parts that is stocked in Helmond. The spare part logistics is important due to keep the equipment operating efficiently. The distributions centers function is to support the regional operations, where the stock is limited (Rolls-Royce 2014). The thought behind the GDCs was to have 50 percent of the stock in Helmond and respectively 25 percent in both Houston and Singapore. With items spread around the world, Rolls-Royce were not able to distribute complete shipments. The cost for operating three different GDCs were also tied to high operating costs. On the background of this, and that Rolls-Royce did not have a sufficient client base around Houston and Singapore, the two GDCs were closed down.

As of today, Rolls-Royce are using the warehouse and distribution services from Kuehne+Nagel. The contract between Rolls-Royce and Kuehne+Nagel specify everything from packing standards to service level etc. The GDC is functioning as a pick&pack warehouse, which means that Kuehne+Nagel`s employees do not have any form of knowledge about Rolls-Royce's products. The staff pick, pack and ship the goods only based on the item number.

Rolls-Royce Marine are one of many companies that are renting warehouse space in Kuehne+Nagel´s warehouse. On this background, there are strict rules and standards related to packing that Rolls-Royce Marine have to follow. Kuehne+Nagel can also invoice Rolls-Royce for the extra hours they have to spend if the cargo is not packed proper after the packing standards. The employees at the GDC use approximately two hours to count the inventory every morning, and then asks Rolls-Royce Spares division to adjust the stock. Kuehne+Nagel do not have the responsibility if cargos get damaged or missing.

1.1.3 Transportation

The production centers at Sunnmøre are of today using DHL as their distributor. They use DHL`s Express 12:00 services, where aircraft is the main transport mode. This include daily pick-up`s at the production centers and a guarantee that the cargo is delivered before 12 pm the next possible working day. DHL Express do not accept cargo that has a weight over 1000 kg, individual cargo over 300 kg, cargo with length over 300 cm or if the cargo is not correctly packed (DHL Express 2019). If a cargo has one of the weight or length characteristics listed above, it has to be transported by truck. These restrictions are requirements that Rolls-Royce have to follow when transporting cargo to the GDC in Helmond. The production centers use airfreight or road freight as their mode of transport. The closest airport, and which is used, are located at Vigra, outside of Ålesund. The spare part division at Ulsteinvik states that the production centers are primarily using airfreight as mode of transport in order to meet customer demand.

The production centers are operating with two different types of service order. The 600-orders represent the service order and are based on actual demand from a customer. A service order can be activities related to warranty cases, maintenance, installation, repair etc. One service order can therefore involve several numbers of different items. An item can be a part that can be shipped directly to the customer as a spare part or it can be a part that will be used in order to finalize a service order. The 770-orders are involving spare parts that are going to be stored at the GDC based on forecasting in anticipation of a demand.

When distribution cargo to the GDC, the production center in Ulsteinvik are distributing these two order types together, whereas the production center at Brattvåg are distributing the 770-orders with truck once a week. A distributed cargo can involve a certain amount of items that makes up one or several service orders, depending on the size and volume of the service order. As mention above, an individual cargo can be maximum 300 kg.

When planning the spare part logistics, the employees at Rolls-Royce Marine Ulsteinvik are operating with a transportation time on five days, excluding weekends and holidays. The production centers at Brattvåg and Longva are operating with eight transportation days. The transportation time includes some buffer days in case of delays from the transporters side and time of inbound and outbound at the warehouses. This could be customs clearance etc. The production centers also have three safety days (SOT-days), which originally was meant to be a time-buffer in the transportation chain, but has now become a buffer time for the warehouse-employees. If the item is in stock in Helmond, Ulsteinvik have a delivery time on eight days, while Brattvåg and Longva have a delivery time on eleven days.

1.1.4 Description of Spare Part Supply Chain

Figure 5 shows Rolls-Royce's spare part supply chain and how the material flow is functioning. The first tier in the supply chain is the vendor that provides the production centers with either raw material or finished items. For Rolls-Royce Spares division, this could be an external supplier or the production unit at the production center. The production unit produces items that the service unit are using to perform service on a product. The finished products are then moved to the warehouses at the production centers before they are transported to the GDC or to another production center for final completion. The item that the production unit provides can also be defined as a spare part and will then be shipped directly to the GDC. If it is an external supplier the items are shipped directly to the GDC. At the GDC the items are either stored or distributed directly out to the customers.

Several of Rolls-Royce´s customers are located at Sunnmøre, which means that the items are often transported to Helmond to be stored at the GDC, and later again shipped out from the GDC to cover a demand from a customer at Sunnmøre. As mention, Rolls-Royce stores items at the GDC that often is used in further configurations at the production centers at Sunnmøre. This means that the item will have to be transported back to the production center, finalized and then distributed out to customer.

When an order for an item comes in, the ERP-system automatically generates the orders from the production centers to the GDC if a demand is needed at the GDC. This do not work the other way around if there is a demand at the production center and the items are in the inventory at the GDC. The employees at the Spares division will then have to manually create a transfer order from Helmond to the production center at Sunnmøre.

A worst case scenario is if both vendor and customer are located at Sunnmøre and there is a stock-out in Helmond. The item will then be shipped from the vendor to Helmond, sent to the production center for further configurations and then again delivered to the customer at Sunnmøre.

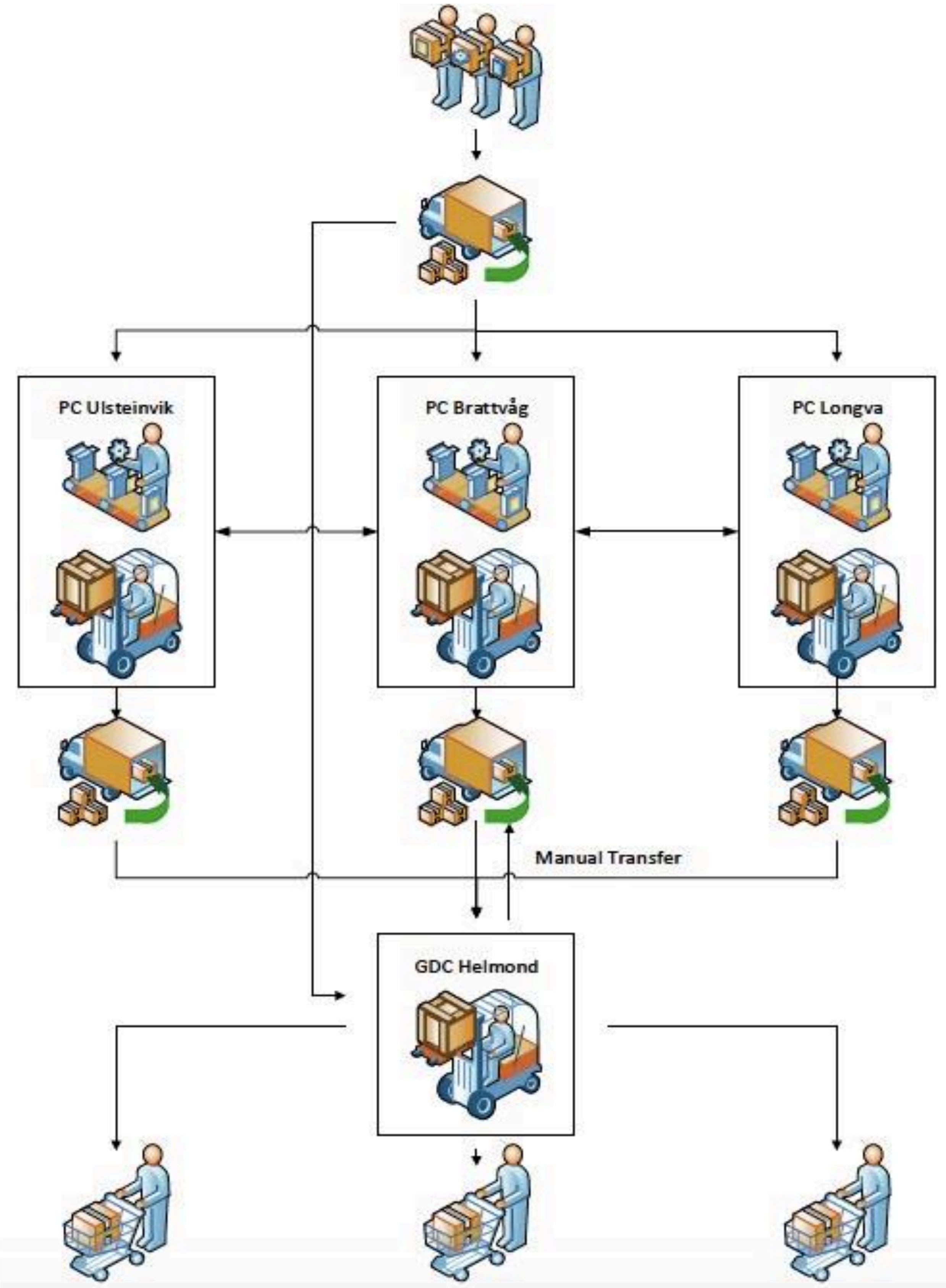


Figure 5-The spare part supply chain

1.2 Structure of the Thesis

Chapter 2 presents the description of the problem where we explain why we have chosen this problem in addition to limitations for the case study. In this chapter, the research questions are presented. Chapter 3 presents the literature review conducted for this study. Chapter 4 presents and justifies the methodological choices. Based on the nature of the problem, semi-structured interviews were chosen as empirical methods. In addition, we have analyzed internal data reports and performed a facility location analysis. In chapter 5, the results from the research are presented. Further, in chapter 6, the discussion is presented. In this chapter, we are discussing the results from case study findings towards the literature conducted in chapter 2. The conclusion and further research is presented in chapter 7.

2.0 Problem Description

This chapter presents a description of the current situation and the problems we intend to investigate. The research questions are introduced in the first section, while the limitation for the case study is introduced at the end of this chapter.

The title we have chosen for our master thesis is:

- Warehouse location for Rolls-Royce´s production centers at Sunnmøre: A case study

Before the global distribution center was established, the production center in Ulsteinvik held and managed their whole inventory at the warehouse in Ulsteinvik. This was also the case for all of the other production centers at Sunnmøre. On the background of greater distance, safety times and strict requirements for packing, Rolls-Royce`s production centers at Sunnmøre have to deal with much longer lead-times after the centralization and establishment of the GDC in Helmond. The production centers have their own warehouses, which is mainly used by the production departments. A production order involves the production of a new product, whereas service orders involves different activities related to the maintenance, repair, upgrading, etc. of a given product. A service order can also be items that are defined as spare part that will be delivered to a customer. Rolls-Royce are therefore operating with "common parts" that can be used in production orders, in service orders that is used in maintenance etc. of a product or in a service order that involves spare parts going out to a customer. The spares divisions, which handles the service orders, have therefore several items stocked at the production centers. The different spare part divisions are also experiencing that they do not have the item at the right location when needed. They state that items often are shipped back and forth between the production centers and Helmond. Some of the items are stocked at the production centers and others are stocked at the GDC. If an item stored in Helmond is needed at the production center to cover a demand or in order to complete the service order, the item has to be shipped back to the production centers.

Rolls-Royce are a part of the strong maritime cluster at Møre and Romsdal. This means that they are placed closed to many of their most important customers. The direct shipments from the production center in Ulsteinvik to their customers has also been categorized as unproblematic. This gave the production centers more flexibility, instead of working with an external GDC, where there are strict rules related to packing, different routines and costs related to these routines. Rolls-Royce state that they experience that the items are often shipped back and forth between the production centers and Helmond before it can be delivered to the end-customers.

2.1.1 Research Questions

The research questions are essential in the research process due to finding answers to the issues, and should reflect what we want to find out (Bell, Bryman, and Harley 2018). The employees at the production center in Ulsteinvik have over time speculated if a warehouse should be located at Sunnmøre. They therefore want to map how their local customers is experiencing todays situation with the GDC located in Helmond, and what their thoughts are about the previous warehouse situation. In addition, they want to find the best location for a warehouse serving the local customers and the production centers at Sunnmøre. The focus areas are therefore:

- RQ 1: How does the centralization of the GDC provide advantages and disadvantages?
- RQ 2: How has the delivery performance been affected by the establishment of the GDC-model?
- RQ 3: Why is it desirable to have a warehouse located at Sunnmøre?
- RQ 4: Where could a potential warehouse be located at Sunnmøre?

2.1.2 Limitations for the Case Study

Rolls-Royce wanted us to investigate where a potential warehouse could be located at Sunnmøre. Locating the warehouse will therefore be done in the connection to one of the already existing sites in either Ulsteinvik, Brattvåg, Longva, Ålesund or Hjørungavåg. We focus on transportation costs, demand and establishment costs. The production center involves both the production unit and the service unit. The focus area in this thesis will be limited to the spare division within the service unit. This is because the spare division coordinates the distribution of spare parts at the production centers and in Helmond. Lastly, the customers interviewed are limited to those located at Sunnmøre.

3.0 Literature Review

In this chapter, relevant literature will be presented to form a frame of reference to the stated problem. The literature conducted in this chapter is collected from different literature reviews, which will further be used in the discussion chapter.

3.1 Supply Chain Management

A supply chain is *a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users* (Aitken 1998). According to Govil (2002), supply chain is a global network where organizations collaborate to improve the flows of material and information between suppliers and customer at the lowest cost and with rapid speed. The importance of the supply chain is customer satisfaction.

Further, supply chain management is defined as the management of goods and information flow through the supply chain from raw material to final customer, which reflects the inter-organizational coordination of the different actors within the supply chain (Mentzer 2001). On the other hand, Prater and Whitehead (2013) define supply chain management as the cost-effective organizing of the flow and storage of goods, in-process inventory and finished goods. It is important to satisfy customer requirements through the supply chain. In order to satisfy these requirements, the information flow goes from place of origin to the place of consumption. According to Christopher (2016) supply chain management is rather defined as

"The management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole."

Christopher (2016) also states that the goal of supply chain management is to achieve linkage and co-ordination between the processes of suppliers and customers, and the organization itself. It is important that the supply chain aim to reduce or eliminate the buffers of inventory that exist between organizations. To achieve this, information sharing regarding demand and current stock levels are essential. While Christopher (2016) mention the importance of achieving linkage and co-ordination between suppliers and customers, Prater and Whitehead (2013) mention the importance of having focus on product design, planning and forecasting, order management, inventory management, order fulfillment and return management through the supply chain management. The activities within supply chain management include forecasting demand, selecting suppliers, ordering materials, receiving and managing inventory, shipping and delivery, and organizing information sharing (Prater and Whitehead 2013).

3.1.1 The Cluster

Clusters are defined as a geographically concentration of interconnected companies and institutions within a particular area. The cluster consists of an array of linked industries, which are important to the competition. In addition, suppliers of specialized inputs such as components, machinery and services, as well as providers of specialized infrastructure are a part of the cluster. The cluster also includes channels, customers, and manufacturers of complementary products and companies in industries related to skills, technologies and common inputs (Porter 1998).

The Maritime Cluster in Møre and Romsdal

Rolls-Royce are an important part of the maritime cluster where several of their customers and suppliers are located. The maritime cluster involves all businesses that owns, operates, designs, builds, deliver supplies or specialized services to, all types of ship and other floating units (Benito et al. 2003). Figure 6 shows how the maritime cluster in Møre and Romsdal is built up. The ship consultants have a core role as a supplier of design to the ship owners. They have direct dialog with the shipyards regarding the building and also interact with the suppliers regarding the ship equipment. The ship owner´s customers are not a part of the maritime cluster (Rødal, Bergem, and Sandsmark 2018)

The maritime cluster located in Møre and Romsdal is often defined as a “complementary supply chain” where all the companies in the region are working close together, which have contributed to competitive advantages and high innovative capabilities in previous decades (Rødal, Bergem, and Sandsmark 2018).

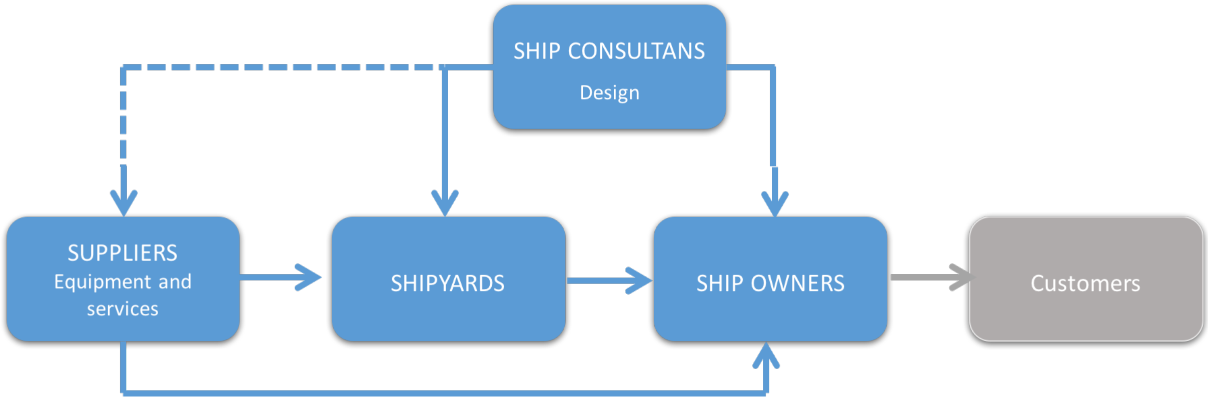


Figure 6- Members in the maritime cluster (Rødal, Bergem, and Sandsmark 2018)

The maritime industry consists in general of ship owners, ship consultants, shipyards and ship equipment suppliers. The maritime cluster in Møre and Romsdal has its largest geographical center at Sunnmøre, where the majority of ship owner companies, the biggest shipyards and equipment suppliers is located (Oterhals, Hervik, and Bergem 2014). In 2018 there was 215 companies involved in the maritime cluster. Out of the 215 companies, 170 where equipment supplies companies (ÅlesundKunnskapspark 2018).

The supplier industry delivers a broad specter of equipment and components related to ship building, assembly of equipment, supplies of spare parts and technical services. Among the largest actors in the supplier category are Rolls-Royce Marine. In 2016, 47 percent of the supplier's income came from local ship owners, which shows the importance of the maritime cluster (Rødal, Bergem, and Sandsmark 2018).

3.1.2 Logistics Management

The term logistics management is the management of coordinating material flow and information flow across the supply chain to meet end-customer needs. Logistics is an important prerequisite for the management of supply chain (Harrison 2011).

Within logistics, there are different types of transportation logistics; maritime logistics, airfreight logistics and land logistics. Tseng, Yue, and Taylor (2005) describe the three types of logistics. Maritime logistics can provide a cheap and high carrying capacity conveyance for the customers. However, maritime logistics has its disadvantages that it needs longer transport time and that weather affects the schedule. Customers of maritime often care more about the service quality rather than the delivery price. In order to satisfy the customers, it could be necessary to have real-time information, accurate time windows and goods tracking systems. The airfreight logistics is necessary for many industries and services in order to finalize the supply chain and its functions. The advantages with airfreight logistics is that the services are delivered with speed, at a low risk of damage, security, flexibility, high frequency and approachability. The disadvantage is, however, the high delivery fee. The land logistics is essential due to link the logistics activities. Road freight transport is a type of land logistics where the advantages is cheaper investment funds, high accessibility and availability. The disadvantages are lower speed and lower safety. By using land transportation, this could be affected by problems such as traffic jams, contamination and traffic accidents. Another type of land logistics is railway transport, which has its advantages such as high carrying capacity, not affected by weather conditions and lower energy consumptions. The disadvantages could be high costs related to facility and complicated and expensive maintenance.

According to Tseng, Yue and Taylor (2005), transportation costs is seen as the most important economy activity, where around one third to two third of a company's logistics expenses are used on transportation. Chopra (2018) stated that, if the number of facilities increases, the transportation cost will decrease. On the other hand, the transportation cost will increase if the number of facilities increases to a point where the advantage of economic of scale is lost. The importance of the network design is to ensure customer satisfaction while reducing total logistics costs. The number of facilities should minimize the total logistics costs. However, a company could increase the number of facilities in order to improve the response time to its customers (Chopra 2018). If a company decreases the number of facilities, the preferred sites should be those with highest demand such that the transportation costs are minimized. From the preferred sites, the other locations will then be served from them (Krugman 1990).

3.2 Inventory Management

Inventory management can be defined as the process of replenishing stock inventory with the right quantity, of the right item, in the right location, at the right time. By managing the inventory investment, it could maximize the profits while at the same time maintaining customer service goals (Schreibfeder 2008). Inventory management is important due to know how much inventory that is needed in order to handle any fluctuations in forecasting, customer demand and supplier deliveries. Further, inventory management is crucial due to fulfil conflicting objectives. These objectives are maximizing customer service, maximizing efficiency of purchasing and production, minimizing inventory management, and maximizing profit (Viale 1996).

Bloomberg, LeMay, and Hanna (2002) introduce the importance of having inventory. Inventory is important due to achieve economies of scale, balance demand and supply, production specialization and protection against uncertainties.

Economies of scale

By having inventory, a company can achieve economies of scale in manufacturing, purchasing, and transportation. A company can achieve this through purchasing large amounts, so that they get discounts on the product. Then a company can transport higher volumes and achieve economies of scale through better equipment utilization. If more material is stored, manufacturing can have longer production runs. This result in reduced fixed cost per unit.

Balancing supply and demand

Some companies have to adjust for fluctuations in demand in order to have available inventory. One solution to be able to deal with fluctuations in demand is by manufacturing to stock. This involves producing in low-demand periods to be able to meet customer requirements in high-demand periods. By doing this, the production can keep the level throughout the year. This helps to keep low costs and gives a stable workforce.

Specialization

By having production specialization, each plant can gain economies of scale through long production runs. A specialized manufacturer will produce a product and place it in storage in anticipation for a demand or it can be delivered straight to the customer. These kind of manufacturers does not need to produce a high variety of products.

Protection from uncertainties

Uncertainties in demand could be crucial. If there is an unpredicted demand, and raw materials or other different products are not in stock, the production lines will have to be stopped in anticipation for material replenishment (Bloomberg, LeMay, and Hanna 2002).

3.2.1 Cost Factors in Inventory Management

Christopher (2016) describe the true costs of storing inventory, which can be cost of capital, storage and handling, obsolescence, damage and deterioration, shrinkage, insurance and management costs. The largest cost element is typically cost of capital, where the shareholders expect a high return from the equity investment.

Further, Silver, Pyke, and Peterson (1998) mention important cost factors for inventory management. The first cost factor is the unit value, and depending on the value of the unit, this will have an effect on the total purchasing cost or the total production costs per year. The unit value will also effect the second cost factor, which is the cost of carrying an item in inventory. This factor includes the opportunity cost of the money invested, which is the most dominant factor where the rate of interest is high. Attractive investment opportunity where it could be high earnings on the return of investments cannot be taken advantage of if the investment is tied up in the inventory. Other cost related to the second factor are expenses related to operating a warehouse, handling and counting costs, the costs of special storage requirements, deterioration of stock, in addition to damage, theft and obsolescence. The third cost factor is the ordering cost, which is associated with replenishment. This includes all costs related to ordering an item. This involves order forms, receiving orders, follow up unexpected situations and handling vendor invoices etc.

The fourth cost factor is the cost of avoiding stock-outs and the costs that occur when stock-outs happens. Silver, Pyke, and Peterson (1998) pointed out two extreme cases as a result of stock-out.

1. The first case is *backordering.* The customers will have to wait to get their orders, which can influence the companies service level.
2. The last one is *lost sales.* Every demand that comes in when there is a stock-out is lost. The cost of lost sale is the lost profit from the sale and the firm loses not only a sale but also future sales and goodwill (Bloomberg, LeMay, and Hanna 2002).

Bloomberg, LeMay, and Hanna (2002) state that a customer has a diversity of choices if their supplier are facing stock-outs. The customer can simply wait, substitute, buy from another supplier as a one-time thing or find another supplier to start buying from as a permanent solution. A customer's choice will be affected by the frequency of the supplier's stock-out and the competition in the market. The customer will probably wait or backorder if stock-outs are infrequent. This will depend if the product is standardized or customized. A customer will often be willing to or forced to wait for a customized product. If the product is standardized they will, in most cases, use another supplier. However, even with customized products where there are repeated stock-outs, can cause the customer to substitute or seek another supplier.

Further, Silver, Pyke, and Peterson (1998) present several ways to manage a inventory and avoiding stock-outs, such as cycle inventories and safety stock. Cycle inventories is an attempt to order or produce in batches rather than one unit at a time. How much inventory that is on hand is called cycle stock, and is the part of the inventory, which can be replaced cyclically. By ordering and producing in batches, this results in economies of scale, quantity discounts in purchase price or freight cost. The number of cycle stock on hand depends on how frequently the orders are placed. The safety stock, which also is inventory on hand, can be defined as the average level of stock in the inventory before a new batch of replenishment is arriving. A safety stock is functioning as a buffer against unpredictable changes in demand or supply in the short run. The cost of carrying these kind of items is called the Safety Stock Cost.

Another important factor is the replenishment lead-time, which is defined as the time that elapses from placing an order, until it is physically in storage ready to satisfy customer demands. Stock-outs occur when demand in lead-time is greater than the reordering point, which means that a company sell more than they have in stock before the new order is arrived. Stock-outs can also occur when inventory on hand is low. By increasing reorder point, the safety stock will also increase, which can reduce the chance of stock-outs occurring. It is important to decide how low the inventory should be allowed to be depleted before the order arrives, which basically decides when an order should be placed. An order should be placed early enough such that stock-outs does not occur often.

The inventory costs will not be further mentioned in this case, since the investigation is limited to warehouse location for Rolls-Royce. However, the inventory costs are important to mention because of the cost elements that follow inventory. A company tries to balance order costs against cyclic inventory costs, in addition to balance costs for safety stock against the costs for stock-out in case of uncertain demand. The inventory costs are assumed the same regardless of location at Sunnmøre.

3.2.2 Delivery Performance

A companies' delivery performance is often used as a measure of a company's service level (Milgate 2001, Stewart 1995). There are several definitions of service level. Silver, Pyke, and Peterson (1998) have pointed out the two most common measures of service level:

P1: Cycle service level: Probability of having no stock-out per replenishment cycle.
This is called the cycle service level where P_1 is the fraction of order cycles where there is no occurrence of stock-out. It is the probability of not having a stock-out in an order cycle.

P2: Fill rate: Fraction of demand to be satisfied routinely from shelf.
Indicate the fraction of the total demand that the company has been able to meet without stock-out.

Stewart (1995) stated that delivery performance is a leading factor to increase a supply chains performance based on that it can be controlled by the supply chain management. Increasing the delivery performance would lead to a higher level of customer satisfaction, which again would increase a company's competiveness (Gunasekaran, Patel, and McGaughey 2004).

A company's service level is an indication on how good their performance is on being able to meet the customers demand. It is often measured as a percentage of demand met on time or within a certain amount of time from the time the customer place its order. To have a service level on 100 percent indicates that all customers will receive its order in time and there is no stock out or disservice. However, having a policy on providing a service level on 100 percent is typically not profitable nor possible. Since the safety stock can be seen in correlation with the service level, where providing a service level on 100 percent will lead the safety stock cost to increase forcefully. It is not possible to achieve a service level on 100 percent in cases of uncertain demand, where it always will be a possibility for stock-outs. The companies therefore decide a service level often close to a 100 percent, where there is an appropriate number of stock-outs and the possibility to avoid stock-outs decreases. However, this is costly due to having a large safety stock (Tersine 1994).

3.3 Warehouse Management

According to Hompel and Schmidt (2006) warehouse management is defined as the art of operating a warehouse and distribution system, and how to operate it efficiently. Customers want high speed and quality in addition to minimized costs. If the logistic performance is outstanding, it could open up new markets. Within the goods flow, both warehouses and material handling systems are important due to the connection between producer and consumer.

Bloomberg, LeMay, and Hanna (2002) also mention warehouse management, where the facility structure is connected to the management of warehouses and distribution centers. While warehouses store goods until customers require them, distribution centers focus on product throughout and not long time storage. Distribution centers usually serve a larger area than warehouses. Warehouse management influence customer service, stock-out rates, and both sales and marketing to a company. Warehousing is a source of integrated logistic cost reduction and productivity improvement.

Warehousing is important due to the linkage between the production facility and the consumer, or between the production facility and the suppliers. In addition, warehousing help integrate inbound materials and distributing them to the production facility at the right time. On the other hand, the consumers can buy on demand without a nearby production plant with outbound warehouses. The cost of warehousing is expensive, and often exceed all of the logistics costs except transportation. This cost is about 10 percent or more of the total integrated logistics costs, which applies for most of companies (Bloomberg, LeMay, and Hanna 2002).

3.3.1 Warehouse Location

Richards (2017) mention that locating a warehouse is one of the most important strategic decisions a company will make. It is also important due to locate the warehouse in the most cost-effective geographic location. Crucial criteria when deciding where to locate the warehouse is the need for locating near a highway network, and proximity to ports and airports such as in the case of Rolls-Royce. Further, Richards (2017) present essential factors when deciding a warehouse location. These are mentioned below.

- Cost of land, rent and rates
- Access to transport networks
- Proximity to multimodal hubs
- Availability of affordable, skilled labour
- Transport links for staff
- Availability of funding, grants, etc.
- Availability of existing buildings
- Availability and cost of utilities including telecoms
- Availability of finance and resources
- Goods traffic flows
- Proximity to ports and airports
- Location of suppliers and manufacturing points
- The potential neighbors

Prologis (2016) mention the three most essential location factors where proximity to economic network, transportation cost and real estate cost. The report also mentions other important factors such as availability of qualified staff, improving global trade volumes and infrastructure improvements.

3.3.2 Spare Part Management

Spare parts are necessary to maintain equipment, and it is a common inventory stock item. The spare part products take a large share of product life cycle cost. If the availability of spare parts is low, it could result in financial loss. Hence, spare part management is important due to achieve the desired equipment availability at a minimum cost (Hu et al. 2018).

Further, Boylan and Syntetos (2010) mention spare parts management as common in many industries. In addition, forecasting spare parts is an essential operational issue. Spare parts demand is difficult to forecast. To have an effective inventory management of spare parts is important for many companies. The management of the spare parts is important due to availability and inventory holding. The spare parts are characterized by a variable demand pattern, where the demand can be zero in some periods, while higher in other periods. This can cause uncertainties, where the company does not know when the demand is low and when it is high.

Planning the logistics of spare parts is different from the other materials. As the demand for spare parts can be very sporadic and difficult to forecast, in addition to possible high prices of the individual spare part, the effect of stock-outs may be financially remarkable. The service requirements are therefore higher (Huiskonen 2001).

3.4 Centralization and Decentralization Systems

As of today, most companies have restructured their distribution system towards a centralized system. According to Kohn and Huge-Brodin (2008) centralization involves a distribution system where the goods are shipped from the production center and central warehouse, via a centralized warehouse/distribution center, before reaching the end-customer. This differs from a decentralized distribution system where the flow of goods is shipped from the production center, to a regional warehouse and then to a local warehouse close to the customers, before it is sold (Abrahamsson 1993).

A negative consequence with a centralized warehouse/distribution center is that the products are shipped over larger distances, since the products have to go through the central hub rather than being delivered directly to the customer (Kohn and Huge-Brodin 2008). McKinnon (2003) stated that with centralization of warehouse/distribution center, the average distance from the warehouse to the customers will increase. This means that the total of tonne –kilometres, which is the transport intensity of goods distributed, will be higher within a centralized distribution system. This is often more damaging from an environmental perspective (Kohn and Huge-Brodin 2008).

Duan and Warren Liao (2013) stated that the difference between decentralized and centralized supply chains can also be seen in the decision making process. If there is decentralization, the decisions are made by each member with no consideration to the other parts. In a supply chain that is decentralized, all the participants take decisions based on local information independently. With centralization, decisions are made centrally by considering all of the members. The decisions are made to minimize the overall supply chain inventory cost. A centralized supply chain is recognized as more cost-effective than a decentralized supply chain. However, a centralized supply chain must have a higher degree of integration (Duan and Warren Liao 2013).

Kohn and Huge-Brodin (2008) describe three key characteristics with a centralized distribution system. These are consolidation, change in mode of transport and decrease in emergency deliveries.

3.4.1 Consolidation

Consolidation of freight flows is situations where different shipments are grouped together into larger shipments. This grouping utilizes a transport vehicle's capacity and the cost of transport per weight unit will decrease. There is a risk with consolidation. The consolidation has to be weighed against the risk that customer service might be influenced in a negative manner. With delivery frequently, the goods are collected and grouped. By improving the fill-rates, this could lead to longer lead times (Gümüş and Bookbinder 2004).

Within centralized distribution systems, consolidation shipments are an essential aspect. In a centralized distribution system, all the goods are transported via the central distribution center. This is the reason why a centralized distribution system has a high flow of goods for replenishment purposes between the production center and the central warehouse. Comparing it to a decentralized distribution system, the regional warehouses receive shipments from the production center (Kohn and Huge-Brodin 2008). As of today, there are no consolidation of the transport between the production centers at Sunnmøre. The distribution is done individually from each of the production centers.

3.4.2 Change in Mode of Transport

As mention, there are four different transport modes, which are road, rail, air, and maritime transport (Stock and Lambert 2001).The transport modes have different characteristics, and the company may choose one or more depending on the goal of the system and its context. The consolidation of flows is essential in centralization of distribution systems, where it is important to have a cost efficient transport mode. In order to accomplish a cost effective transport mode, a change in the mode of transport may occur (Kohn and Huge-Brodin 2008).

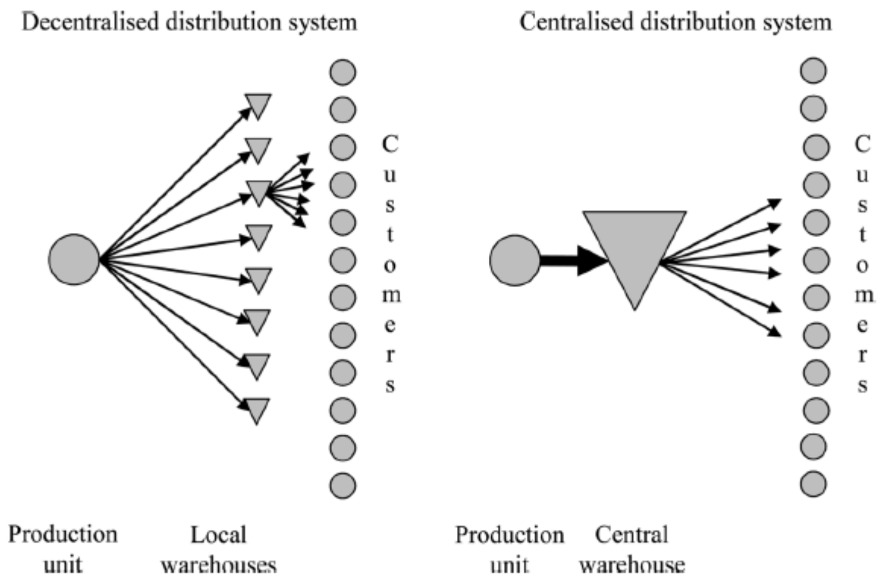


Figure 7-Decentralized versus centralized distribution system(Kohn and Huge-Brodin 2008)

There are many factors to consider when choosing the best mode of transport. This decision depends on customer service objectives, existing network of facilities and access to infrastructure (Riopel, Langevin, and Campbell 2005). When deciding mode of transportation, volume and distance are two factors that needs to be considered. These two factors are the reason why the transportation costs can vary within the cost-of-service pricing approach. Other characteristics shown in Table 1 become secondary when comparing volume and distance. In some cases, a transport mode is not an option. Then only two or three of the modes are given as an alternative, which can be compared with each other (Stock and Lambert 2001).

Financial Characteristics	**Road**	**Air**
Cost Level	Moderate	High
Balanced fixed/variable costs	High level of variable costs; low level of fixed costs	High variable costs, low fixed costs
Market coverage	Point to point	Terminal to terminal
Predominant traffic/goods	All types	High value; low-mod density; small shipments
Length of haul	Short to long	Medium to long
Service characteristics		
Speed (time in transit)	Moderate	Fast (major advantage)
Availability	High (distinct advantage)	Moderate
Delivery accuracy (on time delivery)	High	High
Loss and damage	Low	Low
Flexibility (adjustment to shipper's need)	High	Low-moderate

Table 1-Characteristics and limitations for different transport modes(Stock and Lambert 2001)

3.4.3 Decrease in Emergency Deliveries

Kohn and Huge-Brodin (2008) found in their research that deliveries is appearing more frequently in decentralized distribution systems and one should expect the emergency deliveries to decrease in a centralized system. This was based on Abrahamsson (1993) argument that a decentralized distribution system would have difficulties to stock a whole range of product, since the inventory usually are stocked at a local warehouse that only serve a particular market of customers. A centralized warehouse is able to hold a greater range of products than the separate local warehouse. Further, Yu (2008) state that there are higher variety of products when there are fewer warehouses. In order to utilize the larger product variety, the warehouses have to become larger. This cause longer travel time in picking orders and afterwards impacts order response time. In a decentralized distribution system, where the product is not in the inventory at the local warehouse, the material typically has to be shipped as an emergency delivery from the supplier producing the item to be able to complete the order. These emergency deliveries are also often provided by using transport that is more environmentally damaging than the preferable within the distribution system (Abrahamsson 1993).

3.5 Facility Location Problem

Facility location problem include determining the best location for one or several facilities or equipment due to serve a set of demand points. Which location is the best depends on the nature of the problem that are studied (Laporte, Saldanha-da-Gama, and Nickel 2015). The facility location problem is a well study concept and can be defined as two given sets; A number of customers and a number of possible locations facilities to supply customer demands (Owen and Daskin 1998). Owen and Daskin (1998) have provided a strategic review of the facility location problem. They point out that before constructing and building a facility, a large amount of challenging strategic location planning is necessary. The decision makers have to choose location sites that will continue to be profitable in the future, even when influenced by uncertainty like population shift and market trends. This review gives an overviews over studies related to facility location problems in regard to deterministic or stochastic aspects (Owen and Daskin 1998). A facility location problem is deterministic when all the parameters are known. A stochastic problem is, on the other hand, when some parameters are uncertain (Dantrakul, Likasiri, and Pongvuthithum 2014).

To have a successful supply chain, the manufactures need to have the capability to connect the parties in the supply chain smoothly. Distribution centers are often used to improve the material flow by working as a connection between the manufacturers and their customers. A well designed distribution center can give competitive advantages in form of increased productivity and profits (Yang et al. 2007).

The distribution center location problem, also called the facility location problem, involves where to locate the distribution center based on a set of potential locations. It includes how the transportation has to be set up in order to minimize the total transportation cost from the manufacturer to their customers via the distribution center (Yang et al. 2007).

3.5.1 Facility Location Models

Dantrakul, Likasiri, and Pongvuthithum (2014) have in their study classified deterministic location problems into four categories; Facility location problems, p-median problems, p-center problems and covering problems.

The objective of facility location problem is to minimize the total setup cost and the total cost of transportations between facilities and customers by finding where to locate a facility (Dantrakul, Likasiri, and Pongvuthithum 2014). The second location problem is the p-median problem, which is often the most applied location model. The p-median model minimizes the demand-weighted average distance between a demand node and the facility to which it is assigned. The p-median problem finds the location of p facilities on a network, such that the total cost is minimized (Segura, Carmona-Benitez, and Lozano 2017). As the objective function in the p-median problem minimizes the total travel time for all customers, each customer is served by the nearest facility. The demand is generated at a set of demand points, which is given as a weight (Drezner and Drezner 2007).

While p-median problem seeks to minimize the total cost of transportation, the p-center problem seeks to minimize the maximum distance between the clients and the assigned facility. The p-center is a minimax solution that involve a set of p points that minimizes the maximum distance between a demand point and the closest point to that set. However, using p-center may not be the right decision criterion for placing a facility. This depends on the actual problem, where in some cases it is important to minimize the maximum distance rather than minimizing the total distance. If the p-center is not the right criterion, it could lead to discrimination of clients for the ones which is poorest served (Daskin and Maass 2015).

Another facility location model is the covering problem, which is important due to finding the number of facilities to serve all the clients. The client should be served by at least one facility within a certain distance. The clients receive services by a facility dependent on the distance between the client and the facility in most of the covering problems (Farahani et al. 2012).

In this thesis, it would be relevant to use the p-median problem. Since the different production centers have different demand, a weighted p-median model would be considered. This model could give an indication of where a potential warehouse could be located. The p-median problem would be based on transportation cost including, distance, cost per kilometer and ferry fares, demand and establishment costs. Because the different production centers have different needs, it is natural to solve a weighted p-median problem. Because of the establishment of one warehouse, p = 1.

3.5.2 The P-median Problem

According to Segura, Carmona-Benitez, and Lozano (2017) the p-median basically consist of locating p facilities in a given space, which satisfy n demand points in such a way that the total sum of distances between demand point and its nearest facility is minimized. The p-median problem can be non-capacitated or capacitated. If the p-median problem is non-capacitated, each facility can satisfy an unlimited number of demand points. If the p-median problem is capacitated, each facility has a fixed capacity, which could mean the maximum number of demand points it can satisfy.

Kariv and Hakimi (1979) stated that the p-median problem is NP-hard on a general graph. This means that the p-median problem cannot be solved in polynomial time. When the circumstances becomes too difficult, one may use heuristic techniques in order to find a sub-optimal solution (Segura, Carmona-Benitez, and Lozano 2017). However, there are many ways to solve the p-median problem, both effective algorithms and approaches. A possible solution to the p-median problem could be to locate only on the existing nodes. However, moving the facility to one of the nodes could result in reassignment of demands to and from the facility. This could result in reducing the objective function. On the other hand, reassignment will improve the objective function. Furthermore, the marginal improvement in the demand weighted total (or average) cost or distance would decrease as facilities are added (Daskin and Maass 2015).

4.0 Methodology

This chapter include the methodology used for our thesis where we describe our research design, how we collected our data in addition to judging the quality of the research. The research methodology is used in order to answer the research questions.

4.1 Definition of Methodology

The methodology is a way to go forward to collect empirical data, or collect data about reality. It is also a tool to give a description of reality. However, it is disagreements about what reality is and what the truth is. The research questions will be affected of how the researcher sees reality, and thus what kind of method is considered best. The collection of the empirical data should satisfy two requirements. Firstly, the empirical data should be valid and relevant. Secondly, the data should be reliable and trustworthy. With validity and relevance, the empirical data should give answers to the research questions. With reliability and credibility, the research has to be trusted (Jacobsen 2015). This chapter will describe the methodological approach for this research. In order to solve the research problem we have chosen both a qualitative and a quantitative approach in this case study. The following subchapters will describe the research design, methods of data collection and quality criteria of the research.

4.2 Research Design

The definition of research design is that it links the data to be collected to the first questions of the study. The research design is the logical sequence, which links the empirical data to the research questions, in addition to the conclusions (Yin 2018). This is a case study where the method is empirical, which involves study of a case within real-life, contemporary context or setting. The boundaries between a phenomenon and a context may not be obviously (Yin 2018). Further, Gillham (2000) state that there has to be an investigation in a case study to be able to answer the research questions. Case study is used to find a range of different kinds of evidence. The evidence has to be collected in order to get a fruitful answer to the research questions. A key characteristic with case study research is the need for multiple sources of evidence. No sources of evidence is most likely to be sufficient on its own (Gillham 2000). Five components are essential of a research design in case study research. These are a case study's questions, its propositions, its case, the logic linking the data to the propositions, and the criteria for interpreting the findings. This type of research involves "how" and "why" questions (Yin 2018).

Jacobsen (2015) define two forms of research approaches, inductive and deductive approach. In the inductive approach, the researchers goes from empiricism to theory. The development of theory does not need to be a goal. When using an inductive approach, an exploratory research design is used in order to acquire new knowledge on subjects and areas where there exists little research from before. In the deductive approach, the researchers go from theory to empiricism. The data collection is essential in this case, whether to confirm or deny hypothesis and assumptions in areas where there exists much research from before. The relevant research approach in this case would be to have a deductive approach, where we are investigating in areas where there exists much theoretical research from before. In addition, we have a descriptive design where the purpose is to describe the situation in a particular area. This can be the level of a single variable or the relationship between two or more variables, which we want to map (Gripsrud, Olsson, and Silkoset 2016).

In case study design, there are six sources of evidence. Yin (2018) mention documentation, archival records, interviews, direct observations, participant-observation, and physical artefacts as the sources of evidence. By using as much sources as possible, this could lead to a good case study. The sources included in this case study are documentation, archival records and interviews. We have considered documentary information such as emails, progress reports, internal records and investigated other studies relevant to the case we are studying. The documentary information we have collected comes from Rolls-Royce.

Through our contact person, we have received administrative documents, such as cargo report between the production centers and Helmond in the years 2012-2018, and distribution plans over manually created transfer orders. Further, we have received the delivery performance of service orders delivered on time from April 2012 to April 2018, and the sales turnover on service orders from 2016-2018. In addition, we have received the amount of service orders sent directly from the suppliers from 2016 to 2018. Lastly, customer based on the income amount of the production centers from 2014 to 2018. These documents have been used to gather and withdraw the information we wanted to investigate. The contact with Rolls-Royce has mainly been through telephone and emails. There have also been physical meetings as well.

We have also used archival records, which include "Public use files", in addition to maps and charts of the geographical characteristics of a place. Public files are used in order to calculate the transportation costs. Further, the interviews have been an important source of evidence. With documentation, archival records, and interviews, there are strengths and weaknesses. The strengths of documentation and archival records is the stability, non-intrusiveness, specificity, and broadness. The information can be reviewed repeatedly. On the other hand, the weaknesses of documentation and archival records are the difficulties of finding information, or the accessibility of possible withheld information. In addition, the archival records is both precise and usually quantitative. However, the accessibility to archival records may be complicated due to privacy reasons. The strengths of using interviews are the directly focus on the topic of the case study, in addition to insight into personal opinions and views on the topic. However, there are some weaknesses with interviewing. The interviewee may say what he/she thinks we want to hear, or the response to the questions could be poorly (Yin 2018).

Within single case design, there are two types; holistic where there is a single unit of analysis, and embedded where there are multiple units of analysis (Yin 2018). The question is whether our case is a holistic or embedded design. Since we receive information from several units within a restricted area, this is an embedded, single case design. In this case, the units are our contact person at Rolls-Royce, and the customers related to Rolls-Royce that we have interviewed.

4.3 Data Collection

This section explain how we collected the data. Yin (2018) mention four principles of data collection. The first principle is the recommendation of using multiple sources of evidence. In the previous section, these sources of evidence are mentioned. By using more than one sources of evidence, the quality of the research may increase. The second principle is about creating a case study database, where organizing and documentation of the data take place. The third principle is about maintaining a chain of evidence, where the reader can follow the derivation of any evidence from first research questions to the very best case study findings. The fourth principle is about carefully using the data from social media sources. It is important to take the cautions in considerations when finding information in the social media.

Further, the data collection is based on primary and secondary data. Both primary and secondary data is used to categorize the data. Bradley (2010) explain secondary and primary data. While primary data is data that describe information collected for a specific purpose, secondary data is normally old primary data, which is called second-hand data. Secondary data is data that already exists, and is usually less expensive than primary data. Usually, the secondary data has already been collected for another research problem, and may not be accurate or fit the current problem. On the other hand, the information could be outdated.

Telephone interviewing are essential primary data that has been useful in this thesis to map the current situation at Rolls-Royce. We have not conducted personal interviews due to save time for the customers. The advantages of using telephone interviewing are quick results and that it is usually more cost-effective. This approach is useful when the interviewee is not easily accessible by face-to-face (Bradley 2010). However, using telephone interviews decreases the establishment of trust and openness. The interviewer could easily lose control over the situation (Jacobsen 2015). We experienced no loss of control during the telephone interviews, and we felt that the interviewees where open when answering the questions. If we had used personal interviewing, the advantages had been the control and the opportunity for long-term interview. However, the disadvantages had been the costs of such labour-intensive technique and that the process could be slowly (Bradley 2010).

The interview guide was sent to the interviewee before the telephone interview started. This gave the interviewees an opportunity to be reflected around the questions. Before beginning with the interviews, we asked the interviewee if we could record the telephone call. This was in order to be able to present the statements of the interviewees in a legitimate way.

Furthermore, we received secondary data from our contact person at Rolls-Royce. These data are mentioned under the six sources of evidence. In order to solve the research problem regarding the possible warehouse location, these data have been helpful during the process. However, there was data that we could not access. We could not access the data regarding transportation costs. In order to find information about the transportation costs, we have assumed the transportation cost and used DHL's service guide where price levels based on weight in kilogram is calculated. This was done in collaboration with Rolls-Royce.

4.3.1 Qualitative Methods

The methodology to qualitative research are characterized as inductive, emerging and outlined by the experience to the researcher in collecting and analyzing the data. Qualitative research focus on assumptions and the usage of interpretive and theoretical framework, which is used to inform the study of the research problems that indicate the importance of individuals or groups attributing a social or human problem. When using qualitative research, the researchers benefit an emerging qualitative approach to inquiry. The collection of the data is usual in a natural setting for both the people and places during the study (Creswell 2013).

In this thesis, a qualitative research is essential due to a problem or issue that needs to be explored. A qualitative approach is used to develop theories when partial or inadequate theories exist for certain populations. However, the existing theories will not normally capture the complexity of the problem we are examining (Creswell 2013). Furthermore, Jacobsen (2015) describe qualitative study as intensive where the data is collected as words. Methods for collecting qualitative data are through interviews, focus group interviews, observations and documentation, where interviews is the most common method in this case.

We search for problems or issues with the current situation through documentary information, archival records, and interviews. This is related to finding a potential warehouse location. However, by only using a qualitative approach, we would have received data that may not provide the correct or accurate answer. By using a quantitative approach as well, this can help us to find the possible location of a warehouse. The qualitative method does not provide complete answers such as the quantitative method. However, this depends if the input data that is collected is correct and complete.

4.3.1.1 Interviews

The purpose of the interviews was to get an overview of the current situation. Interviews are essential in the sources of case study evidence and is helpful to explain how and why questions (Yin 2018). In qualitative interviewing, there are two major types of interviewing, unstructured and semi-structured. In unstructured interviews, the interviewer usually use a checklist, and the interviewee normally answer freely. In semi-structured interviews, the interviewer has the questions listed in advance on relevant topics. This list is referred as the interview guide (Bryman 2011). Further, Gillham (2000) mention that semi-structured interviews is an essential form of interviewing in case study research. In this form of interviewing, the questions could be open and closed. An interview is useful only if it is confident to use for the actual research purposes. It is important to be aware of the key issues in the research investigation.

In this study, the interview form has been semi-structured. This type of interviewing is flexible, and allow asking questions that are not included in the interview guide. When performing interviews with the customers, we asked several followed-up questions that were not included in the guide. This gave us a better understanding of how certain activities occurred.

4.3.1.2 Choice of Informants

The choice of informants was selected in collaboration with our contact person at Rolls-Royce. The informants are key customers by Rolls-Royce. These customers are ship-owners, which have been customers before the establishment of the GDC-model. However, there was customers that declined to be interviewed, and therefore we had to take considerations regarding the fact that not all customers had the possibility to be interviewed. The reason of why some customers declined was due to their limited time schedule.

The completed telephone interviews are confidential, and identity of the customer will therefore not be mentioned. The interviewees will therefore be called customer 1, customer 2, and customer 3. There has been completed three telephone interviews with different customers from different companies.

4.3.1.3 Interview Guides

The questions to ask in the interview guide was based on the research questions. When finishing the interview guide, it was sent to the supervisor and the contact person at Rolls-Royce, such that they could give feedback and approve. It was necessary to conduct an interview guide based on the aim for this research. This was in order to operationalize theoretical concepts into empirical data. The interview guide is given in Appendix A. The research questions were divided into different topics, which we believe cover the questions around the research problem. The subjects were general information about the company we interviewed, about the GDC-model in Helmond, potential customer relationships before the establishment of the GDC-model, and delivery performance. We used the same interview guide on all customers.

4.3.2 Quantitative methods

A quantitative approach is also relevant for this case study. Quantitative research can be defined as a measurement of quantity or amount (Kothari 2004). The logic behind quantitative data is that the researcher wants to standardize the information. The quantitative study usually collect primary data through questionnaire with closed answer options. However, the quantitative study can also use secondary data in the form of available statistics. When using this kind of data, the problems will be identical to those discussed in collecting secondary data for qualitative surveys (Jacobsen 2015).

The purpose of using this method is to investigate the placement of a potential warehouse at Sunnmøre. There will be a simple optimization model with calculations, which could give an indication of the location. However, there are many aspects to consider. Usually, the mathematical model would not include all considerable options. To be able to find a warehouse location, there will be conducted a facility location analysis where we use a p-median model in order to find a potential location. In this analysis, we are aiming for expansion of one of the already established warehouses at the production centers in Ulsteinvik, Brattvåg and Longva or building a warehouse in either Hjørungavåg or Ålesund. Hjørungavåg are a branch office of Brattvåg, where they have a non-operative warehouse. Ålesund have only an office and no production. The establishment costs are therefore assumed higher for both Hjørungavåg and Ålesund than for the other production centers, where they have operative warehouses. For the three production centers, the establishment costs are assumed the same. In order to find a possible solution, we have used a simple optimization model in Microsoft Excel. The goal of using facility location analysis is to find the best place to locate the warehouse on the given criteria. The model finds the solution with assumed lowest cost for transportation between the production centers and the warehouse.

4.4 Quality of the Research

In this part, we will elaborate about what we have done to increase the quality of the research. Both validity and reliability are usually used to establish the quality of the empirical research (Yin 2018). Further, Grønmo (2004) describe validity and reliability. The validity of the data material is important for the issues to be investigated. The validity is high if the exploring and the data collection give results that is relevant to the research issues. It is higher the better the actual data corresponds with the intentions of the researcher. Reliability refers to the trustworthiness of the data material. The reliability is high if exploring and the data collection give trustworthy data. High reliability is a prerequisite for high validity. However, there is no guarantee that with high reliability, the validity is also high.

Yin (2018) mention tests for judging the quality of the research design. These are construct validity, external validity and reliability, which will be further explained below.

With construct validity, it is essential to identify the right operational measurements for the concept being studied. Case study tactics when doing test of construct validity are using multiple sources of evidence and having key informants who review the draft of the case study. However, this test is challenging in case study research. In our case, it is essential to study the changes that have occurred after the centralization.

With external validity, it is important to demonstrate whether or how the findings in a case study can be generalized. How the questions are formed can influence the preference of seeking generalizations, and in the strategy of striving for external validity. A case study tactic when increasing external validity is using theory in a single-case study. Using "how" and "why" questions may be helpful during to increase external validity.

With reliability, it is essential that the data collection procedures can be repeated with the same results. This applies for the operations of the study. Reliability aim to reduce the biases and errors in a study. However, if a researcher investigates the same issue later on, the researcher should get the same results and come up with the same conclusion.

The question is what we have done to increase the validity and reliability of the research. To increase the validity of the research, key informants of Rolls-Royce have either confirmed or denied key information. In addition, we have used multiple sources of evidence, such as documentation, archival records and interviews. Some of the findings made in the data reports are in the context of what the customers have stated. Further, the interview guide was sent to the spare division at Rolls-Royce in Ulsteinvik, which approved the questions. To increase the reliability of the study, the data collection has been carried out thoroughly and systematically.

A weakness of the facility location analysis and the calculation of the annual transportation is that the demand is based on the cargo reports, where we have no indication of how many items that is within one cargo. However, the analyses will still provide a good indication of where to locate the warehouse.

5.0 Results

In this chapter, the results are presented. The empirical data that is collected is from interviews with important customers in addition to internal data documents received from Rolls-Royce. First, we describe the current situation after the centralization. Secondly, we present the results from the facility location analysis.

5.1 The Current Situation

In this subchapter, we will describe the current situation involving how the situation at Rolls-Royce has developed since the establishment of the GDC-model. This could give an indication if the centralization has been valuable related to providing higher customer satisfaction, and if the production centers have achieved a higher level of distribution efficiency.

5.1.1 The GDC-model

The GDC-model represent the establishment of the centralized global distribution center in Helmond. The information collected was to get an overview of customer opinions regarding the centralized network. This involves advantages and disadvantages related to the GDC-model, and how Rolls-Royce delivery performance has been affected. The data collection from the interviews is presented through a mix of arguments and statements from the informants.

Advantages

Customer 1 mention that the GDC-model works well for them considering their vessels are operating in the areas around North of Europe. After Rolls-Royce established a global distribution center in Helmond, the distance to the vessels operating in the area has decreased. The customer highlights the benefit with shipments that goes directly from Helmond to Aberdeen where several vessels are located. The delivery time to the vessels operating in both Northern Europe and farther South has also been reduced. Customer 1 is also using Kuehne +

Nagel in Rotterdam or in Bergen to consolidate larger shipments to vessels operating outside North of Europe. Further, customer 2 where not able to state any advantages with the current GDC-model. While customer 2 mention none advantages, customer 3 mention the advantage of the vessels that operates closely to Helmond. This customer has vessels operating in Brazil, Singapore, Australia etc. For these vessels, it is positive that the distribution center is located in Helmond.

Disadvantages

Customer 1 mention that the disadvantages applies for the vessels operating in Norway. The delivery time is now longer for these ships. In addition, the location of the GDC applies additional costs on the import. This is not the first choice as this customer would rather wanted the shipments within Norway, such that the additional costs had been avoided. Considering the higher costs, customer 1 would rather prefer to have the warehouse located in Norway. The customer also experience that operations have become more complicated. When the warehouse was operated from the production centers, they could order the spare part and receive it the same day. The procedures were more simple and flexible before the GDC-model. Today, the operations are more standardized, and the customer mention that it is more cumbersome than before.

Customer 2 mention disadvantages such as customs charges and longer delivery times, which has occurred with the GDC-model. This customer is negative to this model, which cause additional costs for vessels operating in Norwegian waters. This is because the goods must be declared to Norway. When ordering a product from, for example, Ulsteinvik, one does not expect custom clearance on the product if it is delivered within Norway. The customer also states that the employees in Helmond treat urgent deliveries poorly. Spare part delivered from Ulsteinvik is supplied quickly to the vessels. When the warehouse was located at Sunnmøre, it was shorter delivery times and lower costs.

Customer 3 state that there are more disadvantages than advantages with the model. The customer further state that the majority of their vessels is operating in Norway, which makes it more difficult when the GDC are located in Helmond. The freight costs are now higher. It would have been better if the warehouse was located in Norway. This company have their docking in Norway and have most of their ships here. In case of urgent deliveries and the needed spare part is in Helmond, the waiting time is now longer than before. Customer 3 also highlights the strong incorporate maritime cluster, where they have several cooperation with both suppliers and shipyards in the region. They state that this is a strong argument for moving the warehouse closer to the cluster.

5.1.2 Description of the Transportation Routes

The transportation routes between the production centers and GDC illustrates how the cargo flow has been since the establishment of GDC. A cargo is containing several boxes, which again contains several items. These items represent the service orders out to the customers, and the forecasting orders that are going to the shelfs in the warehouse. By looking at the cargo flow, this can give an overview over the distribution efficiency of the transportation routes. It can be assumed that since the production center in Ulsteinvik distributes items that are of larger size and weight than the other two production centers, it could have had an impact on the total amount of tonnage transported. It will therefore be more sufficient to look at the amount of cargo transported, instead of amount of tonnes.

Cargo-flow between Ulsteinvik and Helmond

For the years 2012 to 2018, 4333 cargos with a tonnage of 1264.22 was transported between the production center in Ulsteinvik and the GDC. The cargo-flow was the largest of the transport routes based on both cargo and tonnage size. The largest cargo-flow was from Ulsteinvik to Helmond on 3500 cargos and represented approximately 81 percent of the total cargo transported. The cargo shipped from Helmond to Ulsteinvik represented 833 cargos of the total 4333 cargos. Further, 1519 cargos were forecasting orders with a tonnage on 484. 55 tonnes.

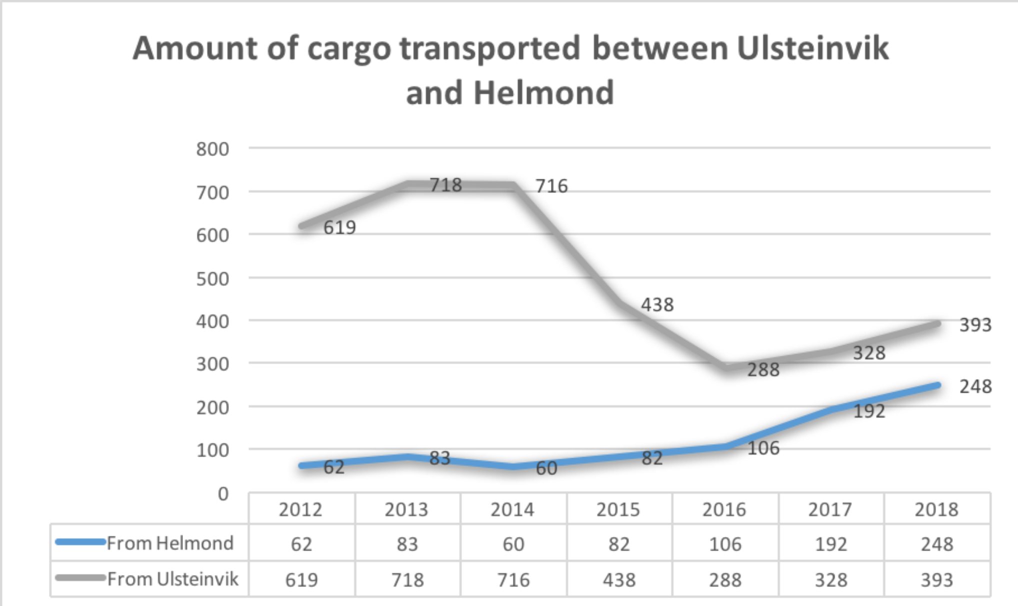


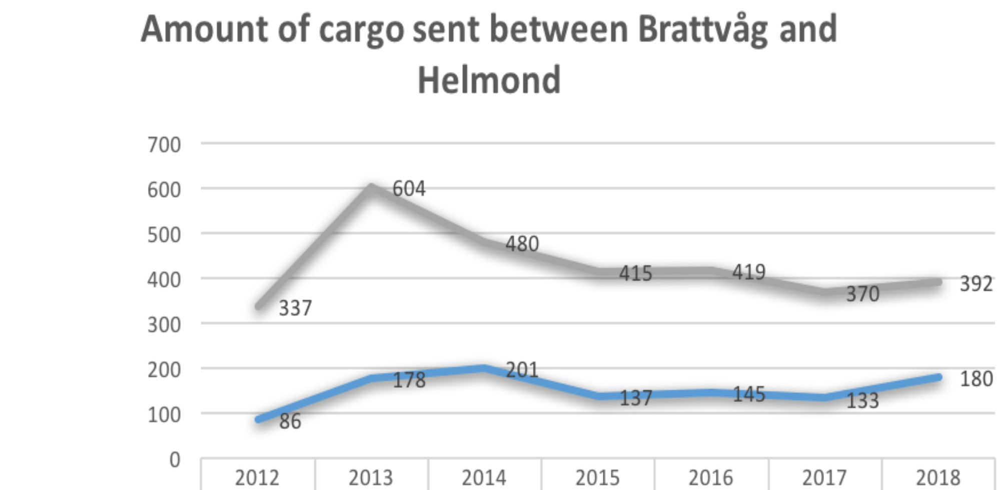
Figure 8-Cargo transported between Ulsteinvik and Helmond from 2012 to 2018

Based on the cargo flow between Ulsteinvik and Helmond one can, in Figure 8, observe a large decrease from 2014 to 2018. It is natural to assume that the reason behind the decrease in cargo transported is the oil crisis that hit in 2014 and gave ripple effects in the following years. Further, one can observe that the amount of cargo shipped to Ulsteinvik increased in the years 2016-2018, compared to a decrease in cargo transported from Ulsteinvik. The amount of cargo transported to Ulsteinvik could be assume to either cover a demand from a local customer or contain "common parts" that was needed at the production center.

Cargo-flow between Brattvåg and Helmond

The cargo transported between Brattvåg and Helmond consisted of a total of 4077 cargos with a tonnage of 632.88. Out of 4077 cargos, 3017 has been sent from Brattvåg to Helmond. This represent approximately 74 percent of the total amount of cargo transported. The cargo-flow from Helmond to Brattvåg has been of greater size than the transport route from Helmond-Ulsteinvik. The remaining 1060 cargos was transported from Helmond to Brattvåg. The forecasting orders had an amount of 970 cargos.

In Figure 9, one can observe that the cargo-flow between the two nodes has been more stable in amount of cargo distributed than the previous mention transport route between Ulsteinvik and Helmond. By looking closer at the amount of cargo distributed between the production center in Brattvåg and the GDC, one can observe a potential trend. From 2014-2018 the fluctuations in the amount of cargo sent for the two nodes has several similarities. These fluctuations could have a connection with the problematic that the employees at the production centers are facing with not having the right items at the right place. This problem is further explored in section 5.1.5.



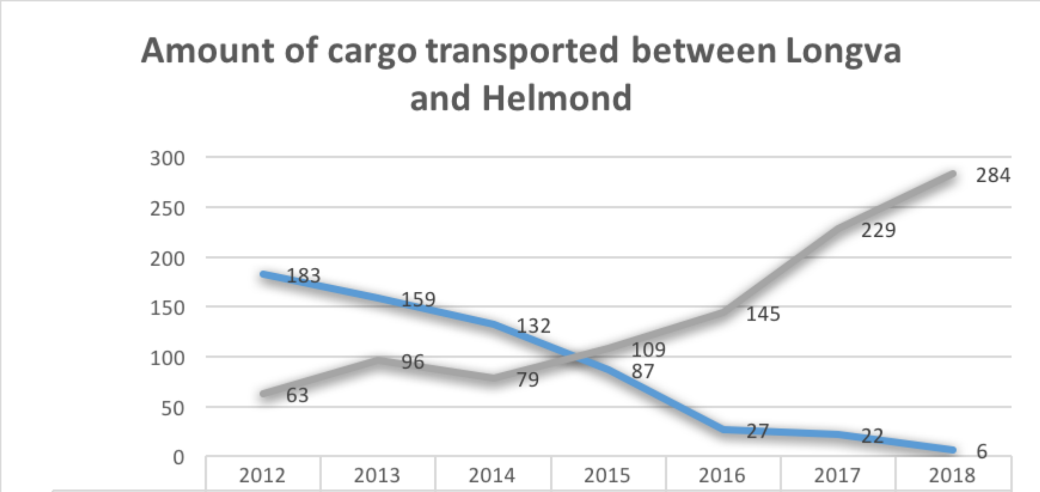
	2012	2013	2014	2015	2016	2017	2018
From Helmond	86	178	201	137	145	133	180
From Brattvåg	337	604	480	415	419	370	392

Figure 9-Cargo transported between Brattvåg and Helmond from 2012-2018

Cargo-flow between Longva and Helmond

The amount of cargo distributed between Longva and Helmond was the lowest of the overall transport routes. A total of 1621 cargo of 78.54 tonnes has been distributed in the period 2012-2018. Further, 616 cargo were distributed from the production center and 1005 cargo was transported from Helmond. There was 22 cargo registered as forecasting orders, which was sent from Helmond to Longva.

Figure 10 shows that the highest cargo-flow was in the early period after establishing the GDC until 2015. The cargo-flow then switched, and the highest amount of cargo was then shipped from Helmond to Longva in the years 2016-2018. This transportation route differs from the two other routes, where the highest amount of cargo has been transported from the GDC to the production center at Longva.



	2012	2013	2014	2015	2016	2017	2018
Longva	183	159	132	87	27	22	6
Helmond	63	96	79	109	145	229	284

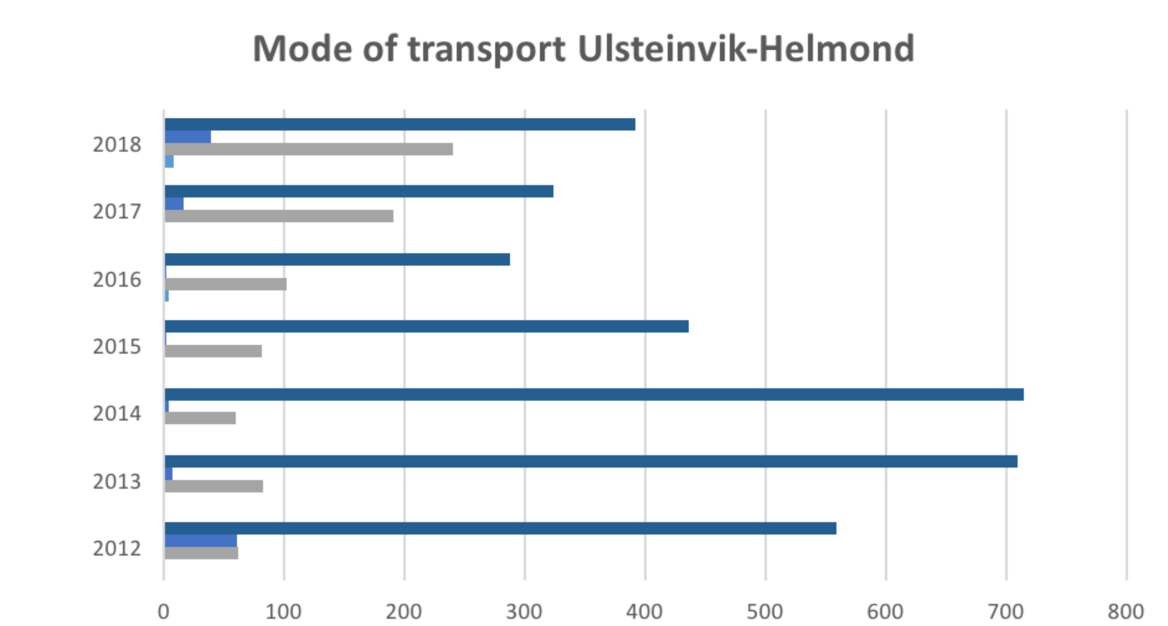
Figure 10-Cargo transported between Longva and Helmond from 2012-2018

5.1.3 Mode of Transport

After the establishment of the GDC in Helmond, the production centers at Sunnmøre have used airfreight and road freight as their mode of transport. The cargo is primarily transported by air to be able to deliver the service orders to the customers in time. If the amount to be transported is of greater size than 1000kg, the production centers have to use road freight as mode of transport. The amount of cargo distributed by the two different modes of transport can further be used to calculate an approximation of the transportation expenses after the establishment of the GDC. The results tied to the mode of transport, are made upon cargo-reports from 2012-2018.

Mode of transport between Ulsteinvik and Helmond

On the transport route between Ulsteinvik and Helmond, approximately 97 percent of the cargo has been transported by air. A total of 78 percent was shipped by air from the production center in Ulsteinvik to Helmond. The remaining 3 percent of the cargo was distributed by truck from Ulsteinvik. There is a trend where the amount of cargo has increased from Helmond to Ulsteinvik by airfreight. This is visualized in Figure 11.

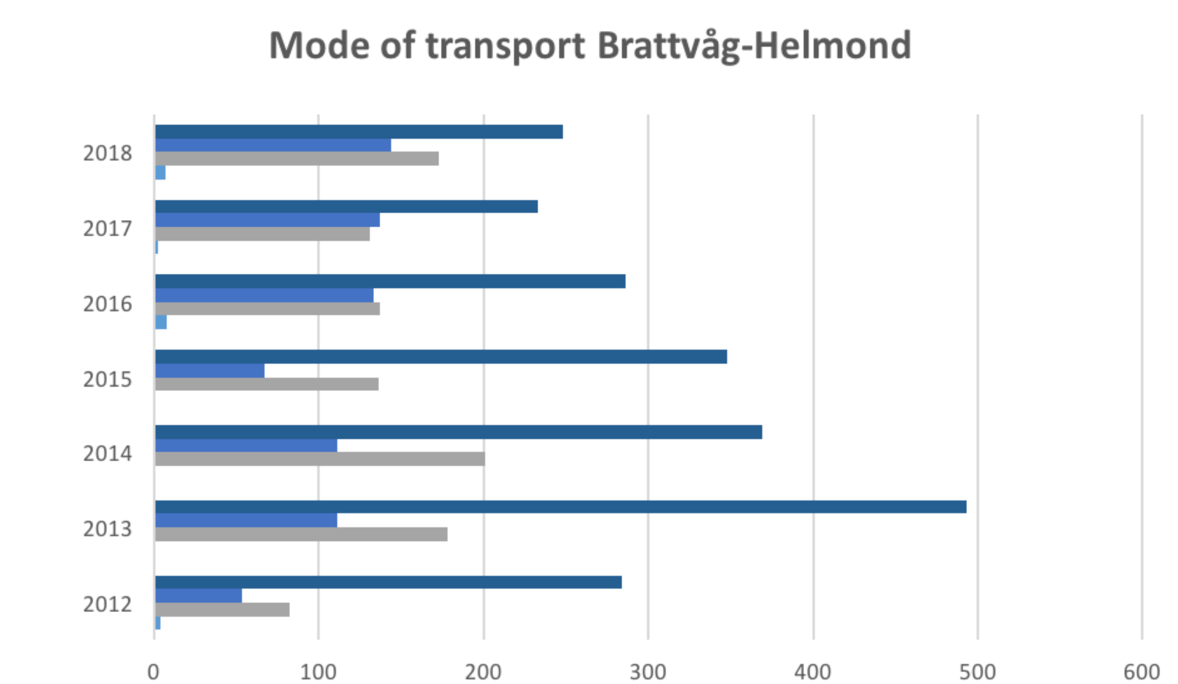


	2012	2013	2014	2015	2016	2017	2018
ULS air	559	710	715	436	288	324	392
ULS truck	61	7	4	2	2	17	39
HLM air	62	83	60	82	102	191	240
HLM truck	0	0	0	0	4	1	8

Figure 11-Mode of transport between Ulsteinvik and Helmond from 2012-2018

Mode of transport between Brattvåg and Helmond

Unlike the site in Ulsteinvik, the mode of transport and the amount of cargo shipped between Brattvåg and Helmond is more evenly distributed (see Figure 12). A total of 80 percent of the cargo distributed between the two nodes was performed by air. The cargo sent from the site in Brattvåg by airfreight represent 55 percent of the cargo transported and the remaining 25 percent was transported from Helmond. The amount of cargo shipped from Brattvåg by truck was 19 percent of the total cargo transported. The last 1 percent represent the amount of cargo distributed from Helmond by truck. The reason why truck as a mode of transport is of greater share could be explained by the weekly pick-up of the forecasting orders, which are transported by truck to Helmond.

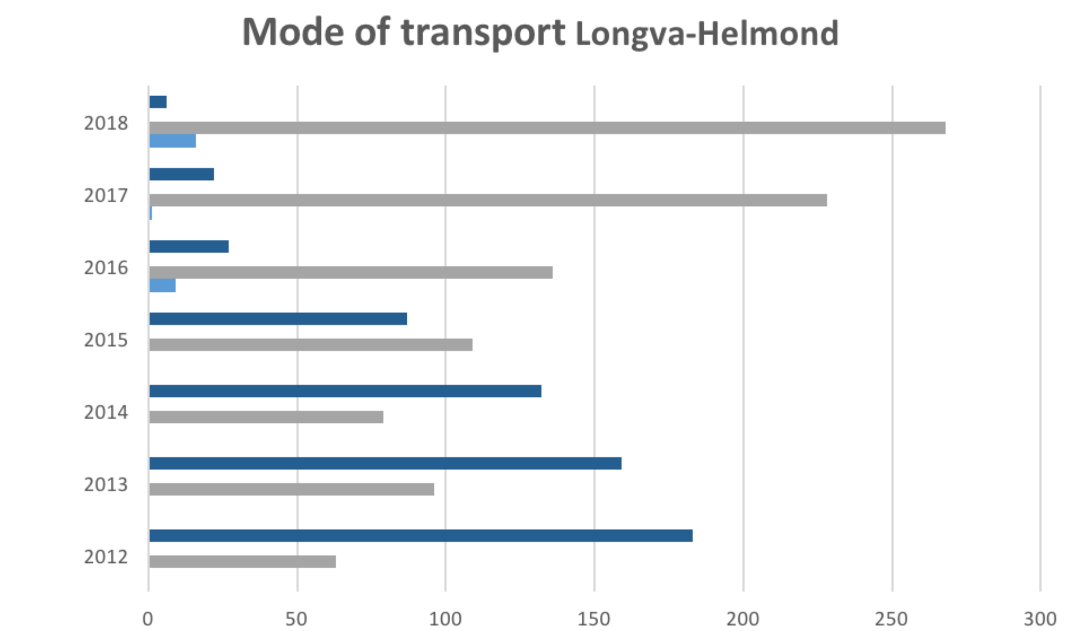


	2012	2013	2014	2015	2016	2017	2018
BVG air	284	493	369	348	286	233	248
BVG truck	53	111	111	67	133	137	144
HLM air	82	178	201	136	137	131	173
HLM truck	4	0	0	1	8	2	7

Figure 12-Mode of transport between Brattvåg and Helmond from 2012-2018

Mode of transport Longva-Helmond

The use of airfreight has nearly been the sole mode of transportation for the cargo-flow between Longva and Helmond, which was also the case for the production center in Ulsteinvik. This transport route has the largest share of airfreight of the involved transport routes. The airfreight from Longva represented 98 percent of the cargo, where the majority of 60 percent was shipped from Helmond and the remaining 38 percent from Longva. The use of airfreight as a mode of transport also show the shift in the cargo flow, as earlier mention in section 5.1.3. Truck as a mode of transport has, according to the cargo-report, been done 26 times throughout the period 2016-2018. All road transport was done from Helmond to Longva and constituted 2 percent of the cargo transported. Since the weight of the cargo is of smaller size, it can be assumed that it would not have been profitable to use truck as mode of transportation.



	2012	2013	2014	2015	2016	2017	2018
LGV air	183	159	132	87	27	22	6
LGV truck	0	0	0	0	0	0	0
HLM air	63	96	79	109	136	228	268
HLM truck	0	0	0	0	9	1	16

Figure 13-Mode of transport between Longva and Helmond from 2012-2018

5.1.4 Transportation Costs between the PCs and GDC

By centralizing their warehouse operations to Helmond, it is natural to assume that the transportation costs have increased. Rolls-Royce were not able to give us an overview over their transportation costs. However, the amount of tonnage transported between the production centers and the GDC can be used as an indication of the transportation costs. The cargo reports from 2012-2018 were used, where we have selected out the information related to the average amount of cargo per year, mode of transport and the average gross weight per cargo. The figures used are listed in Table 2.

Mode of transport	Total amount of cargo	Amount of cargo per year	Total weight in tones	Avg weight per cargo in tones	Cargo sent per day	Total tones sent per day
Truck ULS	142	20.29	113.1	0.796	0.08	0.065
Air ULS	4191	598.71	1150.81	0.275	2.39	0.658
Truck BVG	778	111.14	268.58	0.345	0.44	0.153
Air BVG	3299	471.28	364.3	0.110	1.89	0.208

Table 2-Figures used to calculate transportation costs

Since DHL are Rolls-Royce´s distributor, DHL´s standardized prices are used to calculate the approximately transport costs for the production centers in Ulsteinvik and Brattvåg (DHL Express 2019). DHL Express use air as their main mode of transport and for DHL Economy Selected, road is the main transportation mode. A simplified table over the used price levels are visualized in Table 3 and Table 4. This will only be an approximation, but can give the company an indication on how high the transport expenses have been after the establishment of the GDC.

DHL Express	
Weight in kg	**Prices in NOK**
70	6293
70,1-300,0	111.81

Table 3- DHL Express

DHL Economy Selected	
Weight in kg	**Prices in NOK**
100,0	4.252
For every 5kg-prices in NOK	
70,1-300,1	212.19
300,1-1000	211.68

Table 4- DHL Economy Selected

The transportation costs are only calculated for the production centers in Ulsteinvik and Brattvåg. The reason behind this is that Longva are using the GDC on a different level than the two other production centers. This results in low amounts of distributed cargo and tonnes between Longva and Helmond.

Transport expenses based on air as mode of transport

Based on the average weight in tonnes per cargo transported by air and the DHL´s Express price levels, Ulsteinvik have had a freight cost per trip on an average of 29 214 NOK. This, multiplied by the average amount of cargo transported per year, gives annual transportation cost on 17 490 744 NOK. Brattvåg, on the other hand, have had an average freight cost on 10 756.4 NOK per trip. The annual transportation cost for air freight will then be 5 073 517. 71 NOK.

Transport expenses based on road as mode of transport

The same method is used for road freight, where DHL Economy Selected price levels and the average amount of cargo in tonnes transported by road is used. Ulsteinvik have had an annual transportation cost on 687 127.424 NOK and Brattvåg an annual transportation cost on 1 627 620.85 NOK.

The annual transport expenses for the two production centers based on mode of transport is summarized in Table 5.

Annual transportation expenses	Ulsteinvik	Brattvåg
Air freight	17 490 743.90	5 073 517.71
Road freight	687 127.42	1 627 620.85
Grand total	18 177 871.324	6 701 138.560

Table 5- Total transport expenses

5.1.5 Items shipped back and forth between the PCs and the GDC

Figure 14 is based on the distribution reports for manual transfer orders, created by the employees at the sites to cover a demand at Sunnmøre. In contrast to the previous presented Figures, which was based on the flow of cargo, Figure 14 is based on items.

A high amount of items has been transported back and forth from the production centers at Sunnmøre to Helmond. This could be an indication of unnecessary movement of items between the production centers and GDC. A total of 5741 items has been sent back to the production centers in the years 2012-2018.

Figure 14 shows that Brattvåg have had the largest amount of items sent back and forth for the whole period 2012-2018. In 2015, they had the highest figures, that was abnormally high compared to the other years. Ulsteinvik have also had several items that has been only in Helmond for a short period. Longva, however, have had a low amount of items transported. This is in contrary to the amount of cargo flow between Longva and Helmond, which showed a high amount of cargo sent from Helmond to Longva from 2015-2018.

The production center at Longva differs from the two other production sites, and they have reduced the amount of items that are sent to the GDC. Longva provide service on electronical items that have to be configured at the workshop at Longva, before it can be sent out to the customers. The items that are stored in Helmond are items that can be shipped directly to the customers in the weekends and holidays. The items are stored in Helmond to be able to provide shorter lead-times for the customers in the area around Helmond. This could be the reason why Longva have low amount of items transported back and forth.

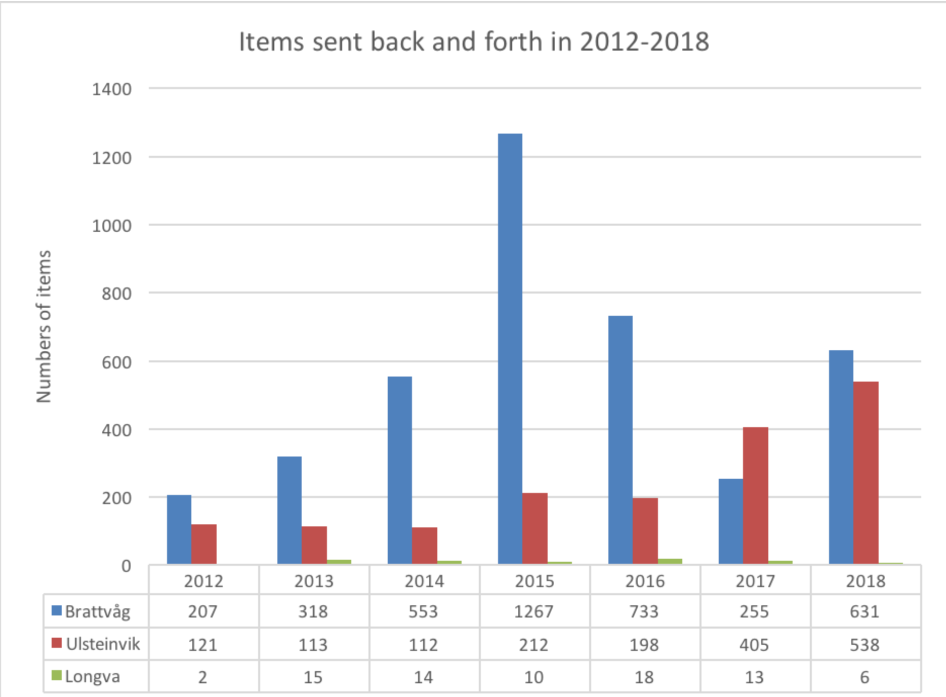


Figure 14-Items sent back and forth between the PCs and GDC

The report could also provide the number of days from the items was transported to Helmond before it had returned back to the given production center. This could strengthen the indication that there have been unnecessary shipments between the production centers and the GDC. Figure 15 visualize how many items, within a given number of days, that has been sent from the production center and then later returned. The result shows that several items have been sent back and forth within a short period of time of four months, where one month is 30 days. The majority of items have returned to the production center within 30 days.

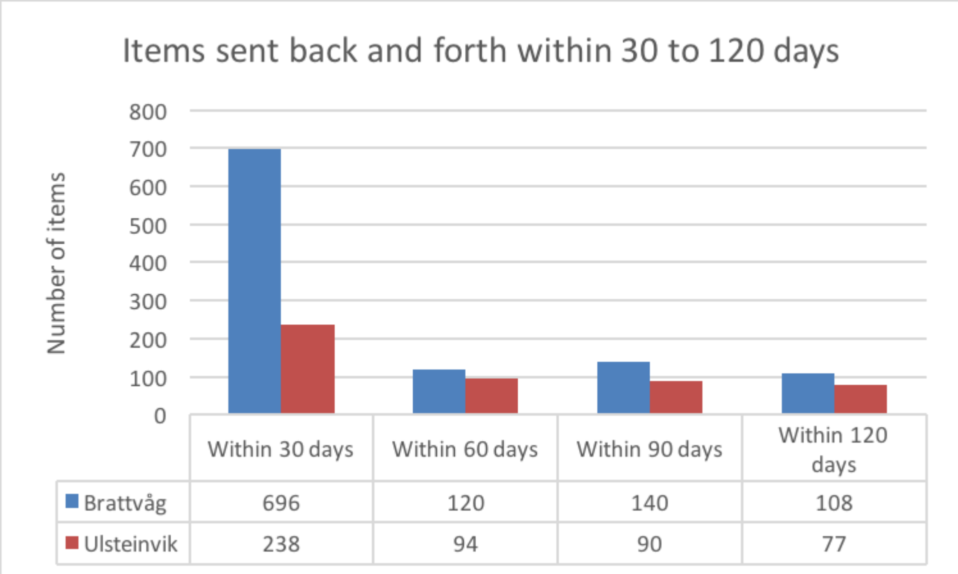


Figure 15-items sent back and forth within 30 to 120 days

5.1.6 Service order sold from the GDC and the production centers

This result is based on the sales turnover on service orders in the year 2016-2018. Rolls-Royces systems were changed in 2016, and therefore, the data related to the first years after the establishment of GDC were not accessible. The amount in the recent years will still be a sufficient indicator to see if there have been any increasing trends. The amount of service orders sold from either the GDC or the production center could be a good supplement to the result over the cargo flows from the different production centers and the GDC.

Sales turnover on service orders related to the production center in Ulsteinvik

Based on Figure 16, the sales turnover had been relatively stable in the recent three years. The highest turnover has been from Helmond, which correspond to the result from the amount of cargo flow distributed in the same years.

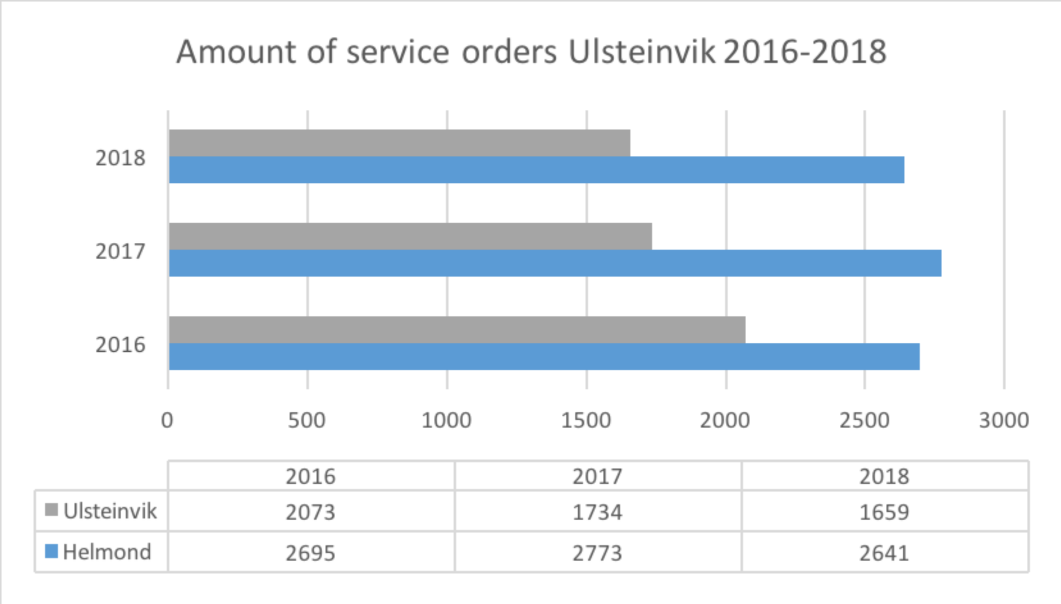


Figure 16-Sales turnover on service orders Ulsteinvik

Sales turnover on service orders related to the production center in Brattvåg

The sales turnover for the product center in Brattvåg have had a development where the turnover was highest in Helmond in 2016 and gone to be the lowest in 2018. This do not correspond with the cargo flow between the production center and the GDC in 2016-2018. The cargo flow showed that the highest amount of cargo was transported from the production center to the GDC. The reason why these two does not correspond could be explained by the high amount of items sent back and forth between Brattvåg and Helmond.

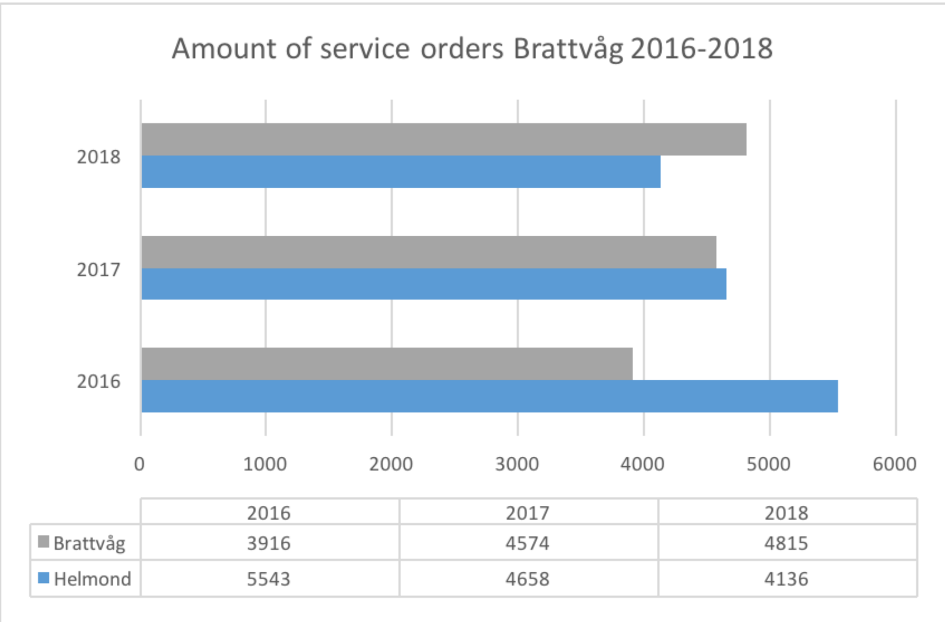
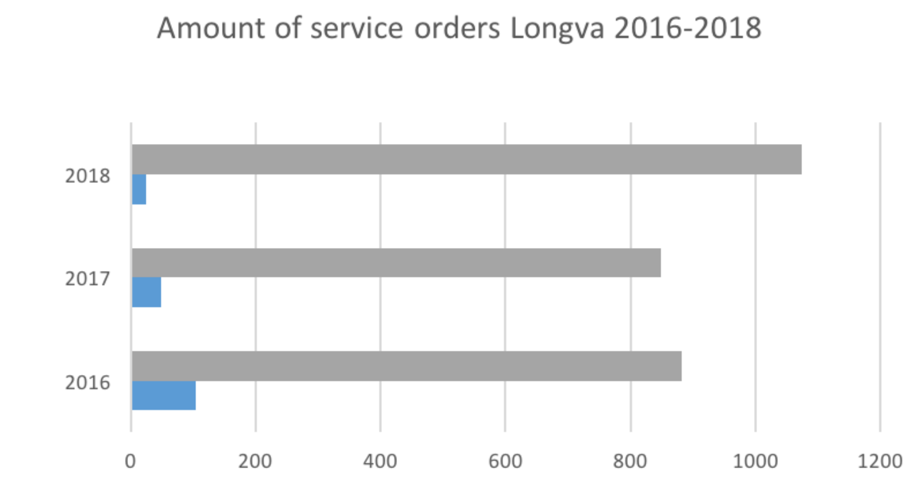


Figure 17-Sales turnover on service orders Brattvåg

Sales turnover on service orders related to the production center in Longva

The result showed that the sales turn over on service order has been the highest from the production centers in the recent years of 2016-2018. There has only been a small amount sold from the GDC in Helmond. This correspond to the result from the cargo flow where the distribution to the GDC almost stopped and the cargo was thereafter sent back to Longva.



	2016	2017	2018
Longva	882	849	1074
Helmond	105	49	25

Figure 18-Sales turnover on service orders Longva

5.1.7 Service orders sent directly from Rolls-Royce´s suppliers

The numbers of service orders sent directly from Rolls-Royces suppliers to Rolls-Royces customers will be used as the measurement of emergency deliveries. An emergency delivery indicates that Rolls-Royce have stock-outs, and that the demanded items have to be delivered directly from a supplier. Since the system to the company changed in 2016, we were not able not collect any data related to direct deliveries in the previous years. The result is therefore based on the year of 2016 to 2018.

The items involved are spare parts that need no further configurations at the production centers and can therefore be sent directly to the customers if the items are not in stock at the GDC or at the production centers. Rolls-Royce deliver primarily customized products. This explains why the amount of service order sent from supplier for the production center is low. The production center in Ulsteinvik have had the highest amount of items sent directly from their supplier to the customer. Brattvåg have only had one service order that needed to be delivered from the supplier. Overall, all the production centers have had a low amount of emergency deliveries.

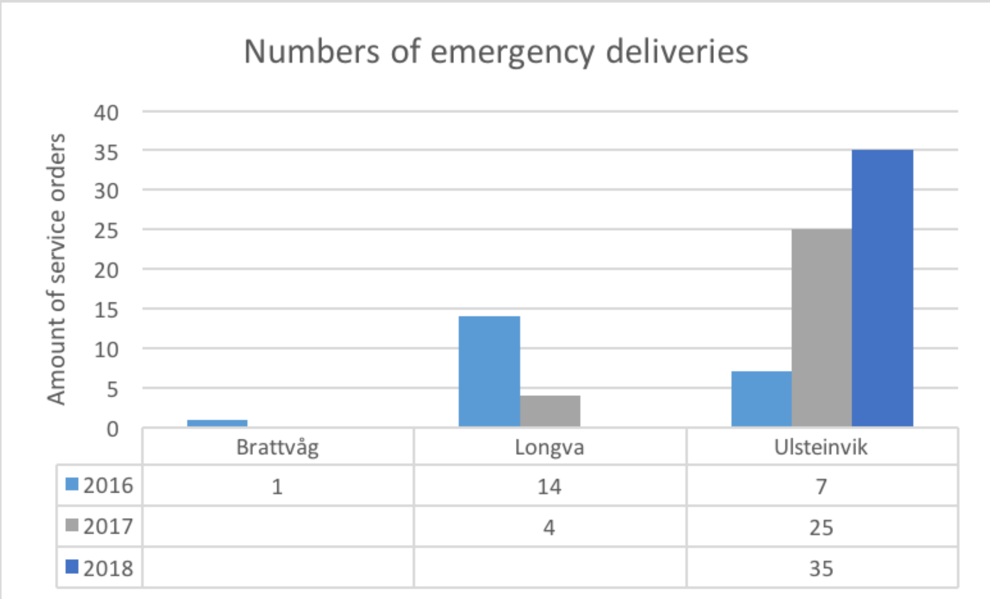


Figure 19-Number of emergency deliveries

5.1.8 Customer Markets

From the data reports in the year 2014-2018, we have collected information on where the largest customers are located based on invoice amount and divided by country and county. Based on the collected information we have created two heat maps to visualize where the three production centers have their largest customer markets based on invoice amount. The darkest areas in the heat maps represent the largest customer markets, whereas the brightest areas are representing the lowest customer markets. The numbers used can be found in Appendix B and D. In addition, the location of the largest customers in Møre and Romsdal can be found in Appendix E.

The heat map visualized in Figure 20, represents the largest customer market to Rolls-Royce Ulsteinvik, Brattvåg and Longva based on countries. The production centers have Norway, United States, United Kingdom, Singapore and Brazil as their largest customer markets. If we look at the production centers individually, these countries are commonly the largest customer markets (see Appendix C). The customer base in Norway accounted for as much as 22 percent, followed by United States with 13 percent.

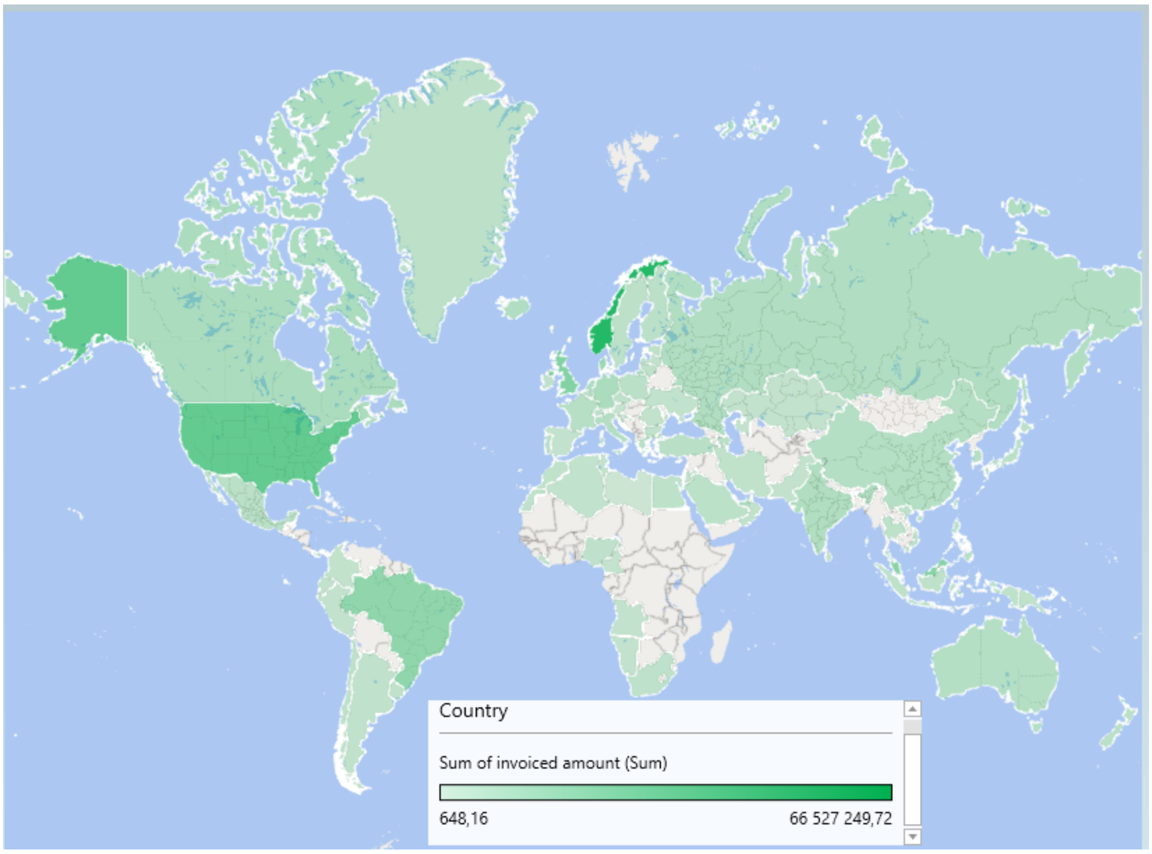


Figure 20- Rolls-Royce customer markets divided by countries

Figure 21 illustrates the production centers largest customer markets divided by county. In the county Møre and Romsdal accounted for 27 percent of the customer base, followed by Rogaland and Hordaland with respectively 23 and 20 percent. Because the largest proportion of customers is located in Møre and Romsdal, within the maritime cluster, it can be desirable to establish a spare part warehouse in this area.

Figure 21-Rolls-Royce customer markets divided by county

5.1.9 Customer Perceptive on Delivery Performance

In this part, Rolls-Royces delivery performance is investigated through interviewing different customers, and how their opinions are regarding delivery performance both before and after the establishment of the GDC-model. The overall delivery performance will then be based on customer opinions on delivery time and delivery performance related to delays where the reason was stock-outs.

Customer 1

According to customer 1, the delivery time was better before creation of the GDC-model, where Rolls-Royce were more flexible. This customer experience that Rolls-Royce have poorer delivery time than before. The customer states that Rolls-Royce often are experiencing stock-outs, where the delivery time then could be several weeks. When Rolls-Royce does not have the ability to deliver, the customer finds alternative suppliers if it is a standard product. The vessels could also borrow the spare part from another vessel within the company's fleet. This is not desirable where they rather prefer to buy spare part directly from Rolls-Royce than to borrow from another vessel.

Customer 2

Customer 2 stated that the delivery time has worsened with the current GDC-model. Rolls-Royces ability to deliver is sometimes very impressive, where employees at Rolls-Royce understand the pressure and thereafter find solutions. In other circumstances, the delivery time may seem long. The delivery time also appear to be longer now than before. In addition, this customer has the impression that Rolls-Royce does not stock everything. However, the customer is satisfied with Rolls-Royce's ability to respond quickly on unforeseen events.

Customer 3

According to customer 3, Rolls-Royce delivery performance is relatively good. This customer state that employees at Rolls-Royce are very understanding towards the customers under urgent deliveries. Rolls-Royce are good at following up orders that have long delivery time while at the same time, being good at pushing and understanding in urgent situations. Even though the employees at the production centers have understanding in urgent situations, it is not much they can do if the items are not in stock at the production centers. Further, the customer state that the delivery time is longer now than before.

The customer has experienced that Rolls-Royce have stock-outs. From their perspective, they fully-understand that Rolls-Royce are not able to have a full stock with finished products in the inventory at all time. For this customer, it is important to be prepared and order the products well in advance. This applies especially the large products. Further, the customer experience occasionally delays. However, there are more positive than negative experiences. If Rolls-Royce does not have the ability to deliver, the customer must wait. Rolls-Royce deliver unique products in which other companies cannot deliver.

Rating on delivery performance

The customers were asked to rate the overall delivery performance. The first question was based on the delivery performance with the current GDC-model, while the other question was related to the previous model. They were asked to rate the delivery performance of Rolls-Royce from

1 to 5, where 1 is lowest and 5 is highest. The customers all agreed that the overall delivery performance has weakened. As illustrated in Figure 22, the current GDC-model is farther away from the target than the previous model.

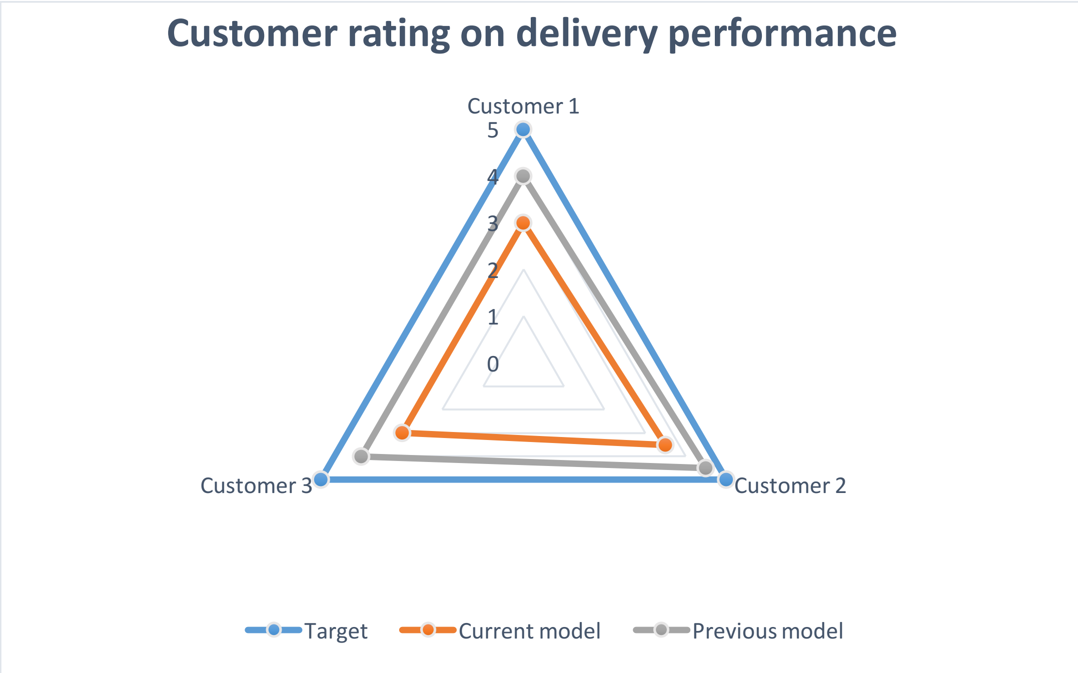


Figure 22-Customer rating on delivery performance

5.1.10 Delivery Performance based on service orders delivered on time

Rolls-Royce have provided an overview over their delivery performance in period 2012 to 2018. The delivery performance is measured on service orders delivered on time.

Ulsteinvik

The production center in Ulsteinvik have had a delivery performance on an average of 77 percent. The lowest delivery performance was on 50 percent in 2012 and the highest peak was in 2016 on 93 percent. From 2014, the performance started to increase, and from 2015 to the last period in 2018, the average was on 85 percent. Overall, the delivery performance has been unstable.

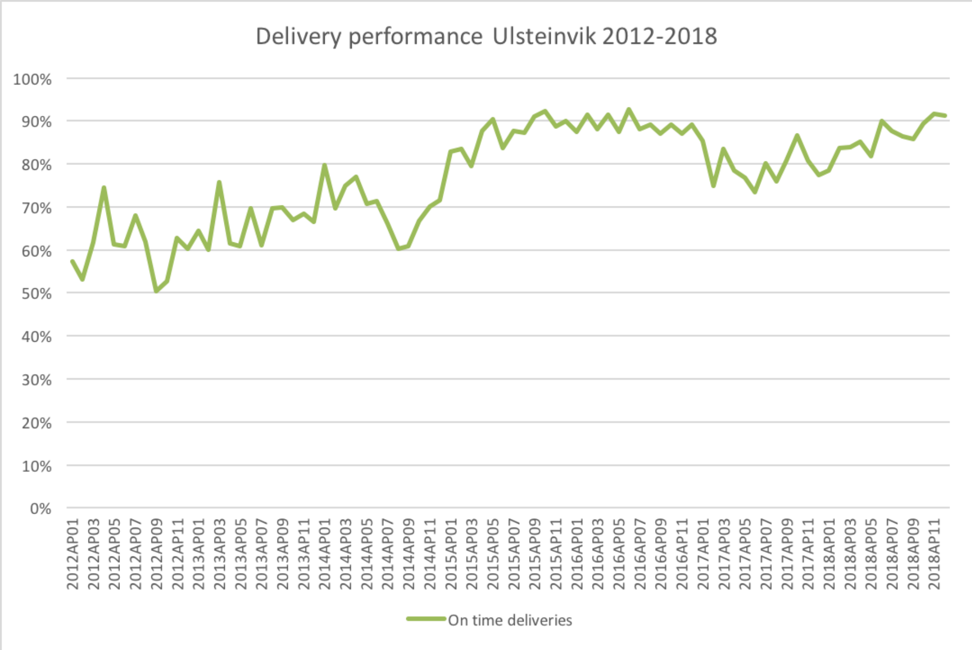


Figure 23-Delivery performance for Ulsteinvik from 2012-2018

Brattvåg

The average delivery performance for Brattvåg and Helmond has been on 77 percent in the given period. The production center had the lowest delivery performance in 2012 on 48 percent and the highest performance on 92 percent in 2015. The results show several similarities between the production centers in Ulsteinvik and Brattvåg. The production centers have had exactly the same delivery performance on average and they also had its lowest delivery performance in 2012. Since the GDC was established in the late 2011, the low delivery performance can be the effects of the implementation period of the GDC. The production centers also had a drop from 2016, but it occurred earlier for the production center in Brattvåg. Another similarity between the two production centers, is that there was an overall increase in performance from 2014-2018. Brattvåg had an average delivery performance on 84 percent in 2015-2018.

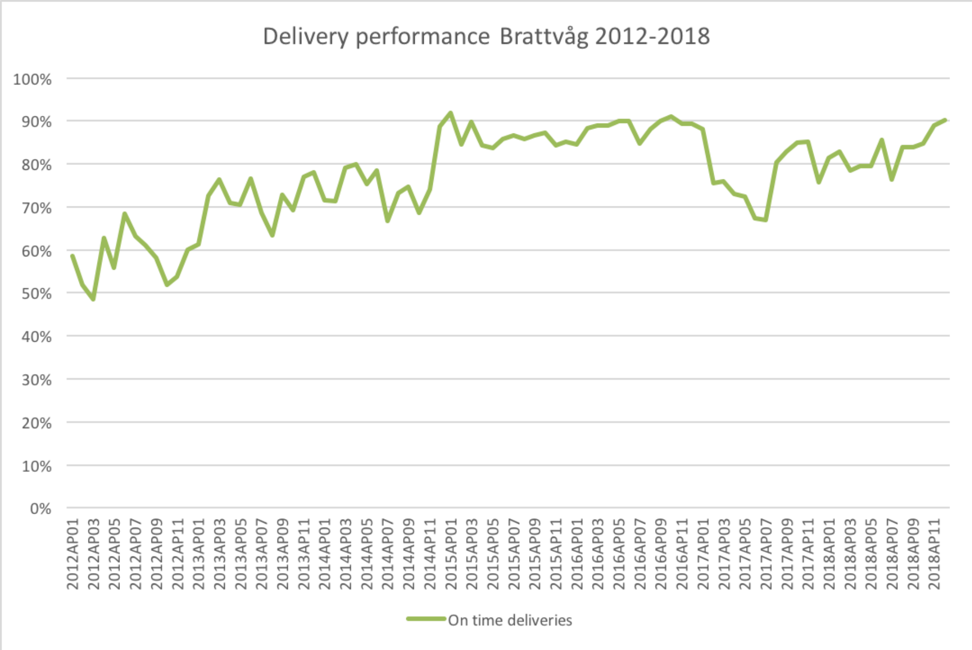


Figure 24-Delivery performance for Brattvåg from 2012-2018

Longva

The overall delivery performance for the production center in Longva has been on 76 percent, which is very similar to the two other production centers. The performance has, however, been more stable than the two other sites, Ulsteinvik and Brattvåg. Longva have also experienced a drop in the delivery performance, but not at the same level as for the two other production centers. The production center had its lowest delivery performance in 2013 on 43 percent and highest in 2015 on 96 percent. In contrast to the other production centers at Sunnmøre, Longva have had a minor declining performance from 2015 up to today. However, the performance is relatively stable on 83 percent on 2015-2018, which was almost the same as for the other production centers.

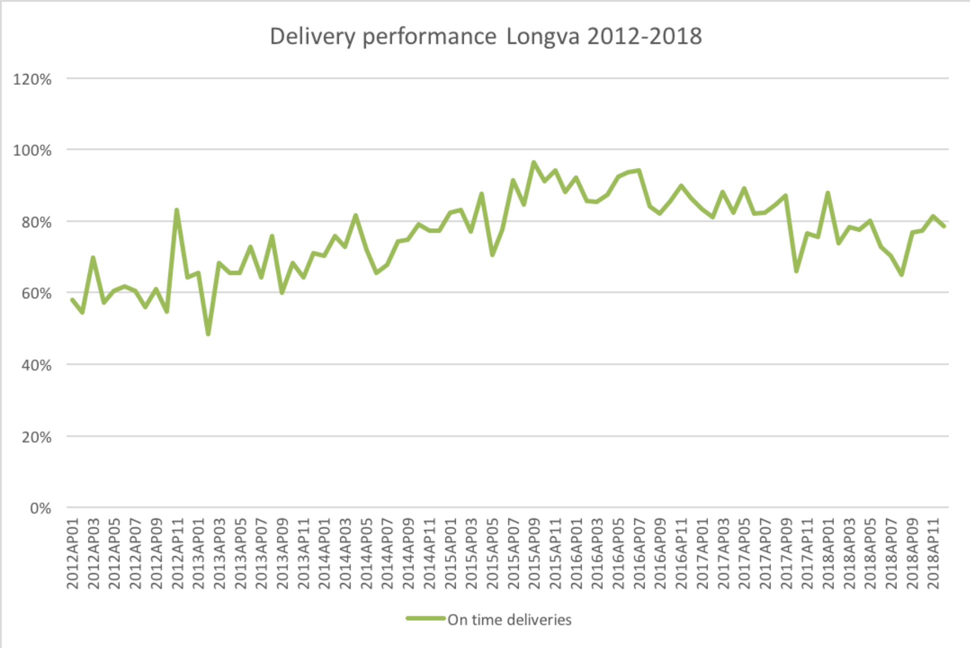


Figure 25-Delivery performance for Longva from 2012-2018

5.2 Facility Location Analysis

In this subchapter, the facility location analysis will be explained. This analyze assume that there will be establish exactly one warehouse at Sunnmøre. Because of the establishment of one warehouse, p = 1. As a basis, the p-median and the p-center model have been considered. In this case, the p-median model is weighted. The p-median model is more relevant than the p-center model because it takes the amount of transport into account. The p-center model cannot be weighted at the same way as for the p-median model. The p-center model finds the minimal maximum distance between a warehouse and other facilities. This will most likely conclude with an establishment of a warehouse in Ålesund since it is located in the center of the alternatives. It has to be built a warehouse in Ålesund and the non-operative warehouse in Hjørungavåg have to be reconstructed. There will be higher establishment costs for these alternatives than Ulsteinvik, Brattvåg and Longva. The costs of building a new warehouse is high and locating the warehouse in either Ulsteinvik, Brattvåg and Longva is probably better and less expensive for Rolls-Royce. A weighted p-median model could give an indication of where the warehouse could be placed.

First, the assumption regarding the analysis is presented. Further, the mathematical model, locations, demand, distance, and lastly, the results will be described. The reason of using this kind of analysis is to find the best solution based on the alternatives, which finds the location with the assumed lowest cost for transportation between production centers and the warehouse.

5.2.1 Assumptions

In this case, assumptions have been made in order to solve the mathematical model. The assumptions are made in consultation with Rolls-Royce, and are presented below.

- The distances gathered from google maps is the same as the actual distances. However, any delays or detours are not included.
- The establishment costs are assumed similar for Ulsteinvik, Brattvåg and Longva. The establishment costs for Hjørungavåg and Ålesund are assumed higher and have investment costs on respectively 2 000 000 NOK and 4 000 000 NOK.
- The demand is based on the cargo flow between the production centers and Helmond from 2012-2018, where the average of cargo flow per year is the demand.
- Assuming that Rolls-Royce needs large vans with a length of 6 to 7 meters.
- Assuming that the cars is returning to the production centers such that the actual transportation cost is twice as high.

5.2.2 P-median

The model for p-median is built in collaboration with our supervisor. The objective function (1) minimizes the demand-weighted total cost and minimizes the establishment cost for a facility. Constraints (2) describe that exactly p = 1 facilities to be located.

Parameters

n	Number of nodes	
N	Set of nodes	$N = \{1, 2, \ldots, n\}$
D_i	Demand at node i	$i \in N$
a_{ij}	Distance (cost) between node i and node j	$i \in N, j \in N$
F_i	Establishing cost for a facility in node i	$i \in N$

Variables

X_i	States whether a stock is established in node i or not	$i \in N, X_i \in \{0, 1\}$

$$min \sum_{i \in N} F_i X_i + \sum_{i \in N} \sum_{j \in N} a_{ij} D_i X_i \quad (1)$$

Such that

$$\sum_{i \in N} X_i = 1 \quad (2)$$

5.2.3 Locations

There are five locations considered in the model, Ulsteinvik, Brattvåg, Longva, Hjørungavåg and Ålesund. We have selected the alternatives in cooperation with Rolls-Royce. To find the distances between the nodes, we have used Google maps. These are illustrated in Table 6. As visualized in the table, the distance between the alternatives is relatively short.

Distance between nodes in km	Ulsteinvik	Hjørungavåg	Ålesund	Brattvåg	Longva
Ulsteinvik	0.0	14.9	46.4	72.3	99.6
Hjørungavåg	14.9	0.0	37.7	63.6	91.0
Ålesund	46.4	37.7	0.0	43.1	74.7
Brattvåg	72.3	63.6	43.1	0.0	27.2
Longva	99.6	91.0	74.1	27.2	0.0

Table 6- Distances between the different nodes

Further, the establishment costs play an important role in the final decision of locating the warehouse. For Ulsteinvik, Brattvåg and Longva, the establishment costs are assumed similar because they already have existing warehouses. The establishment costs are assumed higher for both Ålesund and Hjørungavåg because there has to be built a new warehouse in Ålesund and reconstruct the non-operative warehouse in Hjørungavåg. The establishment costs will be crucial when locating the warehouse. The establishment costs are assumed to be 4 000 000 NOK for Ålesund and 2 000 000 NOK for Hjørungavåg, which has depreciation costs of 100 000 NOK and 200 000 NOK per year for 20 years. Given that the establishment costs are higher in Ålesund and Hjørungavåg, these options will be excluded in the discussion chapter.

There are other factors than establishment costs to consider when locating a warehouse. Important factors such as transport network, availability to existing buildings, proximity to airports and location of suppliers are essential. These factors will be further discussed in chapter 6, where we discuss where the warehouse should be located.

5.2.4 Demand

The demand is based on average cargo flow between the production centers and Helmond from the years 2012-2018. Since Ålesund and Hjørungavåg does not have operative warehouses, they do not have an overview over the demand and therefore assumed to be zero. Therefore, we are considering establishment costs for these alternatives in the model.

Production center	Demand
Ulsteinvik	619
Brattvåg	582
Longva	232
Hjørungavåg	0
Ålesund	0

Table 7- Demand based on cargo flow for the different nodes

5.2.5 Distances Cost

Between the production centers there are either one or two ferries, which also has to be considered in the analysis. To calculate the ferry fares as well, we have used Norled's national regulation (Norled 2019). The ferry fares differ in price based on the length of the vehicle. Cost models for transportation developed by Norway`s Institute of Transport Economics are used to calculate the distance costs for the different site (Grønland 2018, 2011). The distance cost for a van is 3,14 NOK per km. It is assumed that the van is between 6,01- 7,0 meters.

- Between Ulsteinvik and Brattvåg there are one ferry (Hareid-Sulesund). The cost for a vehicle between 6,01-7,0 meters is 341 NOK.
- Between Ulsteinvik and Longva here are two ferries (Hareid-Sulesund and Haramsøya-Skjeltene). The cost for both the ferries are 645 NOK for a vehicle between 6,01-7,0 meters.
- Between Brattvåg and Longva there are one ferry (Haramsøya- Skjeltene). The cost for a vehicle between 6,01-7,0 meters is 304 NOK.

Distance cost between the alternatives	Ulsteinvik	Hjørungavåg	Ålesund	Brattvåg	Longva
Ulsteinvik	0.0	46.8	486.7	568.0	957.7
Hjørungavåg	46.8	0.0	459.4	540.7	930.7
Ålesund	486.7	459.4	0.0	135.3	538.6
Brattvåg	568.0	540.7	135.3	0.0	389.4
Longva	957.7	930.7	538.6	389.4	0.0

Table 8- Distance cost per km

5.2.6 Total Demand Weighted Distance

In order to find the location with the lowest weighted distance, we have solved the problem by using the p-median model. This is because the different alternatives have different demand. The input numbers in the model were based on the demand and distance cost, including ferry fares, for the different location alternatives.

Based on the p-median problem, which seek to minimize the total cost of transportation, we found that Brattvåg had the lowest total demand weighted distance of the production centers at Sunnmøre. This is illustrated in Table 9, which the values correspond to the objective function in the model when selecting the different locations.

Alternative	Weighted distance
Ulsteinvik	1 105 570.80
Hjørungavåg	3 119 163,80
Ålesund	5 009 949,40
Brattvåg	883 896.60
Longva	1 638 958.00

Table 9- Weighted distance for the different nodes

6.0 Discussion

In this chapter, the research questions will be discussed and answered respectively in the subchapters. In order to answer the research questions, we have reviewed the results from the case study findings. This would be discussed towards the literature conducted in chapter 2.

6.1 RQ 1: How does the centralization of the GDC provide advantages and disadvantages?

This research question describes how the centralization of the GDC has provided possible advantages and disadvantages. Firstly, the advantages and disadvantages based on the customer´s statements will be discussed. Secondly, the advantageous characteristics with centralization will be presented and if the production centers have been able to benefit from them.

6.1.1 Advantages with Centralization

Rolls-Royce have restructured their distribution system towards a centralized system. Centralization involves a distribution system where goods are shipped from the production center and central warehouse, via a centralized warehouse/distribution center before reaching the end-customer (Kohn and Huge-Brodin 2008). Instead of having several decentralized warehouses, a centralized distribution center could lead to cost reduction by having the spare parts in one location.

Customer 1 and customer 3 find it advantageous to have a centralized distribution center in Helmond. Both customers have vessels operating in the areas around Helmond. Customer 1 is using the same logistics provider that are managing the GDC in Helmond. This has allowed them to consolidate their shipments to the vessels operating farther south of Northern-Europe. The delivery time for the vessels operating outside Norwegian waters has been reduced.

6.1.2 Disadvantages with Centralization

A disadvantage with a centralized warehouse or distribution center is that the products has to be shipped over longer distances than with a decentralized warehouse or distribution center

(Kohn and Huge-Brodin 2008). The average distances from the warehouse to the customers will increase (McKinnon 2003).

The customers were able to list more disadvantages than advantages after the centralization of Rolls-Royce distribution system. This is not surprising since all of the customers are primarily operating in the North Sea. The most prominent disadvantages that the customer state is the inflexibility, long lead-times and high cost related to customs clearance that occur if the product are sent from the GDC in Helmond. When the production centers managed their own warehouse, the customers could receive the product the same day as ordered. After the centralization, Rolls-Royce are operating with SOT-days to be able to maintain their current delivery performance. The SOT-days will force the customers at Sunnmøre to wait three days, even if the spare part is in stock at the production centers at Sunnmøre.

The customers also state that in case of urgent deliveries, Rolls-Royce perform poorly. Since Rolls-Royce are manufacturing product that are customized, the customers do not want to purchase spare parts from other suppliers that are replicas of Rolls-Royce original parts. The long delivery time can therefore be assumed to cause the customers problems if they have to go off-hire for a long period.

6.1.3 Advantageous Characteristics with Centralization

We will use the three advantageous characteristics with centralization presented in Kohn and Huge-Brodin (2008) to review if these are achieved. The discussion will primarily be based on the results of the internal data reports and a minor part will be based on the interviewees statements. This will be a part of answering the research question on the advantages and disadvantages with the GDC-model.

Consolidation of flows

Kohn and Huge-Brodin (2008) stated that in a centralized distribution system, the companies should be able to consolidate their flow of cargo into larger shipments between the production centers and the distribution center. This can be assumed to reduce the transportation costs by achieving a higher utilization rate of the given mode of transport. As of today, Rolls-Royces production centers at Sunnmøre are not using a strategy where they are consolidating their shipments. The production centers have daily pick-ups at their sites, where the average weight of each cargo has been under 300 kg. The reason why they have not consolidated their shipment is based on the service level to the customer. The employees at the production center in Ulsteinvik states that they need to have a high frequency of daily shipments to be able to meet customer demand and maintain the current level of delivery performance.

The amount and stability of the cargo-flow

The cargo flow between Ulsteinvik and Helmond and Longva and Helmond, as mention in the previous chapter, has been unstable and had a declining trend in the form of amount transported between the two nodes per year. In a functioning centralized distribution system the cargo flow should be expected to have a higher the degree of stability and the cargo-flow from the production centers should be higher than the flow of goods from the GDC (Kohn and Huge-Brodin 2008).

All the production centers have had an increase in the cargo transported from Helmond in the recent years of 2016 to 2018. The worst case has been the flow of cargos between Longva and Helmond. As visualized in Figure 10, the cargo flow from Helmond was higher than the one from Longva. This means that the items that has been sent from Longva to be stored in Helmond, has later been sent back to the production center. They have therefore had the need of transporting several items back to the production center to be able to get a turnover on the items. Based on the fact that the majority of the items have to be configured at the workshop at Longva, before it can be sent out to the customers, can explain the reason why the GDC-model has not been functioning for the given production center.

The cargo flow between Brattvåg and Helmond has been more stable than the two other routes. This could be explained by the consolidation of the forecasting orders that are sent once a week. However, Brattvåg have had the highest amount of items sent back and forth between the production center and the GDC. This could be that the demand comes from either the customer or the production center, which is in need of a common part. As mentioned, common parts can be used of both the production unit and spares unit.

Mode of Transport

Riopel, Langevin, and Campbell (2005) stated that when deciding on which mode of transport that is the best fit, it depends on service level, the facility in the distribution system and the access to infrastructure. Further, the volume and distance is two factors that is the reason why transportation costs in the form of pricing varies (Stock and Lambert 2001). In centralized distribution systems, where they have been able to consolidate the shipments, this has led to the possibility to change the mode of transport to an option that is more cost efficient (Kohn and Huge-Brodin 2008). Because the production center at Sunnmøre are placed far from the distribution center, in addition to not consolidating their shipments, all of the production centers are using airfreight as main mode of transport to be able to satisfy customer demand. The exception is the forecasting orders, which is transported by road from Brattvåg to Helmond.

Airfreight as a transport option is known to be more harmful on the environment in addition to have higher transportation costs than road transport. Table 5 visualize an approximation of the transportation costs for the two sites Brattvåg and Ulsteinvik. The production center in Ulsteinvik have had the majority of transportation cost, which is logic since they have had the largest amount of tonnes transported and 97 percent of the cargo was distributed with airfreight. It can be speculated if the production center in Ulsteinvik could be able to consolidate their shipment and change the mode of transport to a more cost-efficient solution for the forecasting orders. The production center could then have benefitted the advantages with centralization. The risk would then be if the service level would be affected in a negative manner.

Another disadvantage after the establishment of the GDC-model is longer transportation times. The use of airfreight is providing the production centers a transportation time between five to eight days, and a lead-time on a total of eight to eleven days if the product is in stock when ordered. Changing the mode of transport and consolidating the shipments would result in even longer transportation times and it will take longer time for the employees at the distribution center to unpack the goods. The consequence would again be lowering the delivery performance toward the customers and could lead to possible lost sales.

Decrease in Emergency Deliveries

Kohn and Huge-Brodin (2008) stated that a centralized distribution system should expect the emergency deliveries to decrease. An emergency delivery is when the given item that the customer demands is not at stock at the GDC or at the production centers. Rolls-Royce will therefore place an order with their supplier, which sends the delivery directly to the customer. Figure 19 were based on standard items that needed no further configuration from Rolls-Royce. The result is based on the years after the establishment and we are therefore not able to compare if there has been a decrease in the amount of emergency deliveries. However, the results showed that the production centers have had a low amount of emergency deliveries and it seems that this is not a delivery form that the company uses often.

Since the amount of emergency deliveries was low, it can also be questionable if there is a high demand for standardized parts from the customers. The customer also state that they are willing to and often forced to wait for the customized products, since they did not want to buy replicas from other suppliers. For standardized products, customer 1 will use other suppliers if they can provide a shorter delivery time. Based on the low amount of service orders that have been delivered directly from the suppliers to the customers, we can assume that these situations will not be as relevant as a possible advantage of centralization for Rolls-Royce.

6.2 RQ 2: How has the delivery performance been affected by the establishment of the GDC-model?

This research question describe how the delivery performance has been affected by the GDC-model. By looking at how the delivery performance has developed since the establishment of the GDC, it can give us an indication of whether the delivery performance has improved or worsened as a result of longer distances. We are looking at the delivery performance from customer perspective, in addition to delivery performance based on service orders delivered on time out to the customers without experiencing stock-outs. The overall delivery performance from customer perspectives includes their opinion on delivery time and delivery performance related to delivery delays, which was caused by stock-outs.

6.2.1 Customer Perspective

The customers stated that the delivery performance has worsened after the centralization. In case of stock-outs at Rolls-Royce, one of the customer would rather find alternative suppliers if possible or borrow the spare parts from other vessels. Another customer was satisfied with the delivery performance, but stated that the delivery time was better before the establishment. Based on the rating of the delivery performance in Figure 22, none of the customers seems fully satisfied with the current delivery performance. Since the delivery time has increased after the centralization, it is obvious that the customers are not satisfied with the current delivery time. However, since most of Rolls-Royces customers is located in Møre and Romsdal (see Figure 21), it could be crucial for the company to satisfy these customers. However, it is also important to satisfy other customer markets such as United States, Brazil and Singapore etc. If these countries order spare parts from Rolls-Royce at Sunnmøre that have to be produced, they will probably have the same problems as for the customers located in the maritime cluster. This is because the item need to be shipped from Helmond in order to begin the production of the spare part.

Rolls-Royce experience occasionally stock-outs such that the customers have to wait longer for receiving the product. As one of the customers mentioned, they would at times choose another supplier if Rolls-Royce have stock-out on the item they demand. This could lead to an economic loss for Rolls-Royce. It is important to be able to deliver, as delivery performance is a leading factor to increase a supply chains performance (Stewart 1995). As the customers were not fully satisfied with the delivery performance, it is important to focus on increasing this due to higher level of customer satisfaction, which also can increase the competiveness to a company (Gunasekaran, Patel, and McGaughey 2004).

6.2.2 Service orders delivered on time

Most companies are working towards having a service level close to 100 percent, which is a measure on demand delivered on time with an appropriate number of stock-outs (Tersine 1994). The appropriate service level will differ from company to company based on factors such as lead-time and demand. If a company have long delivery time, the service level would be higher than a company that have shorter delivery time.

Based on Figure 23, 24, 25 from the previous chapter, these illustrates service orders delivered on time where no stock-outs has occurred. For all the production centers, they were able to deliver approximately 80 percent on average between the years 2012-2018. The deliveries on time were at its lowest in the year after the establishment of the GDC, but have thereafter had a positive development. This is because GDC can hold a higher amount of items at one location than the separate warehouses did before.

The service orders delivered on time were on its highest from 2015 to 2018, with approximately 85 percent for all of the production sites. By comparing the cargo flow between the production sites and Helmond up against the service orders delivered on time, we can see a correlation. The most obvious connection is for the production center in Longva. The amount of cargo transported from Longva to Helmond nearly stopped in 2015. At the same time, a high amount of cargo was transported from Helmond to Longva. Even though Longva almost stopped sending cargo to Helmond, they were able to hold the service orders delivered on time at a stable level. This could indicate that the production center in Longva were able to hold a steady rate on service orders delivered on time without using GDC in the same degree as the previous years. This is probably because Longva have items that needs to be configured before reaching the end-customer. The GDC in Helmond does not have the competence or the equipment needed in order to complete these orders before delivery.

Comparing amount of service orders delivered on time and cargo flow between Ulsteinvik and Helmond, and Brattvåg and Helmond, the connection is not as clear as for Longva. Both Ulsteinvik and Longva have sent more cargo than Longva, and used the GDC at a higher level. After the establishment of the GDC, the service orders delivered on time was low for both Ulsteinvik and Brattvåg. Then the service orders delivered on time began slowly but surely to increase during 2015. This can indicate a positive development as a result of using the GDC, and that these production centers manage to hold a high level of service orders delivered on time by using the GDC.

6.3 RQ 3: Why is it desirable to have a warehouse located at Sunnmøre?

This research question is important due to investigate why it is desirable to locate a warehouse at Sunnmøre as a supplement to the current GDC in Helmond. The discussion will present important factors describing why it would be beneficial to establish a warehouse at Sunnmøre based on customer opinions and also on the result from the internal data reports.

6.3.1 The Maritime Cluster

The maritime cluster in Møre and Romsdal is a strong argument why it will be desirable to establish a warehouse at Sunnmøre. The companies that are located within the maritime cluster represents a complementary supply chain, where several of Rolls-Royces customers and suppliers is located. The heat maps, presented in Figure 20, visualize that the sites largest source of income nationwide was Norway with 22 percent. United States were the second largest customer market with 13 percent, which is almost half of the share compared to Norway. This gives a good indication on how important the customers in Norway are for the sites at Sunnmøre. Further, the largest customer divided by counties showed that the majority of income came from customers located in the three coast counties Møre and Romsdal (27 percent), Rogaland (23 percent) and Hordaland (20 percent). Due to the fact that the largest customer market is located in Møre and Romsdal, where the production center is also located, it could be desirable to have a warehouse at Sunnmøre. The travel distance towards the two other counties will also be reduced compared to the GDC in Helmond.

The maritime cluster is giving the companies competitive advantages on the background of the high degree of collaboration within the region (Rødal, Bergem, and Sandsmark 2018). It will be important for Rolls-Royce to maintain their position towards the collaborators in the cluster also in the future. Collaboration within the maritime cluster, will be necessary in order to satisfy the customers requirements (Prater and Whitehead 2013). Considering customer opinions related to the subject, they are not fully satisfied with today's situation with a GDC in Helmond. This is due to the inflexibility and long delivery times in situations where they have a need for urgent deliveries. Before the establishment of the GDC, the customers describe situations where the spare part could be received the same day as ordered. This was often done by customers picking up the order themselves. A possible warehouse where customers could pick up their orders might not be a suitable solution, because it could lead to chaos at the facility. However, it can give an indication of how flexible Rolls-Royce were towards the customers before the centralization. The customers further state that although Rolls-Royce are not as flexible as before, they are satisfied with Rolls-Royce. The relationship between the customers and Rolls-Royce is characterised as good, where the customers describe Rolls-Royce as reliable and helpful. However, as a result of less flexibility, the customers rather desire a warehouse located at Sunnmøre.

Another consequence of the establishment of GDC, on the background of longer delivery times, is that the customers stated that they have to plan well in advance when ordering a spare part. As of today, the spare part has to go through the GDC in order to send complete orders, instead of being delivered directly to customers from the production centers. This is an another argument why it is desirable to establish a warehouse for the sites at Sunnmøre. A warehouse located at Sunnmøre, that would send the products directly to their customer within their largest customer market, could possibly improve customer satisfaction by reducing the delivery time. However, a warehouse at Sunnmøre will not be able to hold the same level and variability in products that the GDC will be able to provide. In situations where the spare part is not in stock at the warehouse at Sunnmøre, the customers will then have to relate to the same delivery time as they do today. The potential warehouse at Sunnmøre will therefore work as a supplement to the current distribution center in Helmond. The establishment of the GDC has reduced the distances to the majority of the other world markets and the GDC will still serve the customers located closer to Helmond. The warehouse at Sunnmøre would hold items that is also used by the other sites in addition to store spare parts, which can be directly delivered to the customers in Norway, without going through the GDC.

6.3.2 Distribution

Distribution is an essential factor due to why it is desirable to have a warehouse located at Sunnmøre. Due to the increase in transport distance, both the transportation time and transportation costs are assumed increased. Based on the results of the cargo flows and sales turnover, it can be assumed that the sites in Brattvåg and Longva have started to go away from the standard routines related to the distribution through the GDC. Instead, they have started to distribute the service orders directly to the customers from the production center. The sales turnover (see Figure 17) also shows that Brattvåg have an ongoing trend where the production center has started to sell more and more from the production center At Longva, almost every service order has been sold from the site in the recent years. The reason is the customization that has to be done before sending it to the end-customer and it will be faster to deliver it directly to the customers. The lead-times are also a reason why it has been more sufficient to deliver the product directly to the customers. Ulsteinvik have also had a high amount of service orders sold from their production center.

Another factor to why it is desirable to locate a potential warehouse is the high degree of items that has been shipped from the production centers to the GDC to be stored, and then almost immediately returned back to the given site. The idea behind the GDC is to distribute the spare parts directly out to the customer to improve the response time and reduce the delivery time towards the customer. Figure 15 showed that the majority of items returned within a month from the time it was distributed from the production center. An item is return quickly to the production center due to a demand appearing at the site. The demand is often impossible to predict. This could indicate that the items are stored at the wrong place at the wrong time. This can also be assumed to have led to unnecessary transportation cost and possibly resulted in longer lead-times for the end-customer.

Today, the spare planning division are operating with a transportation time on five days and the three SOT days that has been set up in case of delays from Rolls-Royce external partners DHL and Kuehne + Nagels. By having control over their own warehouse at Sunnmøre, one could assume that the transportation time could have been additionally reduced. The cargos would then be transported directly from the warehouse at Sunnmøre to the customer and also from the warehouse to the other sites at Sunnmøre. One can also assume that if the warehouse was located at Sunnmøre the need of number of SOT days would decrease since the warehouse employees would only handle Rolls-Royce´s items. Further, the product knowledge the Rolls-Royce´s warehouse employees possesses would reduce both the inbound and outbound process time.

Tsung, Yue and Taylor (2005) mention that transportation costs are one of the most expensive logistics costs for a company. Under the assumption that these have increased, the question is how to reduce these costs. If there was established a warehouse at Sunnmøre, the transportation costs could decrease since the distance to the company`s largest customer market will be reduced. The demand is assumed to be high due to the customers in the maritime cluster. In order to achieve economies of scale, the localization should be at the production center with highest demand such that the transportation cost is minimized (Krugman 1990). Based on the facility location analysis, which is minimizing the total transportation cost, we can find where a potential warehouse could be located.

6.4 RQ 4: Where could a potential warehouse be located at Sunnmøre?

The final research question will highlight important factors to consider when locating a facility. It will also give an answer to where the company could locate their potential warehouse based on demand and transportation costs. However, the facility location model only concerns demand, transportation costs and establishment costs for the selected location alternatives. The model gives an indication on which location that will allocate the lowest transportation costs.

6.4.1 Facility Location Factors

Locating a warehouse is one of the most important strategic decisions a company will make. A crucial criterion is the need for locating closely to a highway network, in addition to other criteria such as availability of existing building, proximity to airports, availability of resources, goods traffic flow, and locations of suppliers (Richards 2017). Between the different location alternatives, there are no highway network and the infrastructure is quite complex, where the different roads are connected with ferries. The production centers in Ulsteinvik, Brattvåg and Longva have available existing buildings where they can expand and locate the warehouse. Since Rolls-Royce are using airfreight as their main mode of transportation, it is important that the warehouse has proximity to an airport. The closest airport to the different alternatives is Vigra in Ålesund, and Brattvåg is the nearest option of the three production centers. However, the distances are relatively short, and both Ulsteinvik and Longva are also located close to the airport. By locating a warehouse at Sunnmøre, the delivery can be done by road transportation between the different production centers in addition to out to the customers in Norway. This would be preferable since road transportation has lower cost than airfreight transportation. In addition, Rolls-Royce could consolidate the flow of cargo into larger shipments, such that they could send a fully loaded van and then be able to reduce transportation costs by achieving a higher utilization rate (Kohn and Huge-Brodin 2008). If the warehouse was to be located at Sunnmøre, this will primarily serve the customers in Norway and we assume that they are using airfreight transportation to the customers outside of Norway. The transportation costs are assumed to be reduced if there was established a local warehouse at Sunnmøre due to the maritime cluster where several customers and suppliers are located.

Further, when expanding a warehouse, it is important to have resources available. The question is whether Ulsteinvik, Brattvåg or Longva have the resources needed to expand one of their warehouses. We know that expanding instead of building a new warehouse is less expensive, and that each of these alternatives have resources available in forms of warehouses. Whether the warehouse should be located Ulsteinvik, Brattvåg or Longva would be further described in the next section.

In addition, goods traffic flow is an important factor. By having the warehouse at Sunnmøre, the goods can be shipped directly to the customer instead of going through the global distribution center in Helmond. However, this occasionally occurs today, where the product is shipped directly. Additionally, the location of suppliers is important to consider. Several of Rolls-Royce´s suppliers are located in the maritime cluster such that the warehouse would be located within short distance.

Another facility location factor to consider is the availability of qualified staff (Prologis 2016). It is known that the staff in Helmond have less knowledge about the products of Rolls-Royce. If one of the items has a defect, Helmond would not be able to fix and deliver the product. This is an important factor to why it should be established a warehouse at Sunnmøre, where the staff at the production centers have higher knowledge and longer experience about the products of Rolls-Royce. The importance of having a qualified staff is essential such that the operations of the warehouse is efficient. Establishing a warehouse at Sunnmøre would presumably lead to that Rolls-Royce will have to hire more workers. In order to have qualified staff, Rolls-Royce have to invest in training the staff such that the operations of the warehouse are efficient. However, this could be costly, but could be seen as a necessary factor if the warehouse was to be established. At the same time, Rolls-Royce will probably save warehousing cost in Helmond by not having to store the same amount of items as they do today. Further, transportation cost is also an important facility location factor, where the transportation costs are assumed to decrease when locating a warehouse at Sunnmøre (Prologis 2016). This is because the largest customer market will be located in a shorter distance to the warehouse. In addition, it could reduce the number of items shipped back and forth from Helmond.

None of these mentioned factors are considered in the mathematical model except transportation costs and establishment costs, i.e. availability of existing building. However, these factors are as well as important as the ones included in the mathematical model.

The cost of operating a warehouse is expensive, and is almost as high as the transportation costs (Bloomberg, LeMay, and Hanna 2002). However, this depends on the size of the warehouse, products within the warehouse and where the products have to be transported. As mentioned, the cost of expanding a warehouse instead of building a new one is less expensive. In order to find the best possible location, the p-median problem is solved. We have focused only on the existing nodes, Ulsteinvik, Brattvåg and Longva, since the establishment costs of building a new warehouse would make any other location unsuitable.

6.4.2 Facility Location Model

As the p-median model is one of the models to solve a facility location problem, the optimization model has been solved through distances between the nodes and transportation costs in which includes costs per kilometres and ferry fares. By locating p facilities, which in this case p = 1, the model minimizes weighted costs. The model also include establishment costs where it is applicable (Daskin and Maass 2015).

Since p = 1, we have investigated establishment of one warehouse. Before the establishment of the GDC, all of the production centers where managing their own warehouses. One of the reasons why Rolls-Royce started using GDC was to save costs. If there were to be established one local warehouse for each production center again, this would presumably lead to higher costs than establishing one warehouse applicable for all the production centers. The inventory costs such as cost of capital, storage and handling, damage and deterioration, shrinkage, and insurance and management costs would have increased if all the sites had their own local warehouse (Christopher 2016). However, it is important for Rolls-Royce to be aware of the cost elements, which follows with an establishment of a warehouse. Elements such as cost of carrying an item, ordering cost, cost of avoiding stock-outs and costs when experiencing stock-outs is important factors in inventory management. As stock-outs occur when demand in lead-time is greater than the reordering point, it could be important to increase the reorder point. Then the safety stock also will increase in addition to reduce the possibility of stock-outs occurring. Further, it is important to find the balance between amount of orders and cycle stock, where the company decides how often inventory should be replaced cyclically. The balance between safety stock and costs for having stock-outs is also important to consider. If Rolls-Royce decides to establish, these factors would be essential (Silver, Pyke, and Peterson 1998).

The different alternatives included in the facility location model is presented in the previous chapter. As the establishment costs were higher for Hjørungavåg and Ålesund, these alternatives are excluded. Out of the alternatives, Brattvåg had the lowest total demand weighted distance. Ulsteinvik and Brattvåg were the alternatives with the closest total demand weighted distance. The demand was based on the production centers average number of cargo per year between the production centers and Helmond, where Ulsteinvik had 619 and Brattvåg had 582. Even though Ulsteinvik had a slightly higher demand than Brattvåg, the transportation costs were less for Brattvåg than for Ulsteinvik. The transportation costs are less expensive from Brattvåg compared from the other production centers. Therefore, Brattvåg are the alternative with the lowest costs. Even though Brattvåg had the lowest cost and are the suggested location, all of the alternatives are possible warehouse locations.

7.0 Conclusion and Further Research

This master thesis has investigated warehouse location for Rolls-Royces production sites at Sunnmøre. During the investigation, there have been performed interviews, searched for different findings through internal data reports and conducted a facility location analysis in order to answer the research questions. The interviews were based on semi-structured interviews, which allowed asking follow-up questions. Further, a high amount of information has been gathered through the internal data reports such as cargo flow, sales turnover on service orders and service orders delivered on time etc. There has also been a continuous dialog with Rolls-Royce through the writing process. Lastly, based on the conducted facility location analysis, a potential warehouse location has been suggested.

The first research question was to get an overview over how the centralization has provided advantages and disadvantages, based on customer perspective and actual data related to the transportation flow. The centralization has led to more disadvantages than advantages for the customers and the production centers at Sunnmøre. For the customers at Sunnmøre, the greatest disadvantage has been the increased delivery time. The customers also stated that the centralization has led to higher costs related to customs clearance. In addition, the customers stated that Rolls-Royce have become less flexible, which is most evident in urgent situations. Based on customer statements, the centralization has not led to a significant higher customer satisfaction. However, the centralization has been advantageous for the customers that have vessels operating in the areas close to Helmond. Further, the production centers have not achieved a higher level of distribution efficiency. The findings showed that all the production centers have had a decreasing trend related to distributing the items through the GDC. This can indicate that the production centers have moved towards a more decentralized distribution system, where the goods are shipped from the production centers directly to the end-customers, instead of going through the distribution center. This applies especially for the production center in Longva where the GDC has mainly been used as a supply source. This can also indicate that Longva have developed a more flexible way of using the GDC.

The second research question was to investigate how the delivery performance related to customer opinions on delivery time and occurrences of stock-outs has developed since the centralization. Based on the rating of the overall performance, the customers were less satisfied now than before the centralization. None of the interviewed customers were fully satisfied with Rolls-Royce delivery performance due to longer delivery time, and occasionally delays as a result of stock-outs. In circumstances with stock-outs, this will force the customers to wait if the product is customized. The measured service orders delivered on time showed that the delivery performance had a positive development after the centralization, especially for Ulsteinvik and Brattvåg. Even though Longva almost stopped distributing goods through the GDC in 2015, they were still able to hold a relatively stable delivery performance in the recent years.

The third research question was to point out reasons why it is desirable to locate a warehouse at Sunnmøre. The most important factor is the maritime cluster where several customers and suppliers of Rolls-Royce are located. Because of shorter distances, this could reduce the delivery time and transportation costs towards the production centers largest customer market. Locating a warehouse at Sunnmøre could also open up the possibility to consolidate the shipments and use road transportation in a higher degree than with the current situation. Lastly, it could lead to a reduction in the amount of items sent back and forth between the production centers and the GDC.

The last research question was to find out where a potential warehouse could be located, if Rolls-Royce decides to locate a warehouse at Sunnmøre. To find the best possible location, a facility location analysis has been conducted. The p-median model was based on the total transportation cost, demand and establishment costs. Based on these factors, the warehouse should be located in Brattvåg. Other factors to consider when locating a warehouse are availability of qualified staff, location of suppliers and proximity to airports. Since the employees at the production centers have higher knowledge related to the products than the employees in Helmond, it could be an important factor to establish the warehouse at Sunnmøre. Another significant factor in this case is that several suppliers are located in the maritime cluster. Further, proximity to airports is essential due to the accessibility to the world market, where Brattvåg is the nearest alternative. If the warehouse was to be located in Brattvåg, it is suggested that this warehouse will serve the production centers at Sunnmøre and primarily the customers in Norway. The warehouse will work as a supplement to the GDC, and the activities at the GDC will therefore continue as before. Since the GDC still will be operative, the production centers can use the GDC in case of stock-outs.

7.1 Further Research

Several elements and additional research can be made in order to improve the solutions and get a better insight on real-life situations. Including all the regional production centers, that are using the GDC, will answer if the problem is mutual for all the sites. Further, these could also be used as alternatives in the facility location analysis. Including more alternatives to the analysis, would strengthen the outcome. Eliminating the assumptions made in the analysis will also provide a more realistic model.

In addition, the customers interviewed was limited to the customers located at Sunnmøre. Expanding these interviews to include a larger portion of customers also located in other customer markets will provide additional perspectives related to the current problems. There are also several others elements that have to be taken in consideration before a decision can be made. These could include transportation costs, warehousing costs and inventory costs, compared to the current solution. Inventory cost factors such as unit value, cost of carrying items in inventory, ordering cost etc. will be important to consider before establishing a potential warehouse. Further, how the distribution towards and from the potential warehouse should function will have to be decided. This will involve the purchase of raw-material and components, and also related to the distribution towards the customers.

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9.0 Appendix

9.1 Appendix A-Interview guide

Introduction

- Start by thanking the informant for his/her time and participation. Further ask permission to record the interview
- Ask the informant name, their time in the company, which position he/she has in the company and what their area of responsibilities are
- Inform the interviewee about the research and its purpose

General Information

- *Could you elaborate what your company do?*
- *What service do Rolls Royce provide to you?*
- *How is your relationship with Rolls Royce?*
- *How long has your company been a customer of Rolls Royce?*
- *Could you elaborate the ordering process from the time your company places an order to you receive the spare part?*

The GDC model

- *What is your view on Rolls Royces GDC located in Helmond, Netherland?*
- *Does the GDC model, give you as a customer, advantages?*
- *Does the GDC model give you, as a customer, disadvantages?*

If the customer has had a relationship with Rolls Royce before 2011

- *What differences has your company experienced from Rolls Royce before the GDC model was established?*
- *What was better when the warehouse was located at Sunnmøre?*
- *What is better with the current GDC model?*

Delivery performance

- *How satisfied are your company with Rolls Royce ability to deliver on time?*
- *What do you do if Rolls-Royce has stock-out?*
- *How satisfied are your company with Rolls Royce ability to respond rapidly?*
- *Is the delivery time better with the GDC model? (If customer before 2011?)*

9.2 Appendix B- Customer market divided by country based on total sum of invoice

Country	2014	2015	2016	2017	2018	Grand Total	% of total invoice
NORWAY	21 612 128	11 905 017	9 919 488	11 408 583	11 682 034	66 527 250	22,45 %
UNITED STATES	6 666 977	7 776 827	6 200 188	13 335 925	4 864 431	38 844 348	13,11 %
UNITED KINGDOM	10 232 755	4 536 673	2 836 737	4 254 451	3 283 696	25 144 313	8,49 %
BRAZIL	4 097 712	3 325 687	4 212 022	3 943 228	3 850 427	19 429 076	6,56 %
SINGAPORE	5 198 558	4 316 622	3 109 531	3 157 409	3 045 358	18 827 478	6,35 %
DENMARK	3 224 506	4 763 349	2 395 530	1 946 461	1 841 760	14 171 605	4,78 %
UNITED ARAB EMIRATES	912 278	1 932 350	1 640 122	2 262 847	1 261 208	8 008 805	2,70 %
GERMANY	1 852 913	2 186 777	1 299 734	1 211 846	1 028 035	7 579 305	2,56 %
CANADA	1 089 980	1 231 935	1 505 024	1 915 521	1 687 813	7 430 273	2,51 %
NETHERLANDS	1 005 307	1 003 047	1 024 121	1 089 173	1 928 141	6 049 789	2,04 %
INDIA	1 160 457	1 069 783	971 451	1 327 956	1 049 701	5 579 347	1,88 %
ICELAND	1 050 494	820 502	1 002 818	1 074 243	1 440 409	5 388 467	1,82 %
RUSSIAN FEDERATION	539 380	1 180 307	1 108 825	1 480 094	919 982	5 228 587	1,76 %
ITALY	1 062 765	749 415	894 767	1 051 094	828 021	4 586 062	1,55 %
MALAYSIA	785 108	1 110 496	818 082	422 249	983 323	4 119 258	1,39 %
AUSTRALIA	1 486 621	482 256	888 549	489 194	760 488	4 107 108	1,39 %
CHINA	148 366	812 339	1 609 451	870 085	340 572	3 780 814	1,28 %
FRANCE	587 748	696 450	611 337	924 874	613 943	3 434 352	1,16 %
KOREA, REPUBLIC OF	201 181	782 040	581 392	886 024	587 431	3 038 068	1,03 %
GREECE	393 378	969 631	517 108	403 286	573 471	2 856 874	0,96 %
PHILIPPINES	219 944	693 743	1 038 280	643 466	258 440	2 853 873	0,96 %
CYPRUS	367 593	1 206 610	299 796	369 963	415 986	2 659 948	0,90 %
HONG KONG	462 504	277 929	522 802	439 646	545 617	2 248 497	0,76 %
TURKEY	263 781	186 517	187 142	525 665	918 460	2 081 564	0,70 %
MEXICO	357 911	140 856	315 749	716 167	428 010	1 958 694	0,66 %
NEW ZEALAND	150 566	387 351	672 273	378 725	288 280	1 877 195	0,63 %
FAROE ISLANDS	284 013	386 799	635 391	266 061	212 308	1 784 572	0,60 %
AZERBAIJAN	8 616	380 089	198 945	401 967	633 049	1 622 666	0,55 %
PORTUGAL	972 099	43 400	55 766	215 449	265 609	1 552 323	0,52 %
BELGIUM	123 933	414 875	180 001	370 110	435 712	1 524 631	0,51 %
FINLAND	492 280	219 995	261 852	223 943	232 805	1 430 875	0,48 %
POLAND	423 096	436 810	215 229	219 550	134 416	1 429 102	0,48 %
SPAIN	138 553	256 580	101 350	464 645	436 942	1 398 070	0,47 %
JAPAN	15 813	454 234	809 348	41 881	35 840	1 357 116	0,46 %
GREENLAND	233 850	133 448	387 130	258 293	199 622	1 212 344	0,41 %
SWEDEN	302 638	258 326	228 949	229 854	188 809	1 208 577	0,41 %
SAUDI ARABIA	575 184	142 459	115 332	114 906	197 353	1 145 234	0,39 %
LUXEMBOURG	665 827	54 280	118 978	19 907	54 194	913 186	0,31 %
MALTA	172 394	212 315	192 840	201 933	101 811	881 293	0,30 %
EGYPT	30 787	236 034	121 303	394 991	58 106	841 222	0,28 %
THAILAND	339 267	20 763	6 905	291 713	69 603	728 251	0,25 %
CHILE	57 932	174 124	222 173	67 874	188 627	710 730	0,24 %
VIETNAM	5 554	56 111	133 693	358 672	156 211	710 240	0,24 %
SWITZERLAND	412 631	112 459	76 514	14 913	41 392	657 909	0,22 %
SOUTH AFRICA	109 461	132 834	188 456	69 661	144 915	645 327	0,22 %
ESTONIA	230 513	128 236	45 554	40 179	195 936	640 419	0,22 %
INDONESIA	4 631	63 396	153 725	121 199	113 137	456 088	0,15 %
MARSHALL ISLANDS	19 743	49 003	98 950	95 309	122 274	385 279	0,13 %
IRELAND	52 883	97 265	55 467	51 546	122 539	379 699	0,13 %
CZECH REPUBLIC	139 461	25 497	94 154	68 744	6 675	334 530	0,11 %
QATAR	24 119	102 983	92 950	56 550	54 395	330 997	0,11 %
LITHUANIA	175 937	28 198	21 355	17 869	56 881	300 241	0,10 %
BAHRAIN	1 159	1 202	2 035	97 208	191 698	293 303	0,10 %
SAINT KITTS AND NEVIS	26 169	45 182		162 705		234 056	0,08 %
ISLE OF MAN	160 632	34 283	5 844	17 792	9 873	228 424	0,08 %
NIGERIA	2 959		15 030	102 938	98 839	219 765	0,07 %
ARGENTINA	101 961	17 954	3 700	31 757	26 729	182 100	0,06 %
KUWAIT	6 070	42 759	58 264	34 474	37 635	179 201	0,06 %
IRAN, ISLAMIC REPUBLIC OF				3 508	169 347	172 855	0,06 %

IRAN, ISLAMIC REPUBLIC OF				3 508	169 347	172 855	0,06%
PANAMA	16 215	78 665	15 674	31 617	26 247	168 418	0,06%
MOROCCO	10 002	44 837	4 735	96 846	4 569	160 989	0,05%
OMAN	3 450	7 286	19 642	6 245	119 337	155 960	0,05%
TAIWAN, REPUBLIC OF CHINA	42 355	19 003	2 379	56 636	13 596	133 968	0,05%
URUGUAY	123 059			10 882		133 941	0,05%
MONACO	35 283	19 499	41 235	24 422	13 049	133 488	0,05%
CAYMAN ISLANDS	7 299	5 799	6 175	21 746	91 947	132 966	0,04%
VIRGIN ISLANDS, BRITISH	11 526	53 172	23 877	6 761	17 627	112 963	0,04%
PAPUA NEW GUINEA	21 336	21 458	30 974	304	25 945	100 018	0,03%
To Be Advised	26 522	31 425	311		33 396	91 653	0,03%
BAHAMAS	26 525	5 413	31 460	3 244	24 016	90 658	0,03%
BELIZE		47 078	28 917		3 204	79 199	0,03%
BERMUDA	22 341	6 277	9 979	6 967	33 453	79 018	0,03%
ALGERIA	17 624	8 232	6 964	32 029	11 410	76 260	0,03%
BULGARIA	19 746	3 213	7 265	1 751	37 884	69 859	0,02%
UKRAINE	2 586	18 253	11 831	6 846	21 467	60 983	0,02%
SEYCHELLES	21 302	37 707				59 009	0,02%
CROATIA	13 829	3 909	2 178	6 401	17 334	43 651	0,01%
CURACAO	5 777	28 283	6 374		257	40 691	0,01%
SAINT PIERRE AND MIQUELON	1 965	24 837	4 232	679	628	32 341	0,01%
LIBERIA	2 549	7 519	6 068	2 382	13 508	32 026	0,01%
SRI LANKA	12 663		803		16 950	30 416	0,01%
TRINIDAD AND TOBAGO	2 471	351	3 246	18 829	980	25 878	0,01%
ROMANIA	4 592	3 995	5 939		9 625	24 152	0,01%
SLOVENIA	4 895	6 040	6 852	3 850		21 637	0,01%
GUADELOUPE			21 631			21 631	0,01%
ISRAEL	2 551	18 112	388		102	21 153	0,01%
TUNISIA				19 444		19 444	0,01%
LATVIA	9 679	873	4 524	2 430	1 683	19 189	0,01%
FRENCH POLYNESIA	18 047		542			18 590	0,01%
COLOMBIA					17 272	17 272	0,01%
JERSEY			17 270			17 270	0,01%
TANZANIA, UNITED REPUBLIC OF		13 711				13 711	0,00%
ECUADOR		1 020	4 099	3 655	4 692	13 465	0,00%
GIBRALTAR	12 992					12 992	0,00%
MAURITIUS		2 048	576	9 318		11 942	0,00%
KAZAKHSTAN			11 700			11 700	0,00%
PERU				4 587	5 723	10 309	0,00%
JORDAN				7 180	2 852	10 032	0,00%
NAMIBIA	9 592					9 592	0,00%
BARBADOS		4 509	2 723	1 710		8 942	0,00%
REUNION	5 900	1 074	321			7 295	0,00%
ALAND ISLANDS			4 086	2 010		6 096	0,00%
PAKISTAN		4 867	788			5 655	0,00%
MONTSERRAT			271	4 983		5 254	0,00%
GUERNSEY				253	4 600	4 853	0,00%
BRUNEI DARUSSALAM		4 698				4 698	0,00%
ANGUILLA		4 643				4 643	0,00%
LEBANON	4 515					4 515	0,00%
NETHERLANDS ANTILLES	1 045		1 556	868	765	4 233	0,00%
ANGOLA	-5 513	4 273			4 575	3 334	0,00%
EL SALVADOR				2 313	676	2 988	0,00%
CAMEROON	2 034			615		2 650	0,00%
ANTIGUA AND BARBUDA					2 321	2 321	0,00%
COOK ISLANDS	2 027					2 027	0,00%
AUSTRIA					752	752	0,00%
LIBYAN ARAB JAMAHIRIYA			648			648	0,00%
SAINT VINCENT AND THE GRENADI	405					405	0,00%
Grand Total	**71 960 262**	**59 848 483**	**51 427 733**	**62 054 076**	**51 000 763**	**296 291 317**	100,00%

9.3 Appendix C- Customer market divided by country based on total sum of invoice for the different production centers

Ulsteinvik		Longva		Brattvåg	
Country	Sum of Invoice	Country	Sum of Invoice	Country	Sum of Invoice
NORWAY	35102802,62	NORWAY	3097868,76	NORWAY	28326578,34
UNITED STATES	26326966,71	BRAZIL	1861188,28	UNITED STATES	12006001,69
UNITED KINGDOM	18349471,16	SINGAPORE	1135074,16	SINGAPORE	7896074,8
DENMARK	10401281,34	UNITED KINGDOM	999189,48	BRAZIL	7667359,81
BRAZIL	9900527,78	UNITED STATES	511379,16	UNITED KINGDOM	5795652,25
SINGAPORE	9796329,27	DENMARK	509343	RUSSIAN FEDERATION	4462694,75
UNITED ARAB EMIRATES	4579023,47	AUSTRALIA	432604,79	ICELAND	4219023,38
INDIA	4515982,53	UNITED ARAB EMIRAT	387500,94	CANADA	4033598,05
GERMANY	3537293,68	GERMANY	362160,01	GERMANY	3679851,57
NETHERLANDS	3151698,08	CHINA	331774,23	DENMARK	3260981,12
CANADA	3102159,91	ITALY	324066,38	UNITED ARAB EMIRATES	3042280,62
CHINA	2646260,45	INDIA	320246,31	NETHERLANDS	2745312,78
PHILIPPINES	2506734,8	CANADA	294515,48	MALAYSIA	2225805,89
ITALY	2280453,05	SAUDI ARABIA	271638,83	FRANCE	2191463,66
AUSTRALIA	1800815,08	MEXICO	254795,82	ITALY	1981542,62
MALAYSIA	1781971,33	AZERBAIJAN	158920,08	KOREA, REPUBLIC OF	1969156,2
CYPRUS	1502652,22	NETHERLANDS	152778,36	GREECE	1930802,33
TURKEY	1491855,66	SPAIN	148160,37	AUSTRALIA	1873688,61
MEXICO	1354474	FRANCE	120502,9	HONG KONG	1521014,15
PORTUGAL	1266410,33	MALAYSIA	111480,44	NEW ZEALAND	1495187,31
FINLAND	1214278,88	SWITZERLAND	88550,45	FAROE ISLANDS	1395825,36
JAPAN	1208759,45	ICELAND	86959,1	CYPRUS	1105015,65
FRANCE	1122385	RUSSIAN FEDERATION	81310,56	BELGIUM	1055330,92
ICELAND	1082484,44	HONG KONG	64409,52	GREENLAND	1033493,31
POLAND	1071493,02	CYPRUS	52279,82	CHINA	802779
KOREA, REPUBLIC OF	1045353,99	MALTA	51947,85	SPAIN	763682,08
GREECE	910119,52	TURKEY	46593,22	INDIA	743118,62
AZERBAIJAN	802263,36	ESTONIA	44441,66	AZERBAIJAN	661482,22
EGYPT	774233,44	FAROE ISLANDS	43152,66	SOUTH AFRICA	610547,4
SWEDEN	768896,64	NEW ZEALAND	37611,79	TURKEY	543115,44
LUXEMBOURG	741683,63	BELGIUM	34319,03	SWEDEN	429186,79
RUSSIAN FEDERATION	684581,44	To Be Advised	32258,94	POLAND	350245,63
HONG KONG	663073,71	IRELAND	29415,03	MEXICO	349424,14
MALTA	647449,18	INDONESIA	28781,02	PHILIPPINES	341292,47
SAUDI ARABIA	595024,34	KOREA, REPUBLIC OF	23557,85	SAUDI ARABIA	278570,8
CHILE	557763,6	PORTUGAL	19935,7	PORTUGAL	265976,92
THAILAND	536825,44	GREECE	15952,46	IRELAND	250804,67
VIETNAM	523338,55	BELIZE	15828,73	SWITZERLAND	248388,94
SPAIN	486228	MARSHALL ISLANDS	14391,22	MARSHALL ISLANDS	233479,16
BELGIUM	434980,95	EGYPT	12707,06	FINLAND	216312,3
ESTONIA	415449,87	VIRGIN ISLANDS, BRITI	12674,35	INDONESIA	206774,75
FAROE ISLANDS	345593,8	GREENLAND	11874,36	THAILAND	191425,45
NEW ZEALAND	344395,65	SWEDEN	10493,26	MALTA	181895,6
SWITZERLAND	320970	KAZAKHSTAN	9708,9	ESTONIA	180527,33

BAHRAIN	292100,77	VIETNAM	9660,66	KUWAIT	179201,44
CZECH REPUBLIC	276475,95	NIGERIA	9223,22	VIETNAM	177241,01
QATAR	264006,94	CAYMAN ISLANDS	8286,77	IRAN, ISLAMIC REPUBLIC	172854,55
LITHUANIA	229938,05	SOUTH AFRICA	8237,45	LUXEMBOURG	171502,22
SAINT KITTS AND NEVIS	226179,38	MONACO	8033,57	CHILE	152966,26
INDONESIA	220532,68	POLAND	7363	JAPAN	146361,32
NIGERIA	186220,16	CZECH REPUBLIC	6675,2	PANAMA	118755,93
GREENLAND	166975,98	PHILIPPINES	5845,59	MONACO	90278,33
ISLE OF MAN	159365,71	ANGOLA	4574,62	CAYMAN ISLANDS	88516,48
MOROCCO	148649,89	BERMUDA	4462,98	ARGENTINA	77022,22
MARSHALL ISLANDS	137408,39	TAIWAN, REPUBLIC OF	4348,94	ALGERIA	76260,11
URUGUAY	133941,39	QATAR	4075,03	VIRGIN ISLANDS, BRITISH	72677,77
ARGENTINA	103885,74	CROATIA	3562,06	LITHUANIA	70287
OMAN	101157,91	JAPAN	1994,91	ISLE OF MAN	69057,97
IRELAND	99479,79	TRINIDAD AND TOBAG	1252	PAPUA NEW GUINEA	65911,82
TAIWAN, REPUBLIC OF C	92622,28	ARGENTINA	1191,87	QATAR	62915,19
BAHAMAS	71423,72	ROMANIA	1155,33	SEYCHELLES	59009,48
BELIZE	50382,62	FINLAND	283,55	OMAN	54802,12
PANAMA	49662,55	CURACAO	257,48	EGYPT	54281,2
CAYMAN ISLANDS	36162,27	LATVIA	55,38	BERMUDA	53963,76
MONACO	35175,88	LITHUANIA	15,8	CZECH REPUBLIC	51379,08
PAPUA NEW GUINEA	34105,82	NETHERLANDS ANTILL	0	To Be Advised	48704,26
CURACAO	33949,75			BULGARIA	47863,01
SRI LANKA	29612,7			UKRAINE	39895,21
VIRGIN ISLANDS, BRITISH	27611,32			TAIWAN, REPUBLIC OF C	36997,14
SOUTH AFRICA	26542,06			LIBERIA	27828,04
TRINIDAD AND TOBAGO	24592,96			CROATIA	24666,64
BULGARIA	21995,77			NIGERIA	24321,19
GUADELOUPE	21630,8			TUNISIA	19444,32
UKRAINE	21087,58			BAHAMAS	19233,9
ISRAEL	21083,08			JERSEY	17270,09
BERMUDA	20590,77			ROMANIA	15547,93
SAINT PIERRE AND MIQU	19143,23			SLOVENIA	14907,72
FRENCH POLYNESIA	18589,95			ECUADOR	13465,42
CROATIA	15422,39			SAINT PIERRE AND MIQU	13197,32
TANZANIA, UNITED REPU	13711,34			GIBRALTAR	12991,71
COLOMBIA	13580,79			BELIZE	12987,43
To Be Advised	10689,9			MOROCCO	12339,16
PERU	10309,49			JORDAN	10032,07
LATVIA	9365,15			LATVIA	9768,84
MAURITIUS	7470,17			NAMIBIA	9591,83
ROMANIA	7449,02			BARBADOS	8941,73
SLOVENIA	6729,69			SAINT KITTS AND NEVIS	7876,92
BRUNEI DARUSSALAM	4698,25			REUNION	7294,5
ANGUILLA	4642,79			CURACAO	6484,2

LIBERIA	4197,9			ALAND ISLANDS	6095,7
GUERNSEY	3869,29			PAKISTAN	5655,45
COOK ISLANDS	2027,33			MONTSERRAT	5253,65
NETHERLANDS ANTILLES	804,36			LEBANON	4514,62
AUSTRIA	752,36			MAURITIUS	4472,27
LIBYAN ARAB JAMAHIRIY	648,16			COLOMBIA	3690,89
SAINT VINCENT AND THE	405,25			NETHERLANDS ANTILLES	3428,82
				EL SALVADOR	2988,38
				CAMEROON	2649,62
				ANTIGUA AND BARBUDA	2320,94
				KAZAKHSTAN	1991,22
				BAHRAIN	1201,86
				GUERNSEY	983,43
				SRI LANKA	803,27
				ISRAEL	69,75
				TRINIDAD AND TOBAGO	32,58

9.4 Appendix D- Customer market divided by county based on total sum of invoice

County	**Invoice amount**	% of total amount
Møre og Romsdal	17 655 160	26,5 %
Rogaland	15 163 081	22,8 %
Hordaland	13 140 235	19,8 %
Vest-Agder	5 303 699	8,0 %
Oslo	3 413 394	5,1 %
Akershus	2 995 886	4,5 %
Troms	2 073 237	3,1 %
Trøndelag	1 591 440	2,4 %
Nordland	1 574 110	2,4 %
Sogn og Fjordane	1 262 239	1,9 %
Aust-Agder	1 122 916	1,7 %
Finnmark	708 917	1,1 %
Buskerud	295 945	0,4 %
Vestfold	135 663	0,2 %
Telemark	46 614	0,1 %
Østfold	39 835	0,1 %
Oppland	5 781	0,0 %
Total	66 528 152	0,0 %

9.5 Appendix E-Customer market in Møre and Romsdal based on total sum of invoice

Møre and Romsdal	**Invoiced amount**	**% of total amount**
Fosnavåg	7 110 231	40,49 %
Ålesund	6 051 299	34,46 %
Ulsteinvik	2 278 032	12,97 %
Midsund	520 552	2,96 %
Søvik	358 471	2,04 %
Fiskarstrand	332 812	1,90 %
Brattvåg	197 226	1,12 %
Harøy	118 950	0,68 %
Gjerdsvika	114 592	0,65 %
Valderøy	81 050	0,46 %
Tomrefjord	80 664	0,46 %
Vestnes	49 755	0,28 %
Aukra	42 988	0,24 %
Gursken	40 565	0,23 %
Kristiansund	40 091	0,23 %
Tennfjord	22 301	0,13 %
Haramsøy	19 932	0,11 %
Larsnes	16 059	0,09 %
Averøy	15 405	0,09 %
Molde	14 159	0,08 %
Smøla	12 972	0,07 %
Hareid	12 077	0,07 %
Langevåg	11 686	0,07 %
Vatne	7 231	0,04 %
Elnesvågen	3 220	0,02 %
Volda	2 025	0,01 %
Ellingsøy	1 869	0,01 %
Godøy	1 694	0,01 %
Vågland	1 676	0,01 %
Fjørtoft	1 447	0,01 %
Mauseidvåg	440	0,00 %
Vartdal	192	0,00 %
Åram	74	0,00 %
Mjøsundet	32	0,00 %
Grand total	**17 561 771**	**100 %**