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LOG950 Logistics

Shifting Cargo From Road to Sea

- A case study of Grieg Logistics' base-to-base transport of oil related equipment

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Preface

This research has been conducted as the final and mandatory element of the Master of Science in Logistics at Molde University College. The delivery of this paper represents the fulfilment of the requirements of completing the Master program in June 2011. The work on this thesis has been performed during the months from January to May 2011.

Acknowledgements

I would like to send my regards to all of those who have supported me during the process of writing this thesis.

First and foremost I would like to thank my supervisor, Harald M. Hjelle, for his guidance and mentoring.

A thank you to Morten Graff at Grieg Logistics for giving me the opportunity to conduct this research and including me in a project much larger than this thesis. I would also like to thank Jan A. Norbeck at Marintek for his skills and assistance with analysing and formation of the Excel spreadsheet.

A special thank you to my family who has always supported me in my studies and has motivated and inspired me to become who I am today.

To my loving boyfriend, thank you for your highly cherished love and support through the many years of studying, and for the never-ending patience during the writing of this thesis.

Molde, 24.5.2011

Birgitte Nyhammer

Abstract

Environmental focus in the transport sector has for many years motivated a change in the distribution between the different transport modes in coastal areas. A modal shift from road to short-sea shipping has the potential of realising goals of reducing congestion on road infrastructure, reduce accidents in traffic, and most importantly reduce emissions of greenhouse gases and other pollutants. Though a modal shift is expressed in many forms to be an important and necessary development in reducing emissions, few cases of successful short-sea shipping in the domestic freight market in Norway, exist.

The research done in this paper aims at contributing to the successful transfer of transport of oil related equipment transported between supply bases on the Norwegian coast, given such a shift will be environmentally and financially accepted.

A theoretical study of existing literature on short-sea shipping has contributed to the identification of seven critical success factors for successfully establish a short-sea shipping solution. In determining the environmental and financial benefits (or shortcomings) a case study of an the transport of Grieg Logistics' transport of oil related equipment between three central supply bases performed in 2010 has been conducted. The case study provided comparable measures of CO_2 emissions, which has been used to identify the potential benefits of such a shift.

The result of the study showed that the benefits of transferring the transport of oil related equipment from road to sea can lead to increased emissions, and not just of CO_2. A shift does not have strong financial benefits either. The estimations performed suggest a modal shift is not necessarily environmentally or financially viable.

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PART I

1 Introduction to the research topic

For many years, governments and industries in coastal areas have tried to create a balance between the different modes of transport of freight. Norway is no exception. In 1979 an article was published in “Drammens Tidende og Buskerud Blad” expressing the need for a modal shift from road to sea, establishing shipping as the environmentally friendly means of transport already then (figure 1). More than three decades later the issue of moving cargo from land-based to water-based transport modes is more essential than ever. Since the 1970’s, several 100 projects and researches have been conducted and numerous reports and articles have been published, both on a national and international level, contributing to this statement that shifting cargo from road to sea will have economic and environmental benefits. The increasing concern about the environmental impact of transport has shot the focus on making logistics operations more environmentally friendly, to the skies. The situation today has not changed much

UTKLIPP FR DRAMMENS TIDENDE & BUSKERUD BLAD 3/12-79

NORD-POOLEN II

Noe å tenke på?

Når man ser et av de moderne kystgodsskipene komme inn på havnen med full last, kan man vanskelig tenke seg at denne ganske stille og rolige farkost kan ta like mye last som 140 trailere på landeveien. Og for den del 170.000 kasser brus. Ikke så underlig at landets politikere er blitt enige om at mer av tungtransporten bør over til båt og bane. For dertil kommer dette med miljø og ressurser.

Figure 1 Article from "Drammens Tidende og Buskerud Blad", 1979

over the years, which mostly has resulted in new reports on how the situation is and how crucial it is to reduce air pollution from transport, but not providing guidance on how to improve the modal balance. Despite the many reports praising the economic and environmental effect of shipping, the share of road transport has had a steady increased while the share of sea transport has decreased in the period 1960 to 2007 (cf. figure 2 a and b).

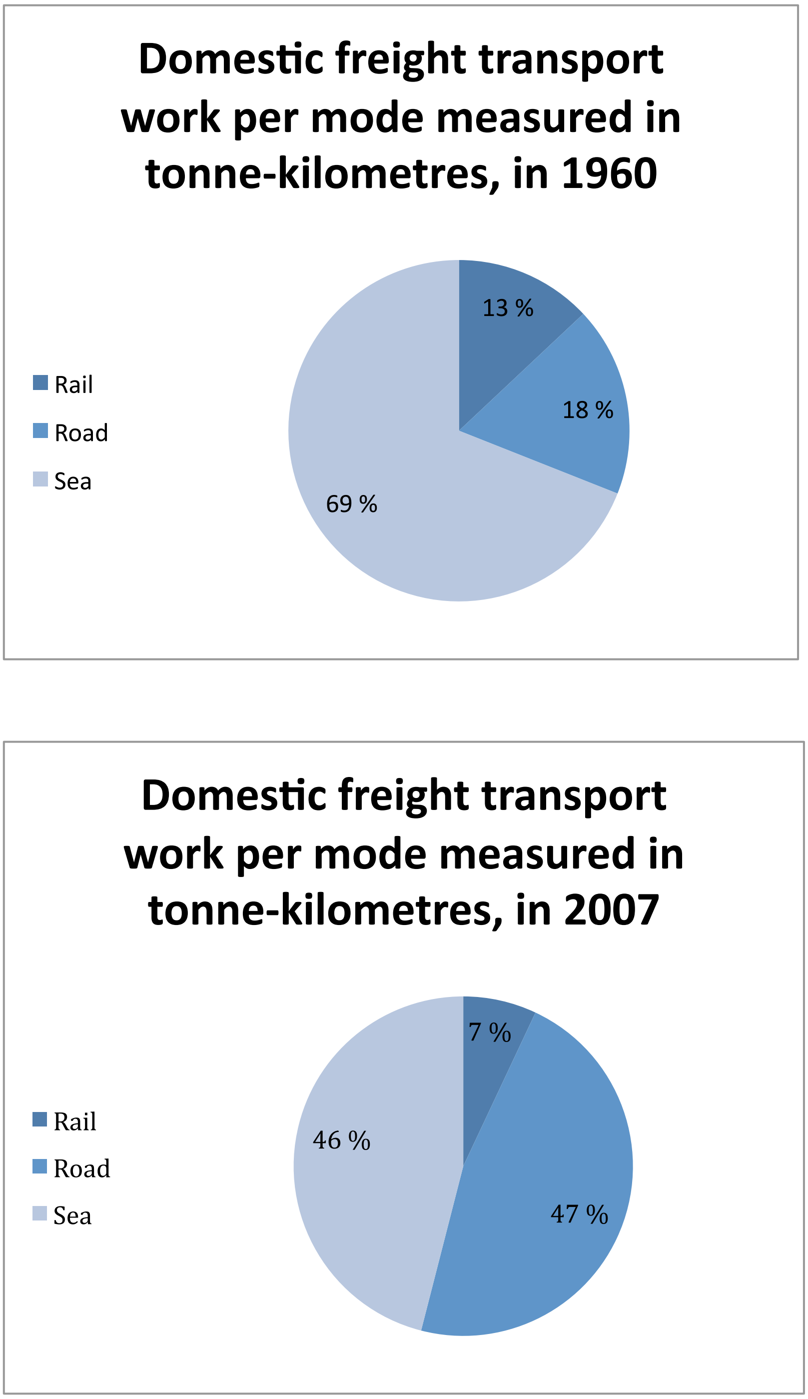


Figure 2a+b Domestic transport work (tkm) per mode in Norway, 1960 and 2007.

The geographical state of Norway, favour short-sea shipping. With a coastline of more than 20 000 km and its many fjords and inland waterways, it is difficult to explain why short-sea shipping has reached its low levels of the market share. On the other hand, the land-based infrastructure does not favour increases in land-based transport work. The roads are in many cases low maintained, are characterised by steep hills and slopes, are often dependent on ferry transits across the many fjords, and is subject to congestion. The rail network is underdeveloped to satisfy freight transport demands, and rail infrastructure investments are high and time consuming. From this perspective the Norwegian freight transport industry has great potential to implement a transport shift from road to sea. Still, such a shift is absent.

The Norwegian Government is currently preparing the next National Transportation Plan (NTP) for 2014-2023. NTP presents the government's strategies for the development of transport in the next decade. This work includes analysis on a regional and a national level, and the past 4 assessment of the plan has emphasised on the climatic impacts of transport and the necessity to increase the use of more environmental friendly modes of transport. In addition to the governments work, other research institutions such as SINTEF[1] and TØI[2] have researched the benefits of a modal shift.

One of the companies in Norway who seeks to capture the benefits of a modal shift is Grieg Logistics. In April 2010 Grieg Logistics established a new project called SHIFT (Grieg logistics and SHIFT is further presented in section 1.1). Grieg Logistics' focus on increasing shipping in their domestic freight transport is the foundation of the research done in this Master Thesis, and is conducted in collaboration with Grieg Logistics. The research aims at identifying the obstacles of short-sea shipping and providing Grieg Logistics with insight into how cargo can be shifted from road to sea for a given cargo flow on the Norwegian coast.

The cargo flow investigated is limited to the transport of oil related equipment between supply bases situated in Stavanger, Mongstad and Kristiansund. The researcher will try to quantify the environmental and financial benefits of shifting this transport to sea in

[1] http://www.sintef.no/home/

[2] http://www.toi.no/category25.html

terms of CO2 emissions and transport costs. This will be done through an empirical study of the relevant transport performed by Grieg Logistics in 2010. The researcher will also make an attempt to establish a potential water-based transport system for the transportation of oil related equipment on the Norwegian coast. In managing this task, the use of established research, literature and publications is an important input. In addition, contact with transport customers has been required to establish a realistic proposal as possible.

In the following a brief description of Grieg Logistics and SHIFT will be presented.

1.1 Grieg Logistics and SHIFT

Grieg Logistics is a "*leading logistics provider to Norwegian oil & gas, shipping, maritime and general industries on a local and global basis*" (Grieg Group 2011). Their products include spare part management, expediting, rig logistics, offshore fleet logistics, project logistics, and base-to-base transport, the latter being at the centre of this research.

At the start of this research work Grieg Logistics was part of the Grieg Group. In February 2011 Grieg Logistics announced that the freight-forwarding segment of Grieg Logistics was being sold to Panalpina, establishing the new and temporary company of Panalpina Grieg[3]. For simplicity, the company will be referred to as Grieg Logistics (or GL) in the remainder of this thesis. The freight-forwarding segment has been transferred to Panalpina without any significant changes, and the base-to-base operations are performed as before, implying that the utility of this research is sustained.

1.1.1 SHIFT – Shifting Transport From Road To Sea

The initiating idea behind this project is that environmental awareness will be a dominating force of change in the global economy, both in the short and the long run. The objective of the project is not to conduct another research on the topic such as many have done before, but to "*pave the way for successful new short sea shipping business initiatives*". SHIFT seeks to propose a plan for shifting cargo from land to sea, resulting in a strengthening of the competitive position of short sea shipping in intermodal transport

[3] http://www.panalpinagrieg.no/home/

chains. The project is sponsored by the Research Council of Norway, and key project partners are:

- Grieg Logistics AS/Panalpina Grieg (project owner)
- Marintek AS (Project leader)
- Det Norske Veritas (DNV)
- Short Sea Promotion Centre Norway
- Nor-Lines
- Eimskip CTG
- Elkem Maritime Center
- Containerships
- Rekom
- Logiteam

The project is divided into two phases, each phase consisting of different work packages (WP). There are 8 WP's in total, each with different deliverables. The project approach is shown in figure 3.

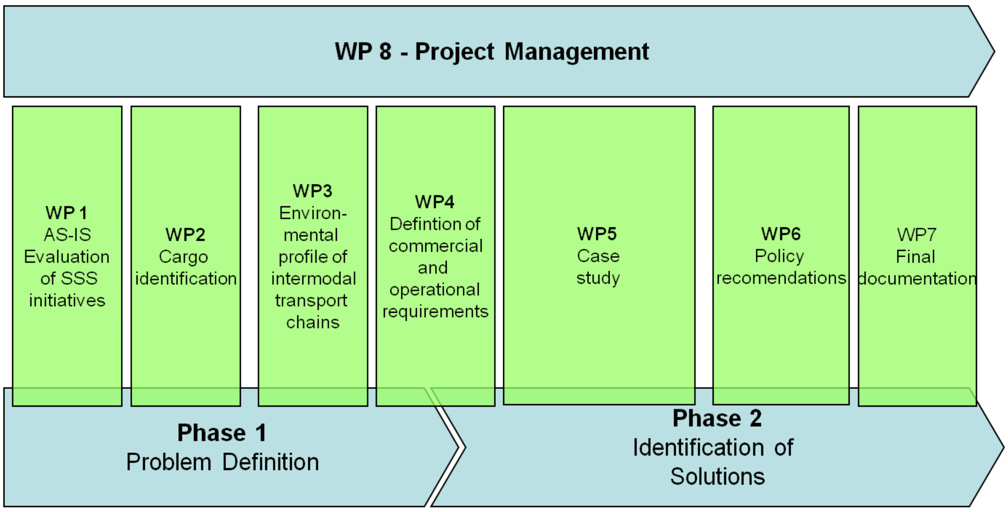


Figure 3 Project workflow of SHIFT

WP1 was completed in September 2010. This work consisted of a literature review of more than 70 articles and reports, which resulted in a report explaining the main contributors to the lack of a modal shift:

1. Characteristics of the service product
2. Business practices
3. Infrastructure
4. Regulation and fee structure

5. Environmental issues

These five is described in greater detail in section 3.2.

The research performed in this thesis is coherent with WP 2 – Cargo Identification and WP 5 – Case Study. The project defines the work of these WP's as below:

- *Cargo identification*: A main objective of task is to identify cargo especially suited for a modal shift from road to sea. Specific and sustainable (i.e. sufficient cargo volume) trade routes will be investigated along with uncovering the main criteria for moving cargo from road to sea. For securing adequate and relevant information, the industry partners themselves will identify cargo particularly suitable for modal shift.
- *Case study*: Based on existing transport operations from industry partners (and/or the baseline established in WP3; the AS-IS description), the main objective of the WP is to establish industry specific case studies. By developing new configurations of existing transport operations ("TO-BE" transport configurations), knowledge and understanding of how changes in supply chain configuration affect both environmental performance and operational cost will be revealed.

The study will thus include the following tasks:

- Identify which cargo types within Grieg Logistics' freight portfolio that has the greatest potential to be shifted from road to sea.
- Perform a case study on the flows of the identified cargo(s).
- Establish the main criteria of a potential shift.

1.2 Structure of this thesis

The thesis is divided into 5 separate parts with a total of 9 main chapters. A brief description of the purpose of each part is presented under.

1.2.1 Part I – Introduction and Methodology

Part 1 provides the reader with an introduction to the research topic in chapter 1. A brief description of Grieg Logistics and SHIFT is also provided. The methodology of the research is present in chapter 2, including research questions, research design, and research method.

1.2.2 Part II – Literature review

Part 2 is allocates to give answer to the first research question: "How can the competitiveness of short-sea shipping be improved?" (Cf. figure 5). A review of existing literature (chapter 3) will provide the knowledge to establish some critical factors which are important to consider when demonstrating how to design an alternative sea-based solution (chapter 4). The work done in chapter 4 will be the foundation for establishing a sea-based solution in part 4.

1.2.3 Part III – Description of today's situation

In chapter 5, the base-to-base transportation as performed today will be presented. In Chapter 6, the environmental and financial performance of today's base-to-base transport system is calculated. This calculation will provide key performance indicators (KPI), which will be used for comparing today's road transport system with a potential short-sea shipping system in part 5, and thus establish the potential benefits of a modal shift.

1.2.4 Part IV – Establishing a short-sea shipping solution

In part 4, chapter 7, a potential short-sea shipping solution for transporting oil related equipment between supply bases on the Norwegian coast, will be presented. This transport solution will be based on the work presented in part 2. Chapter 8 will provide comparable KPI's for the short-sea shipping solution, which will be used in a comparison in part 5.

1.2.5 Part V – Conclusion

This last part of the thesis is assigned to comparing the results of chapter 6 and 8, and the results of the comparison will be discussed. The thesis is finalised with a short conclusion of the research.

The structure portrayed in figure 4.

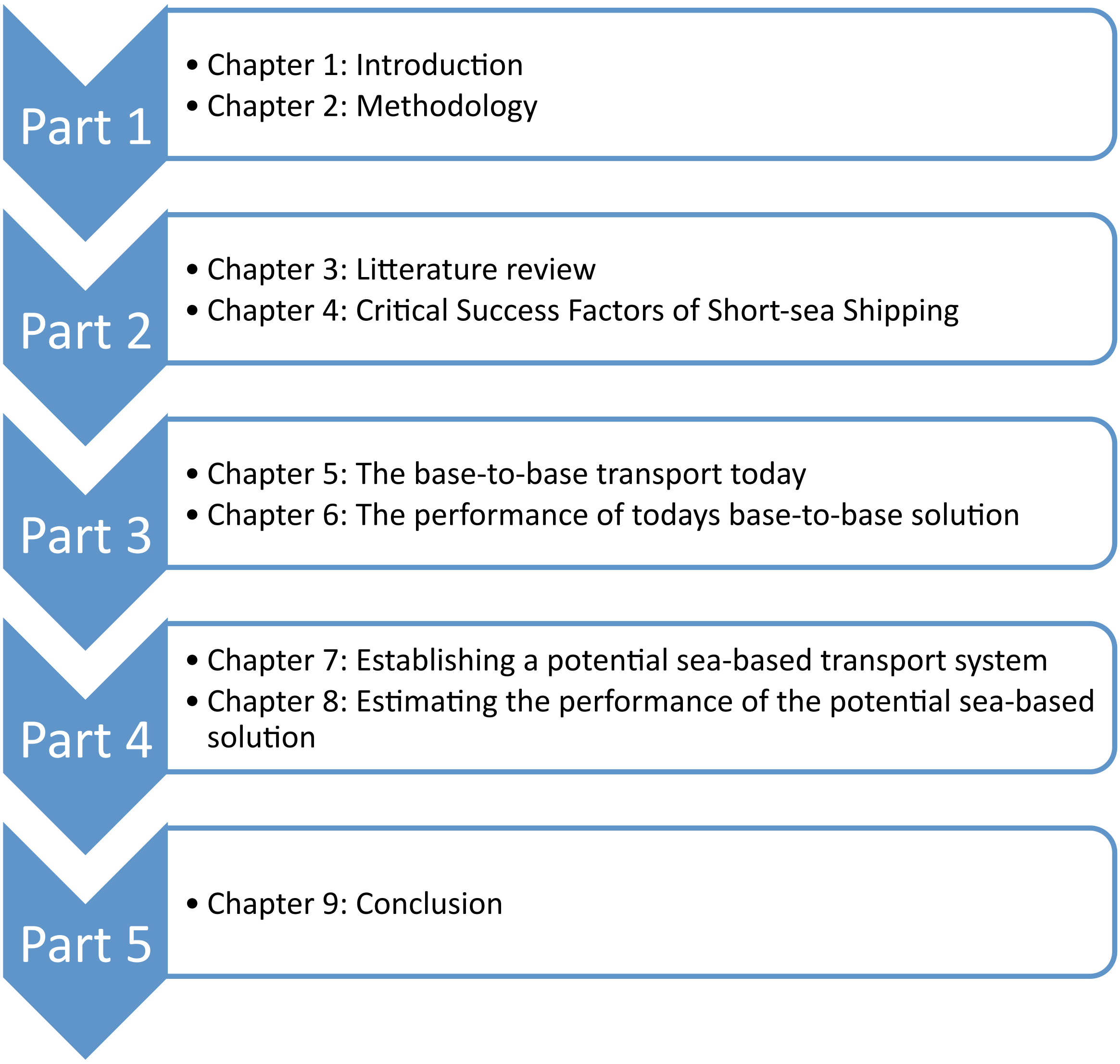


Figure 4 Structure of the thesis

2 Methodology

This chapter will provide the knowledge on the methodology applied in the execution of this master thesis. First the formulation of the research question is described. Second the research design and research methods are presented. Last, comments regarding the data are provided.

2.1 Research question

Research questions are necessary to clarify what is being studied, and guides the literature search, the design of the research, the data collection, the analysis and the writing, and most importantly it narrows down the research topic (Bryman and Bell

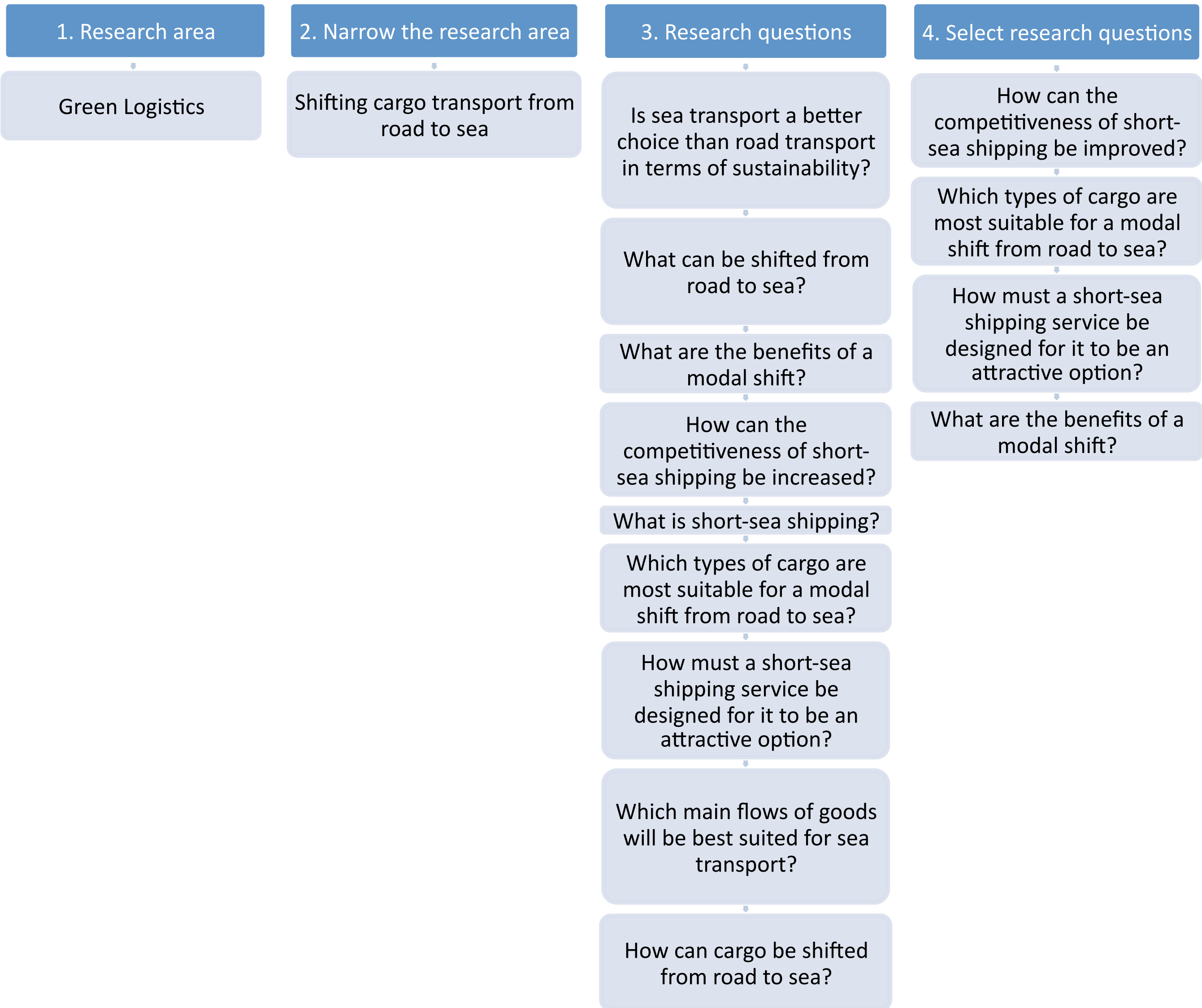


Figure 5 The research question process (Adapted from Bryman and Bell 2011, pg. 80)

2011, pg. 79). According to Bryman and Bell (2011, pg. 82), well-defined research questions are clear and understandable, are researchable, connect established theory and research, are linked to each other, contribute to knowledge, and are not too broad or too narrow.

Generating and selecting the research questions is a 4-step process (Bryman and Bell 2011, pg. 80). As depicted in figure 5, the research questions for this master thesis was selected by first identifying a research area, then narrowing the area of research to an aspect of this area. Then some potential research questions were developed, and finally a selection of the most appropriate questions where chosen.

The research area was chosen from a personal perspective. Green logistics is a popular and trendy subject, which has interested the writer for a long time. In September 2010, Grieg Logistics requested a student for completing his/her master thesis as part of a project called SHIFT, owned by Grieg Logistics (for more details about the project see chapter 1.1.1). This narrowed the chosen research area of green logistics to the topic on shifting cargo from road to sea. With this topic in mind several research questions were formulated (see figure 5). From these potential research questions, four were selected to be the research questions of this master thesis:

1. How can the competitiveness of short-sea shipping be improved?
   - What actions does the Norwegian government suggest to shift freight transport from road to sea?
   - What can be done by the shipping operators?
   - What can be done by the transport customers?
2. Which types of cargo are most suitable for a modal shift from road to sea?
   - Within Grieg Logistics portfolio of cargo transported, which has the potential of being transported by sea?
   - Which main flows of this specified cargo type is most suitable for a shift?
3. How must a short-sea shipping service be designed for it to be an attractive option to land-based transport?
   - How does research and legislative work, both nationally and internationally influence the establishment of short-sea shipping services?
   - From the transport customer’s perspective, what must be offered from short-sea shipping operators in order for this mode to be competitively equal to road transport?

4. What are the benefits of a modal shift from road to sea?
    - Will a modal shift give a better solution in terms sustainability?
        - Environmental effects?
        - Financial effects?

2.2 Research design and research method

The purpose of the research design is to present a plan on how to collect the data and how to analyse the obtained data in order to answer the research questions (Bryman and Bell 2011, pg. 40). The technique used to collect the data is called the research method (Bryman and Bell 2011, pg. 41). The literature describes several different research designs, divided into two main categories of research strategies: qualitative and quantitative research. A quantitative research is a "*research strategy that emphasizes quantification in the collection and analysis of data*", whilst a qualitative research "*emphasizes words rather than quantification*" (Bryman and Bell 2011, pg. 26-27). The differences in research strategies imply different research designs. The nature of the research questions defined above implies that the most appropriate research design for this master thesis is a combination of qualitative and quantitative research, carried out as a case study. The thesis is divided into one part concerning the qualitative characteristics of short-sea shipping and how to achieve a modal shift (questions 1, 3 and 4). In addition, a quantitative case study is appropriate for examining research question 2, providing empirical evidence of how the environmental and financial aspects are affected by a modal shift. A case study is an investigation of a single case or multiple cases focusing on describing, understanding and/or predicting a phenomenon, were a case can be either an organization, a location, an individual, or an event (Gillham 2000, Woodside 2010, Bryman and Bell 2011).

2.3 Reliability and validity

"*Reliability refers to the consistency of a measure of a concept*" (Bryman and Bell 2011, pg. 158). A study consists of different stages such as data collection and analysing. A reliable analysis will repeatedly lead to the same results, i.e. give consistent measures. Reliability is important in both qualitative and quantitative research, however it is imperative that measures of quantitative research is reliable so that there is no doubt regarding the meaning of the measure.

The validity of a research refers to "whether or not an indicator that is devised to gauge a concept really measures that concept" (Bryman and Bell 2011, pg. 159), i.e. the validity reflects the quality of the conclusion. Validity can be divided into three main groupings (Bryman and Bell 2011, pg 42):

- *Measurement validity* refers to whether or not a measure reflects what it is intended to reflect.
- *Internal validity* concerns the causal relationship between two variables.
- *External validity* is related to how well the results of a research can be generalised to other situations.

2.4 Data and data sources

The data in a research can consist of both primary and secondary data, and the data sources can be both internal and external. Primary data is collected by the researcher through interviews, surveys and observations, which provides firsthand information. Secondary data is already existing reports and documents on a subject, were someone other than the researcher has collected the data. The data can be qualitative and quantitative. Internal sources are sources within a firm or organisation, i.e. employees, accountings, and contracts. External sources can be customers and suppliers, reports, articles, statistics and Internet-based information (adapted from Buvik 2010).

2.5 The research method

As defined in section 1.2, the research method is the technique used to collect the data. The data used for the completion of this research can be classified as primary and secondary data, both qualitative and quantitative, collected from internal and external sources. An overview of the different types of data and their sources is provided in table 1.

Type of Data		Data sources	
		Internal	*External*
Primary	*Qualitative*	Interviews with key personnel within Grieg Logistics	E-mail correspondence with a transport customer
	Quantitative		
Secondary	*Qualitative*		Collect data from books, articles, reports, Internet-based information
	Quantitative	Analyse accountings of transport performed by Grieg Logistics	Collect data from statistics and from ship operators

Table 1 Overview of data types and data sources

PART II

3 Literature review

The purpose of this chapter is to establish a theoretical framework. The review starts with defining short-sea shipping and intermodal transport. The second section tries to establish an understanding of why short-sea shipping has failed in the competition of transport. Then a preview of short-sea shipping is provided, including cargo flows and volumes, and future trends in the domestic freight transport market. The last section examines the environmental impacts of transport, looking at relevant emissions and the differences in emissions between road and sea transport.

3.1 Definition of Short-sea Shipping and intermodal transport system

The definition of short-sea shipping (sometimes SSS) varies from complex description of the SSS market to short and to the point statements providing the core essence of SSS. The definitions differ from study to study, and depends on how wide the scope is and how many details are included.

Paixão and Marlow (2002) defines short-sea shipping as the use of feeders, ferries and bulk carriers and tankers less than 3000 dwt operating as part of a broken logistic transport chain in the geographical area from the Barents Sea via the North and Baltic sea down to the Mediterranean and Black Sea (figure 6). In this wide area, short-sea shipping services can range from standard services, characterised by frequent, scheduled and customary seaborne transport services offered between predetermined ports, to dedicated services where the different players are more involved in the supply chain activities performed (Paixão and Marlow 2002).

The European Commission defines short-sea shipping as "*the waterborne transport of cargo and passengers by sea or inland waterways as part of the logistic transport chain in Europe and the regions connected to Europe*" (Commission of the European Communities 2006).

Figure 6 An example of the geographical scope of Short-sea Shipping in Europe (Wikimedia 2011)

According to a project conducted by U.S. and Canadian governments and businesses "*shortsea shipping is the use of vessels of varying size and type to move freight and/or passengers to and from destinations that do not require an ocean crossing. This may include voyages that are both domestic and international in nature and that occur along coastlines, rivers, or lakes*" (IMTCP, 2004).

These different definitions provide an understanding of the scope of a short-sea shipping service. In essence, SSS is the movement of goods and/or passengers by sea, between both national and international destinations without crossing an ocean. Within this, several modified descriptions of what short-sea shipping is can be developed, depending on the nature of the short-sea shipping services offered in the geographical area of that service.

3.1.1 Intermodal transport systems

Intermodal transport systems and 'intermodalism' is two important concepts when discussing short-sea shipping. Due to the nature of the shipping service and its inability to travel on land, it is evident that shipping, in most cases, lacks the capability of delivering door-to-door. In order for goods (and passengers) to be picked up where it's sent from and delivered at the recipient's location, short-sea shipping must be integrated in an intermodal transport chain. An intermodal transport system is composed of a "*series of components (e.g. road, sea, rail) designed for the efficient transfer of cargo from one system to another*" whilst 'intermodalism' *"refers to the specific elements in this system concerned with the transfer of cargo from one mode to another*" (Stopford 2009, pg. 763). Developing a sustainable short-sea shipping industry the successful integration between different modes in a transport system is crucial.

Intermodal transport is often the only option in global trade due to the long distances and the location of the senders and receivers. On shorter distances, however, short-sea shipping is often in direct competition with land-based transport (Stopford 2009, pg. 51). Hence, it can be concluded that intermodal transport chains in smaller markets require integration between sea and land transport in order for an intermodal system to be a competitive alternative to a single-modal transport system using only trucks (Paixão and Marlow 2002).

One of the main challenges of intermodal transport is the transfer of cargo from one mode to another. This transfer must be smooth and with minimum handling, thus avoiding considerable delays. Chopra and Meindl (2007) emphasises that the "*key issue in the intermodal industry involve the exchange of information to facilitate shipment transfer between different modes (…)*". According to Stopford (2009, pg. 52) a seamless flow of cargo between modes can be achieved in three ways:

1. By using international standard cargo carriers (e.g. containers, pallets, bulk bags, baskets)
2. By investing in integrated handling systems for efficient and smooth transfer between modes
3. By designing vehicles to integrate with port facilities

A smooth and seamless transfer of cargo between modes is essential in making an intermodal transport system successful.

Intermodal transport systems are more detailed and complex compared to a single-mode transport, and require more planning and cooperation between the parties involved. As a result, short-sea shipping faces fierce competition from land-based transports such as trucks, which can offer door-to-door services with less complexity. This generates great demands to the organisational skills of short-sea shipping providers. Stopford (2009) says that the success of short-sea shipping require *"knowledge of the precise capabilities of the ships involved, and a flexibility to arrange the disposition of vessels so that customers' requirements are met in an efficient and economic way. Good positioning, minimisation of ballast legs, avoiding being caught over weekends or holidays and accurate reading of the market are crucial for survival*" (Stopford 2009, pg. 51).

Kapros and Panou (2007) describe an important problem concerning an intermodal transport system including short-sea shipping: Load incongruity. Load incongruity creates difficulties trying to balance the demand of many small shipments and the supply of large loads. This is a problem that must be solved if short-sea shipping is to become a part of a intermodal transport system. To solve this problem it is crucial that different players in the transport chain can cooperate with each other. In an intermodal chain this often means cooperation between competitors, which is not an easy task to do. An alternative is for a transport service company to offer a total transport system, providing door-to-door deliveries without having to hire competitors on different transport legs. A second solution is to establish freight distribution centres connected to the ports (Kapros and Panou 2007).

3.2 Why the growth of short-sea shipping is absent.

Much attention has been given to the great potential for moving cargo from road to sea, and the financial and environmental benefits of doing so. Both national and international transport policies has for the last 3-4 decades focused on modal shifts, and many EU initiatives, such as REALISE, PROTRANS, MOSES, CARGOEXPRESS, the Marco Polo Program and Motorways of the Sea, has been executed, aspiring to strengthen the role of short-sea shipping. In spite of all the efforts made, statistics show that though much effort has been made, short-sea shipping has unsuccessfully managed to increase or even maintain its market shares. The short-sea shipping market share in EU is declining while road transport is increasing. This is demonstrated in figure 7.

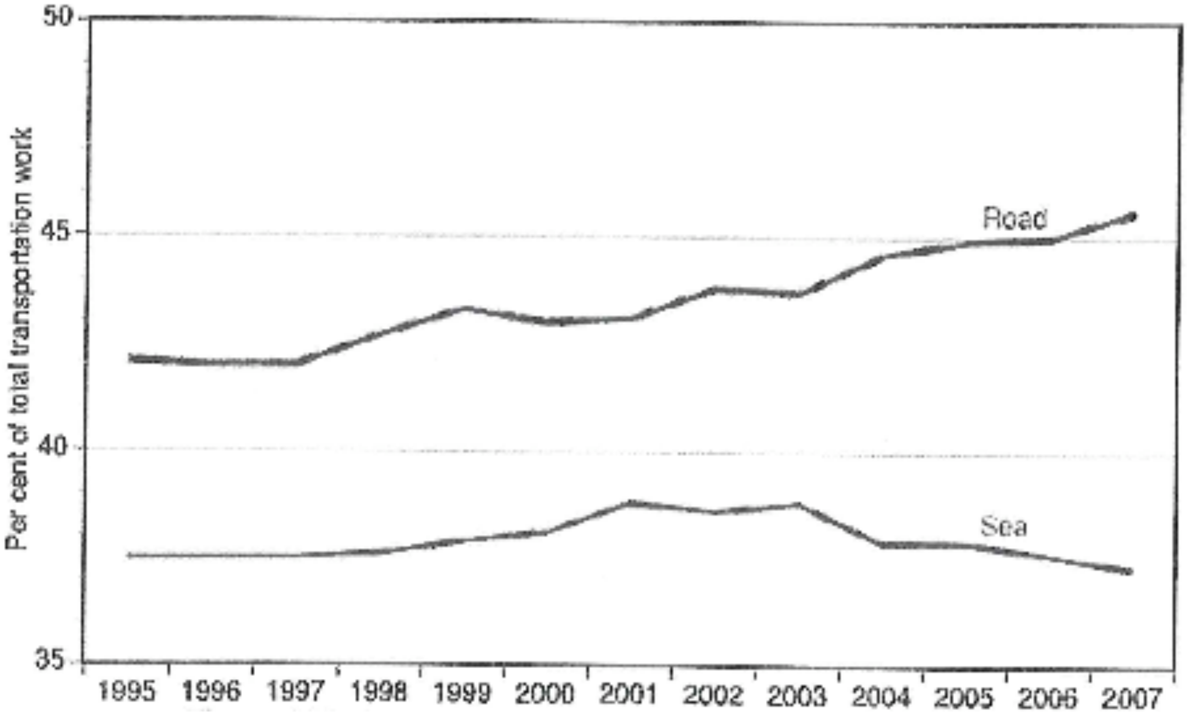


Figure 7 Market share for road and sea in EU-27 transport (Wergeland et.al. 2010)

A similar trend is found in Norwegian transport development (cf. figure 2a and b, pg. 13).

As part of the first phase in the SHIFT project, the lack of short-sea shipping success has been investigated. A literature review of 72 articles and reports were conducted, and five factors were identified as being the main contributors for slowing down the short-sea shipping growth:

1. Characteristics of the service product
2. Business practices
3. Infrastructure
4. Regulation and fee structure
5. Environmental issues

3.2.1 Characteristics of the service product

There are some great differences in characteristics between road and sea transport, which creates competitive advantages and disadvantages for the two modes. Wergeland et.al. (2010) found that the transport customers choose their mode of transport based on flexibility, lead-times, frequency and costs. On the basis of these findings, transport customers will choose road transport since this mode can offer door-2-door deliveries, has the shortest lead times, with frequencies adjusted to the demand and with no need for cargo consolidation in order to achieve economies of scale. Sea transport, on the other hand, is not very flexible, has longer lead times, with frequency dependent on cargo volume and distances, and require high cargo volumes and consolidation in order to exploit economies of scale.

Time is mentioned in several reports and articles as a great contributor to the unsuccessfulness of short-sea shipping. In addition, several other reasons have been identified as characteristics slowing down the growth of short-sea shipping as a means of freight transport. Some of these are

- The type of vessels and loading units used (Kapros and Panou 2007): Larger vessels have the ability to take advantage of economies of scale. However, large ships will increase the capacity and thus needs larger volumes to be able to compete with road transport. The lack of standard loading units has also stagnated the developments of coastal shipping.
- Administrative bottlenecks: As identified by the Commission of the European Communities (2004), administrative procedures in the shipping industry are often too complex, unnecessary and not in harmony between different ports, which creates delays.
- Volatile reliability: The reliability of shipping services is dependent on several things, e.g. weather conditions, working hours of stevedores, port efficiency, time of administrative work, all of which can create unpredictability to deliveries (Zou et.al. 2008).
- Deficient integration with other modes (Commission of the European Communities 2004, Kapros and Panou 2007, Zou et.al. 2008)): the success of short-sea shipping is dependent on the integration between modes at the ports. Without intermodal integration door-to-door deliveries with short-sea shipping is hard to achieve in most cases.
- Image (Commission of the European Communities 2004): perceptions of the shipping industry as old fashioned and slow hold back the demand for sea freight.

It is apparent that the characteristics of short-sea shipping is creating barriers for growth, and makes road transport a more attractive alternative for transport customers.

3.2.2 Business practices

When the cargo owners are buying transport their decision on which modal solution to use is highly depending on how well the service matches the Seven Right's of Logistics (7R's): the *right* product to the *right* customer, at the *right* time and at the *right* place, in the *right* condition and in the *right* quantity, at the *right* price (Wisner et.al. 2008) When comparing road and sea transport in terms of these 7 R's, the overall conclusion of Wergeland's et.al. (2010) assessment is that road transport has a competitive advantage. The only aspect where sea transport is superior is when the transport distance is long and the cargo volumes are high, creating economies of scale and lower prices compared to road transport.

Changing business practices is also a challenging task. Companies who are accustomed customers of road transport have bought transport many times and know the procurement procedures well. For these customers it is easier to buy road transport and it is the most convenient choice (Wijnolst et.al. 1993). Shifting transport from road to sea can create more administrative work for the transport customer, and it will require more and/or better planning (APEC 2007), creating a reluctant attitude towards short-sea shipping. The absence of "one-stop-shops" for and marketing of intermodal transport further increases a company's reluctance to use short-sea shipping instead of road transport. Business practices also seem to exclude environmental decision factors when choosing transport.

3.2.3 Infrastructure

The literature review conducted by Wergeland et al (2010) revealed that an efficient short-sea shipping system is dependent on the efficiency of the port and terminal systems. As mentioned in section 1.1.1 on page 3, integration and smooth cargo flows are crucial for a successful short-sea shipping solution. The main problem areas connected to the ports are:

- There are too many ports
- The ports are inefficient
- Bottlenecks related to working hours
- Low utilization of information and communication technology
- Too much competition between the ports and not enough cooperation

3.2.4 Regulations and fees

The distribution of fees between the different modes of transport is imbalanced. A Norwegian study from 2009 (Ciobanu and Oterhals 2009) presents evidence of uneven distributions of fees, dues and taxes between rail, road and sea transport. While rail faces 4 dues and fees and road 8, shipping faces no less than 27 dues and fees. In addition, the literature review by Wergeland et.al. (2010) showed that there are more regulations directed against shipping compared to road transport. These regulations are related to ports, boarder control, security, and also to the environment, which all affect the competitiveness of short-sea shipping (Wergeland et.al. 2010).

Though the development of short-sea shipping is primarily a job assigned to the industries, political acceptance is essential to breaking the barriers. The authorities have to create a viable framework for short-sea shipping (Commission of the European Communities 2004). According to Wijnolst et.al. (1993) the development of short-sea shipping has the potential to benefit both the environment and the economy: "*If economical and commercially viable, shortsea shipping is a safe and environmental friendly solution which offers increased transport capacity in a simple way and a positive contribution to the national economy of a country*" (Wijnolst et.al. 1993).

3.2.5 Environmental issues

Shipping has long been labelled "the green mode", emitting less CO2 per tonne kilometres than its competitor on the road. However, shipping, as well as road transport, is subject to regulations concerning environmental issues. Though ships emit low levels of CO2, ships are the biggest contributor to SO_x and NO_x emissions. This has led to regulations concerning sulphur contents in bunker oil, which again has led to higher bunker oil prices (Wergeland et.al. 2010). In addition to the emission of greenhouse gasses, there are other aspects of shipping which creates environmental issues that are irrelevant for road transport. This will be discussed briefly in section 3.4.

3.3 The short-sea shipping market in Norway is low and slow

The short-sea shipping market in Norway is present but is to a high degree pertaining to wet bulk and is concentrated on the west coast of Norway (Rogaland, Hordaland and Sogn of Fjordane) (SSB 2009a). Transport of general cargo and container is not a big market. In 2009 Statistics Norway (2009a) examined the freight flows on the Norwegian

coast, analysing data from 27 major public ports, 47 minor public ports and 30 private ports. The study includes traffic between Norwegian ports, between Norwegian ports and offshore installations, and between Norwegian and overseas ports.
The survey shows that the combined transported volume of bulk cargo, container and general cargo in 2007, was 166 million tonnes. 25 million tonnes, equal to 15 % of the total volume, was transported between two Norwegian ports, and 52 % of this volume was loaded or discharged or both in ports located on the west coast of Norway. However, the overall picture is that the volumes transported between the Norwegian ports are very fluctuating. The largest receiver is the southeast coast and the largest sender is the west coast. The ports on the mid coast receive twice the amount of what is sent from this region. In other words, there is a great imbalance in the cargo flows in the Norwegian coastal shipping market.

In terms of cargo types, wet bulk and dry bulk accounts for 87 % of the volumes transported between ports on the Norwegian coast. Only 3,25 million tonnes of general cargo and containers were subject to short-sea shipping in Norway in 2007.
The general cargo loaded and discharged in Norwegian ports is to a large extent metal products, wood and cork, food and animal feed, ores and metal waste, raw minerals, processed minerals, building materials, and chemical products. 36 % of the volume is registered as miscellaneous goods. The explanation for this is that the quantity of a lot of the shipments are so small they are not being registered properly, or the cargo type is actually unknown.
The domestic container transport amounted to 477 000 tonnes, which is about 1 % of the total transport between Norwegian ports. 74 % of the domestic container transport consists of lolo containers of 20 ft to 40 ft.
The remaining 12 % is transport of general cargo.

The analysis performed in this research is restricted to the traffic between the supply bases in Stavanger, Mongstad and Kristiansund. The SSB report (2009a) provides tonnage transported by short-sea shipping between these regions in 2007, divided into wet and dry bulk, general cargo and containerised cargo. The freight flows are shown in table 1, 2, 3, and 4 below.

	To:		
From:	Stavanger	Bergen	Kristiansund
Stavanger		13 112	2 869
Bergen	298 806		258 295
Kristiansund	6 574	7 728	

Table 2 Domestic shipping of wet bulk, in tonnes

	To:		
From:	Stavanger	Bergen	Kristiansund
Stavanger		6 514	12 708
Bergen	41 412		25 579
Kristiansund	9 777	3 539	

Table 3 Domestic shipping of dry bulk, in tonnes

	To:		
From:	Stavanger	Bergen	Kristiansund
Stavanger		8 276	1 493
Bergen	7 340		5 167
Kristiansund	1 103	2 760	

Table 4 Domestic shipping of general cargo, in tonnes

	To:		
From:	Stavanger	Bergen	Kristiansund
Stavanger		137	350
Bergen	81		0
Kristiansund	0	270	

Table 5 Domestic shipping of containerised cargo, in tonnes

These figures show that wet bulk between Bergen and Stavanger and Bergen and Kristiansund is the biggest cargo flow in the domestic short-sea shipping transport. The volumes of general cargo are relatively small on all distances, and containerised cargo transported by sea domestically is on some distances non-existent. The question is why this is. Is it a transport supply issue or is it a low short-sea shipping demand that is slowing down the market development? A new market can potentially be a beneficial opportunity under the right conditions.

3.3.1 Domestic freight transport developments

Short-sea shipping on the Norwegian coast is not growing as steadily as domestic transport by road and rail. For the last two decades, the total tonnage transported domestically has increased with 1 %. Together with an increase of 2,2 % in transport distances, the transport work (tonne kilometres) has increased with 3,2 % in Norway (Tvetene et.al. 2011). Figure 8 shows the historical development of domestic transport work for the years 1985-2008 and estimated developments from 2008 to 2043. The pie chart shows the market shares of the different transport modes, where truck (green) has 48 %, ship (blue) has 45 % and rail (red) has 7 % market share.

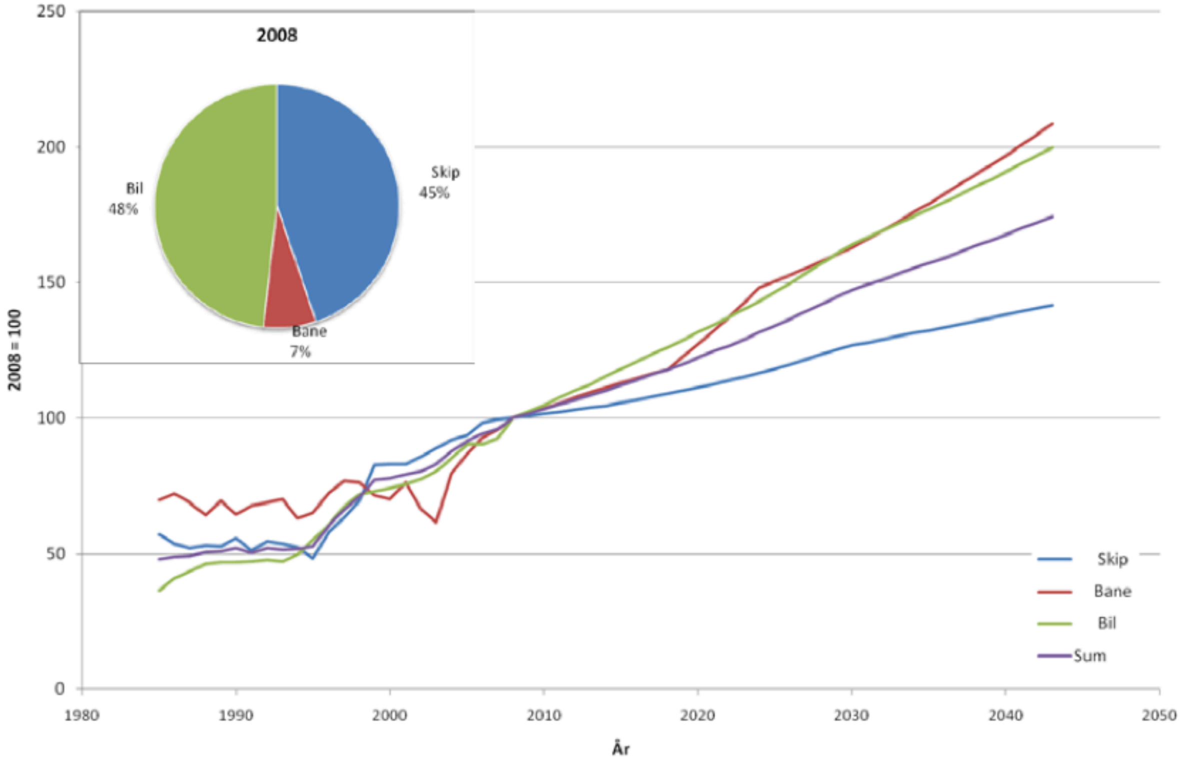


Figure 8 Historic development of domestic transport work 1985-2008, market shares in 2008 and estimated developments 2008-2043 (TOI 2011a).

The figure shows that while sea transport has grown steadily for the past 10 years, prognoses indicate a slower growth for domestic sea transport in the next 30 years and with the lowest market shares for the whole period. Rail and road will both increase with about 2 %, with rail increasing the most.

If distances are excluded, the prognosis shows the same for transported volumes for sea transport. Table 6 shows that the increase in volume will be of 1 % in the period 2008-2043 for sea transport. Volumes transported on rail and road will increase with 1,6 % and 2,0 % respectively. Volumes will in total increase with 1,9 % (TOI 2011a).

	2008	2008-2014	2014-2018	2018-2024	2024-2030	2030-2043	*2008-2043*
Truck	322,2	2,5 %	2,4 %	2,1 %	2,0 %	1,5 %	*2,0 %*
Ship	36,1	0,7 %	1,0 %	1,3 %	1,4 %	0,9 %	*1,0 %*
Rail	7,4	1,5 %	1,6 %	2,2 %	1,2 %	1,7 %	*1,6 %*
Total	365,8	2,3 %	2,3 %	2,1 %	1,9 %	1,4 %	*1,9 %*

Table 6 Domestic trends in cargo flows. In million tonnes in 2008, and yearly growth ratio. Oil and gas excluded (TOI 2011a)

The transport demand will increase for all three modes over the next 3 decades; however, road transport will increase its market share. If a modal shift from road to sea is to be realized, shipping must be an equally good alternative for road transport customers. It is evident from these figures that demand for short-sea shipping can be increased if shipping operators can discover how to capture the demand and increase their market share of domestic freight.

3.4 Short-sea Shipping and the environment

This section will introduce the main pollutants from transportation, and how it is distributed between the different modes. Potential reductions in emissions from a modal shift are also presented.

3.4.1 Environmental impact of shipping

Short-sea shipping is a "trendy" mode of transport and companies and countries have for many years tried to increase the market share of shipping as a mode of freight transport in coastal areas. Studies show that the total global emission of CO_2 per mode of transport is distributed as in table 7:

Mode	Portion of total emissions
Road	74 %
Air	12 %
Shipping	10 %
Rail	4 %

Table 7 Emission per mode of transport (Hensher and Button 2003, pg 52)

The table shows that road transport is the largest contributor of emission, whilst rail has the least portion of emissions. Though shipping in general is perceived as the "green mode", the environmental impacts of transport will not be eliminated by a modal shift. Shipping is, as road transport, contributing to both local and global pollution and must be accounted for when assessing the benefits of increasing transportation by sea. The sources of shipping pollution includes vessel oil spills, ballast water disposal, anti-fouling pollution, dredging, vessel scrapping, waste disposals at sea, and air pollution (Hensher and Button 2003, pgs. 279-291) and leads to environmental impacts such as greenhouse effect, depletion of the ozone layer, acidification, eutrophication, and human and eco-toxicity (IFEU 2008). For the purpose of this research only air pollution will be considered further.

3.4.1.1 Emissions from ships

Emissions from ships are mainly carbon dioxide (CO_2), nitrogen oxides (NO_X), sulphur dioxide (SO_2), carbon monoxide (CO), volatile organic compounds (VOC), black carbon (BC), and particulate matter (PM) (IMO 2009). CO_2, NO_X and SO_2 will be described in more detail below.

3.4.1.1.1 CO_2

CO_2 is a colorless greenhouse gas, which exists naturally in the atmosphere. Greenhouse gases in the atmosphere regulate the temperature of the Earth. The increase of greenhouse gases in the atmosphere has increased the Earth's temperature, and this is commonly known as "global warming". Burning of fossil fuels is the largest source of human-induced emission of CO_2 to the atmosphere, and the primary cause of global warming (Maslin 2004).

3.4.1.1.2 NO_x

NO_X emissions are the sum of nitric oxide (NO) and nitrogen dioxide (NO_2) emissions, and are created through high-temperature fuel combustion. Estimates show that transportation is responsible for 45 % of all NO_X emissions (Hensher and Button 2003, pg 62). NO_X emissions are important in the creation of ozone in the lower atmosphere. Ground-level ozone can cause both acute and chronic damage to the respiratory immune defences, which increases the risk of getting viral and bacterial illnesses in the respiratory system (Hensher and Button 2003, pg 62).

3.4.1.1.3 SO_2

Human-induced emissions of SO_2 are a result of burning fuel with high levels of sulphur. SO2 is harmful to human beings and vegetation, and leads to acid rain (EEA 2011). Exposure to SO_2 damages the lungs and can lead to death by infections and lung cancer (Plattenberg 2007).

Though shipping services is performed away from land, shipping emissions affect on-land vegetation and human health, and "*the health impacts are particularly concentrated near coastlines in Europe, East Asia, and South Asia*" (IMO 2009). Hensher and Button (2003) estimate that "*70 % of ocean-going vessel emissions occur within 400 km of land*", and 44 % and 36 % of all shipping traffic is present only 93 km and 46 km off shore, respectively (IMO 2009). This suggests an increase in short-sea shipping will possibly lead to greater damages to vegetation and human health on land, and neutralize the benefits of controlling emissions from land-based sources (Eyring et.al. 2010). Shipping is the biggest single contributor to polluting fallout in European countries, and EEB et.al. (2004) has listed Norway as one of the European countries where the proportion of air pollutant depositions of sulphur and oxidized nitrogen coming from ships is most marked, with 14 % SO_2 and 16 % NO_X.

The impacts of shipping emissions are portrayed in figure 9.

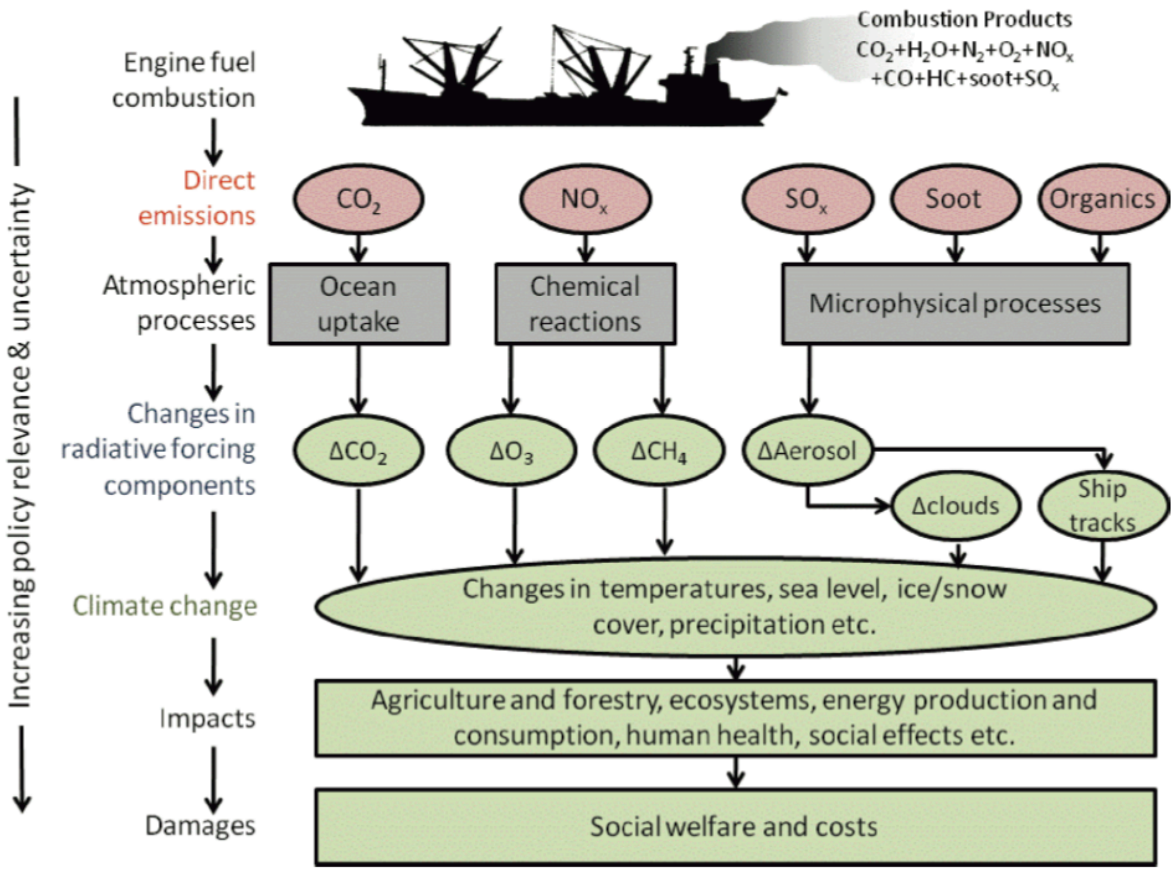


Figure 9 Impacts of emissions from the shipping sector on climate change (IMO 2009)

3.4.1.2 *Short-Sea Shipping vs. Road Transport*

Corbett et.al. (2005) have developed a model for quantifying emissions from an intermodal freight transport system. The model uses information about routing, mode performance and transfer characteristics to develop an optimal intermodal transport chain with the objective to minimize emissions, transport time or cost (Corbett et.al. 2005). The overall results of this research was that an increased use of short-sea shipping in an intermodal transport chain has the potential to reduce transport costs and emissions significantly compared to road transport.

Both shipping and road transport is subject to emissions of environmental hazardous compounds. The apprehension concerning the level of CO_2 in the atmosphere and the amount of human-induced emissions of CO_2 through the combustion of fossil fuels, has led researchers to investigate the difference in emissions between the two transport modes of sea and road. This has resulted in numerous emissions factors determining the CO_2 efficiency of shipping and trucking.

IMO (2009) has developed estimates of gram CO_2 emitted in relation to the performed transport work measured in tonne-kilometres. The emission factors of CO_2 from road transport are provided in table 8, and show an emission range from 80 gCO_2/tkm to 181 gCO_2/tkm.

	CO_2(g/tonne-km)	Method	Source
Heavy goods vehicles	138	Output-based measures combining data from "National Road Traffic Survey" and "Continuing Survey of Road Goods Transport".	[3]
Road freight	127	Top-down approach. Trend Database. Data from Eurostat. Data only from EU region.	[3]
Trucks > 40 tonnes	80	Sample survey, 109 vehicles.	[1]
Trucks < 40 tonnes	181	Sample survey, 44 vehicles.	[1]
Road freight	153	Top-down approach. Data from *National Transportation Statistics 2007*; U.S. Department of Transportation, Research and Innovation Technology Administration: Washington, DC, 2007; and Energy Information Administration Annual Energy Outlook 2007 with Projections to 2030, Supplemental Transportation Tables	Authors' calculation
Road freight	156	Top-down calculation based on EU statistics.	[4]
Road freight, 2007	144*	Top-down calculation based on National Japanese statistics.	[5]

* The 2007 truck transport efficiency in Japan of 144 g/kW·h is significantly better than the 2004 value, which was 174 g/kW·h. This improvement of 20% is attributed in part to the implementation of speed limits for all Japanese trucks, following a major road accident.

Table 8 CO2 emission factors for road transport (IMO 2009)

For shipping vessels, the CO_2 emissions factors ranges from 2,5 gCO_2/tkm for a bulk carrier of more than 200 000 dwt to 60,3 gCO_2/tkm for a 0-1 999 lm Ro-Ro vessel. The list of all the estimated CO_2 emission factors for ships can be found in appendix 1.

Statistics Norway (2009b) provides figures for emissions of CO_2, SO_2 and NO_X per unit of fuel, from domestic freight transport by road and sea (table 9). This shows that heavy vehicles and coastal ships have the same amount of CO_2 emissions per unit of fuel. SO_2 emissions and NO_X emissions are, however, much larger for coastal shipping than for heavy vehicles. SO_2 emissions are 76 times higher and NO_X emissions almost 3 times higher per unit of fuel for short-sea shipping compared to road freight.

	CO_2 (kg/kg)	SO_2 (g/kg)	NO_X (g/kg)
Heavy vehicles (diesel)	3,17	0,02	20,42
Coastal shipping (marine fuels)	3,17	1,53	60,8

Table 9 Emission factors, emission per unit of fuel (Statistics Norway 2009b)

A modal shift in freight transport is reasoned by environmental benefits in terms of CO_2 emission reduction. The research performed by Zou et.al. (2008) presented a potential emission benefit of shifting cargo from road to short-sea shipping. A scenario analysis was performed on an intermodal transport chain consisting of a shipping voyage of 635 km and local truck voyages before and after the shipping leg, of a total of 32 km. The analysis considers different levels of cargo transfer, vessel sizes and speed. The potential CO_2 emission reduction results of the scenario analysis are shown in figure 10.

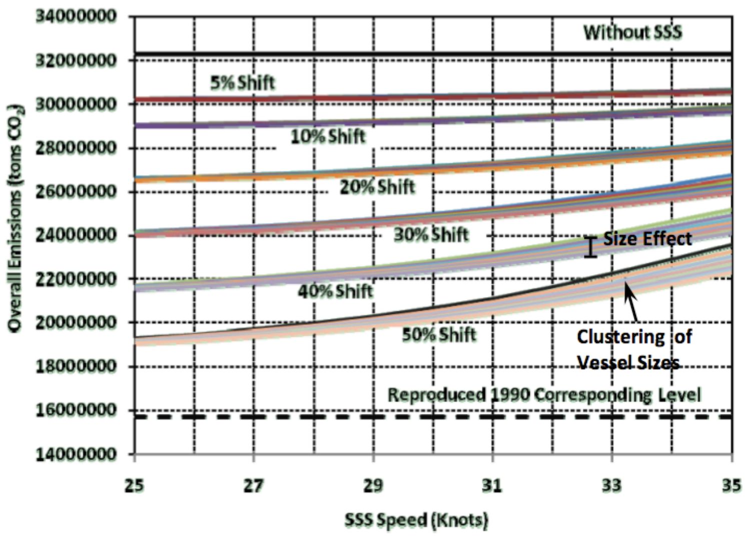


Figure 10 Emission reduction potential under different scenarios (2020) (Zou et.al. 2008)

The figure shows that the largest reduction of CO_2 emissions are obtained with a 50 % cargo transfer and low speed for all ship sizes, with an emission reduction of about 40 %. The figure also shows that even a small transfer of cargo from road to sea will reduce the overall emission of CO_2 from an intermodal transport chain.

4 Increasing the competitiveness of short-sea shipping

In this chapter, critical factors of short-sea shipping success are identified based on the literature review in chapter 3, and described in more detail.
Before establishing the critical factors for increasing short-sea shipping's competitiveness a description of the major strengths and weaknesses of SSS is required.

4.1 Strengths & weaknesses of short-sea shipping

Short-sea shipping, as any other mode of transport, is subject to operational advantages encouraging the growth of SSS, and some disadvantages detaining the forward acceleration. Paixão and Marlow (2002) have conducted a general evaluation of SSS' strengths and weaknesses. The study aims at identifying the advantages and disadvantages of SSS from the users' point of view in order for SSS operators to recognize the opportunities and threats for better strategic planning, which will lead to "*an effective and sustainable shift of freight from road to sea*" Paixão and Marlow (2002). In developing the short-sea shipping industry it is key to recognise were the opportunities lies, and most importantly to assess the weaknesses so that these may be improved. Since short-sea shipping has proved to be difficult to realise but offers great possibilities for both customer and company, the first company that can provide the right product or service will have the opportunity capture large market shares of the short-sea shipping market in Norway. The first task lies at identifying the strengths and weaknesses.

4.1.1 Geographical advantage

Shipping in general has a geographical advantage that supports the development of short-sea shipping as a mode of freight transport. Europe's coastline is about 66,000 km[4], with 60-70 % of the industrial and production centres positioned close to the coast, offering a great foundation for SSS developments. The coastline of Norway is more than 20 000 km long offering great potential for establishing short-sea services along the coast. As in Europe, the population density is largest along the coast, indicating that much of the inland freight transport is going up and down the coast.

[4] https://www.cia.gov/library/publications/the-world-factbook/geos/ee.html

4.1.2 Financial advantage

Second, SSS has a financial competitive advantage, in spite of the financial nature of short-sea shipping as a capital-intensive industry. Already existing actors in the SSS industry has a unique opportunity to develop intermodal transport systems as they already hold the most expensive assets. In addition there is a knowledge advantage within these existing companies. The skills needed to operate a SSS service takes years to establish, creating a disadvantage for outsiders.

4.1.3 Environmental advantage

As pointed at in the literature review, short-sea shipping has environmental advantages. Social costs in terms of air pollution are reduced with the increased use of short-sea shipping. Increased use of SSS will also reduce the number of trucks on the roads, reducing infrastructure maintenance costs and traffic accidents. Energy consumptions can also be reduced with increased use of short-sea shipping, as ships has lower energy consumption than trucks.

4.1.4 Capacity advantage

There is an unlimited capacity of sea, which enables the short-sea shipping service operators to transport 7 days a week, 52 weeks a year. This also means lower investments and lower maintenance costs connected to the infrastructure (ports) compared to road and rail.

4.1.5 Weaknesses

Though these seven strengths of short-sea shipping support the development of short-sea shipping, it is evident today that there exist some weaknesses that have slowed this process down. Most importantly, the transport customers choose their mode of transport not based on these criterions but by considering cost, time, flexibility and reliability (Paixão and Marlow, 2002). In addition, several other factors influence the growth of SSS. These include the fact that short-sea shipping is a part of a broken transport chain. In most cases, other modes of transport must be involved in order for door-to-door deliveries to be achieved. In most cases this will be road transport. This suggests a change in organisational culture within the shipping industry and less focus on sub-optimisation in a transport system (Paixão and Marlow, 2002).

Planning is an issue of great importance when improving the SSS services. This is especially true for the port operators. Costs associated with wastes due to poor planning in the port will affect the whole transport system. Wastes such as inventory and cargo handling times must be eliminated so that the ports can offer competitive services compared to road operators.

From these disadvantages identified by Paixão and Marlow (2002) and from the literature review in chapter 3 we can summarise the critical factors for developing short-sea shipping as in figure 11.

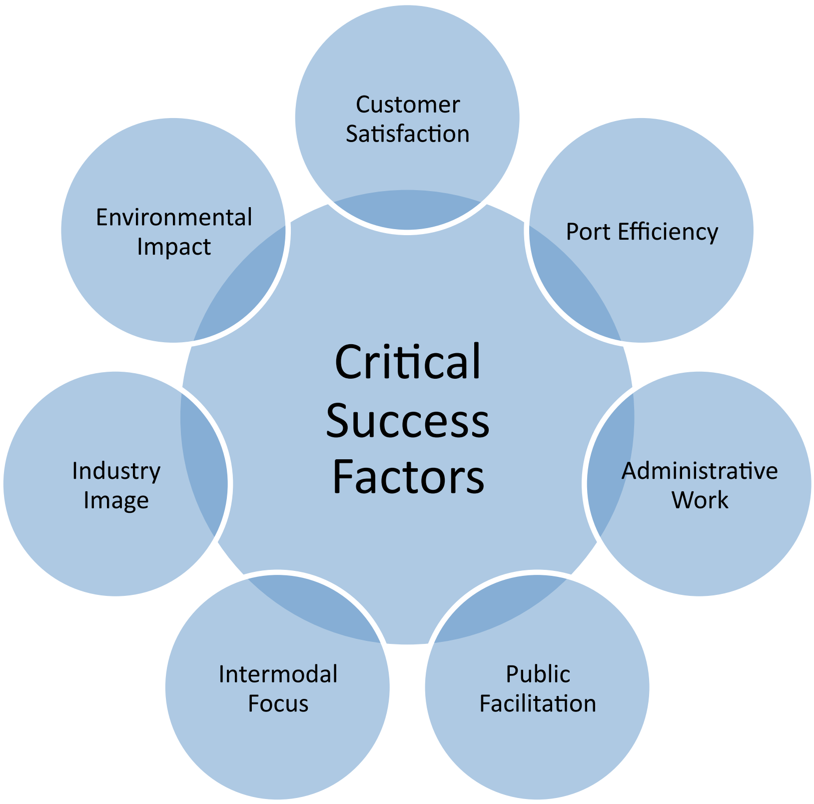


Figure 11 The seven critical success factors of short-sea shipping

Identifying the strengths and weaknesses of short-sea shipping provides a set of critical success factors that must be brought to attention when establishing a short-sea shipping transport system. The seven success factors presented in figure 11 are described in detail in the next section.

4.2 Critical success factors

From the literature and figure 11, seven critical factors of short-sea shipping success have been identified. The development and focus on these factors will be important in establishing a successful short-sea shipping service. In the following each of these factors are presented and described in greater detail.

4.2.1 Customer satisfaction

One of the most important aspects of a product or service is to satisfy the customer's demand. Pursuing customer satisfaction is essentially what a company must do to stay in business (Cochran 2003). From the above literature review we can identify seven service and operational demands request by transport customers. It is especially important for short-sea shipping to at least offer matching values of these factors compared to road transport. Only then will short-sea shipping be able to compete for market shares. The seven customer demands are:

- Reliability and punctuality
- Prices
- Door-to-door
- Time
- Frequency
- Flexibility
- Easy to buy

4.2.1.1 Reliability

Reliability is connected to the quality of the service. The customer must be able to rely on the short-sea shipping company that the cargo will be delivered to the receiver at the appointed time and in the right condition. High risks of damage to the cargo and delays in delivery will avert the customers to choose sea freight. It is therefore crucial that a shipping service is dependable and punctual. A key to improving reliability is to reduce the risk of unforeseen delays and to handle the cargo with care through standardised processes.

4.2.1.2 Prices

The transport price is in many cases the decisive factor for a customer. A survey conducted by SITMA in 2010 revealed that transport customers are willing to consider short-sea shipping as an alternative mode to road transport, but at the same time demanding reduced prices (SITMA 2010). Shipping has the potential to explore economies of scale and thus offer competitive prices. However, this positive effect of economies of scale requires large volumes of goods, which is currently not present in the market for short-sea shipping. At the same time, the costs of port services and taxes are increasing, conflicting with the attempt to create a modal shift. Increasing transport volumes can be done through consolidation of cargo and cooperation with other transporters and customers.

The price issue can be presented as a loop where both parties (short-sea shipping company and the customer) are dependent on each other to satisfy the other part. The customer demands lower prices while the carrier require higher demands to lower prices. A possible solution for exiting the loop is to agree upon a contract establishing mutual responsibilities.

4.2.1.3 Door-to-door delivery

In most cases, door-to-door deliveries require multimodal transport when short-sea shipping is involved. Transport customers will choose simplicity over complexity. If using short-sea shipping requires more planning and administrative work for the customer it will opt out short-sea shipping as a viable alternative. Door-to-door deliveries have to be included in the transport service product and available to the customer without causing extra work for the customer.

4.2.1.4 Time

Time is here referred to as the lead-time of a door-to-door delivery. The lead-time is affected by the transport time, handling time, transfer times, time in port etc. The lead-time is often restricted by the customer and is one of the most important decision variables when choosing transport mode. Efficiency at all stages of an intermodal transport system is essential to reduce the lead-times of short-sea shipping. Longer lead-times can alternatively be balanced with lower transport prices.

4.2.1.5 Frequency

The frequency of a shipping service is highly dependable on the volume. A liner service will have a scheduled route with regular departures from each port. The frequency of departures each week is regulated by the demand for sea freight. The frequency problem is similar to the problem of transport prices. The customer demands higher frequencies while the carrier require increased volumes before increasing the frequency. Similarly, a contracted agreement is appropriate to resolve the frequency problem.

4.2.1.6 Flexibility

Flexibility is here defined as the ability to adapt to changing transport demands. The flexibility offered by road carriers is very hard to match. Trucks can provide the right amount of capacity within reasonable time to a reasonable price and is able to deliver door-to-door with the lowest possible lead-time. In shipping, flexibility can be increased with increased frequencies, which again is dependent on cargo volumes. A suggested solution is that flexibility can be increased through a higher degree of cooperation between the transport suppliers in an intermodal chain.

4.2.1.7 Easy to buy

Short-sea shipping services must be easily accessible. As mentioned earlier, the transport customer will always choose the easiest solution. The European Commission (2004) suggested one-stop-shops for managing and commercialising short-sea shipping: "*Logistics chains involving Short-sea Shipping should be managed and commercialised by one-stop shops, such as freight integrators. These shops should offer customers a single contact point that takes responsibility for the whole intermodal supply chain door to door. This requires efforts from all parties but is a win-win situation*" (Commission of the European Communities 2004).

4.2.2 Port efficiency

Ports are the linkage point between short-sea shipping and other transport modes. As has been mentioned earlier, port efficiency is an important link in improving the lead-time of intermodal transport chains, and thus one of the key elements in developing efficient intermodal transport systems. SITMA (2010) defines five areas of importance when improving the efficiency of ports:

- Good infrastructure at the port
- Good communication between ports and transporters and customers
- Well defined working processes
- Integrated IT systems with partners
- Competent staff

SITMA (2010) also recognises the potential benefits of efficiency in establishing logistical hubs or freight hubs at the ports. Efficiency can also be improved by introducing standardised units for easy transfer and cargo handling.

4.2.3 Administrative work

Administrative work should be minimized in order to make short-sea shipping more competitive and an attractive transport mode. In SITMA's (2010) survey information sharing using Information and Communication Technology (ICT) was one of the attributes demanded by potential short-sea shipping customers. Electronic documents and internet-based portals for communication are necessary when reducing the paper work. Reducing the number of steps in the process of buying short-sea shipping will also reduce administrative work. One-stop-shops can create a good environment for buying sea freight, and documents and paper work is kept to the minimum.

4.2.4 Public Facilitation

Increasing the market share of short-sea shipping require the appropriate facilitation by the government to create equal competitive conditions for the different modes. Players in the maritime transport industry in Norway claims that the public favours road and rail regarding the current fee structure. Though they cannot provide sufficient data to confirm the actual situation, they feel that the public framework of competition is a hindrance for the development of short-sea shipping (SITMA 2010).
According to SITMA (2010) is the fee structure for sea freight subject to higher user financing costs compared to road traffic. However, expenses related to environmental costs are comparatively low for sea transport. In addition maritime transport has significant tax advantages.

SITMA (2010) conducted a case study to examine the level of fees imposed on the sea freight industry. The study revealed 10 taxes and fees connected to short-sea shipping, whereof 9 incurs regardless of the ship is loaded or not. The taxes and fees accounted for 37%-45% of total operating costs of the ships being surveyed. This suggests the fee structure can be a hindrance for short-sea shipping developments.

TOI (TOI 2011b) has performed a scenario analysis, looking at the consequences of reducing taxes and costs in freight transport, and then compared the effect amongst road, sea and rail. The analysis is done for domestic transport of general cargo, and the base scenario is based on prognoses for 2020. The different measures examined are reduced terminal costs (50 % reduction in direct costs and 25 % reduction in loading and unloading times), elimination of commodity fees, elimination of port and call fees, and doubling of fuel fees. The analysis does not consider changes in transport demand for 2020. The effect on transport work for the different modes is given in table 10.

	Effect on tonne-kilometres on domestic cargo transport		
	Road	Sea	Rail
Reduced terminal costs (direct costs -50 %, loading/unloading times - 25 %	*-5.4%*	*+17.9%*	*+1.3%*
Elimination of commodity fees	*-1.0%*	*+23.8%*	*-7.5%*
Elimination of port and call fees	*-0.6%*	*+3.3%*	*-1.5%*
Double fuel fees	*-9%*	*+8%*	*+11%*

Table 10 Scenario analysis of effect on transport work

This scenario analysis shows that all of the measures examined will have a positive effect on inland shipping transport work. Eliminating the commodity fees will have greatest effect on the distribution of transport work between the three modes. While inland sea transport work increases, all of these measures will reduce road transport work of general cargo.

4.2.5 Intermodal focus

In section 3.1.1, intermodal transport systems were described as crucial in developing short-sea shipping. Creating efficient intermodal transport systems will to a large extent require cooperation between the involved parties, including the transport customer and the suppliers of transport on the different legs in an intermodal chain. The European Commission (2001) suggested in 2001 a development of a new profession within logistics: freight integrators, specialising in the integrated transport of full loads. The Norwegian government emphasises the development of freight interchanges or hubs (Avinor et.al. 2010). Freight hubs are important in establishing intermodal solutions, and to eliminate sub-optimisation in the different transportation sectors (i.e. road, rail, shipping). Such hubs will enable the transporters to consolidate transport volumes, to take advantage of the strengths of each transport mode, and to develop efficient transfer processes between different modes.

4.2.6 Industry image

The perceived image of the short-sea shipping industry can have a negative effect on the demand. Fancy, new trucks with bright colours and up to date technology seems more attractive than a rusty, old fleet with slow speed and black smoke. Though this is not a representative description of all ships, it is possible that such perceptions are creating a lack of enthusiasm to explore the possible benefits of short-sea shipping. A renewing of the short-sea shipping service's image can help motivating transport customers to demand sea freight. Better marketing and promotion of short-sea shipping is key to an improvement of the image. Marketing and promotion will also help to spread knowledge about short-sea shipping possibilities and the potential benefits of a modal shift.

4.2.7 Environmental issues

Shipping is environmentally friendly in terms of CO2 emissions from burning fossil fuels. However, shipping is subject to relatively large emissions of SO2 and NOx, which must be dealt with and reduced in order for a short-sea shipping transport system to be environmentally friendly in the future. Reduction in SO2 and NOx emissions can be achieved by using ships operating on liquid natural gas (LNG) instead of fossil fuels. LNG is a non-toxic and non-corrosive gas primarily composed of methane, and is described by CLNG (2011) as a safe and environmentally friendly fuel. Studies show that using LNG as fuel in ships has the potential to reduce CO2 emissions by 30 %, NOx emissions by 80 % and close to eliminating the emissions of SO2 and particulate matter (Petro Maritim 2010, Bellona 2009).

However, since LNG is composed of mainly methane, which is a heavy greenhouse gas, the combustion of LNG will cause emissions of methane so large it can potentially naturalize the benefits of reducing CO2, NOx and SO2 emissions (Gass Magasinet 2011). This emission is especially significant when LNG is combusted in small engines, and is thus a threat to the environmental friendliness label of short-sea shipping. A recent article says that LNG-vessels are larger air polluters than ships in today's fleet (Teknisk Ukeblad 2011).

PART III

5 AS-IS situation: Grieg Logistics' cargo flows

This chapter is dedicated to describing how the base-to-base transport of oil related equipment is performed by Grieg Logistics at present. The scope of the research is limited to the transport of oil related equipment between supply bases located in Tananger and Dusavik (Stavanger,) Mongstad and Kristiansund. The supply bases are described in the first section, then the cargo characteristics are exmined. Data on the cargo volumes and flows are presented for the last three years (2008-2010).

5.1 The supply bases

The following sections give a general description of the three supply bases included in this research. A complete view of the location of these supply bases and all the other supply bases on the Norwegian coast in provided in appendix 1.

5.1.1 Stavanger

There are two supply bases located in the Stavanger region; NorSea Tananger and NorSea Dusavik.
NorSea Tananger was the first offshore supply base on the Norwegian coast, established in 1965. Situated in Risavika Harbour 18 km outside Stavanger, NorSea Tananger has served the oilfields in the southern parts of the Norwegian Sea for over 30 years. Today Risavika Harbour is the main commercial port in this region. 60 % of the 950 000 m^2 is fully developed, and there is an additional 150 000 m^2 available for future expansion (Norsk Oljemuseum 2005a, NorSea Group 2011a). Risavika Harbour is a national and international centre for oil-related activities and logistics, hosting over 60 international companies (NorSea Group 2011a).

NorSea Dusavik was establishe only a year after NorSea Tananger, due to the increased oil exploration activities in the Norwegian Sea. With more than 60 service companies specialising in drilling, fabrication and workshop activities, sub sea and heavy duty mooring equipment, NorSea Dusavik is the center for supply and support activities in the southern North Sea for Statoil, Total E&P Norway and ExxonMobil (NorSea Group 2011b).

5.1.2 Mongstad

Located just north of Bergen, Mongstad Base is currently the largest supply base in Norway, measured in tonnage and number of ship calls. Fully owned by Frank Mohn AS, Mongstad Base supplies Statoil's installations on the continental shelf, offering total solutions for logistics, repair and modification work (Mongstadbase 2011, Norsk Oljemuseum 2005b).

5.1.3 Kristiansund

There are two supply bases located in Kristiansund; Vestbase and Kristiansund Base. Vestbase, which is owned by the NorSea Group, is strategically placed for providing efficient services to the oilfields off the coast of Mid-Norway. Vestbase was built in 1980 in cooperation with Statoil and Kristiansund Municipality (NorSea Group 2011c, Vestbase 2011, Norsk Oljemuseum 2005c).

Kristiansund Base is located on Averøy, just south of Kristiansund. Established as a joint venture between ASCO Norge AS and Mongstad Base in March 2009 this is the newest supply base on the Norwegian Coast (Kristiansund Base 2011).

5.2 Description of the cargo

The base-to-base transport is primarily oil related equipment being transported from the equipment supplier to the supply base and then to the oilrigs that needs the equipment. 99 % of all the base-to-base traffic is transport of oil related equipment. Due to the nature of the operations on the offshore installations, equipment demand is often unpredictable and supply is often critical. This cargo is thus characterised by a high level of urgency and high renting costs, making delivery times an important issue.

The equipment in question range from (Offshore Norway 2011):

- Drilling equipment
- Material and product handling equipment
- Pumps
- Tanks, vessels and columns
- Instruments and control equipment
- Pipes, tubes and hoses
- Valves
- Chemicals, oils, paint

Picture 2 12ft Offshore Container
Source:
http://www.swireos.com/Portals/0/PDF_datasheet/12ft%20container.pdf

Picture 1 10ft Half Height Basket
Source:
http://www.swireos.com/Portals/0/PDF_datasheet/10ft%20Half%20Height%20Basket.pdf

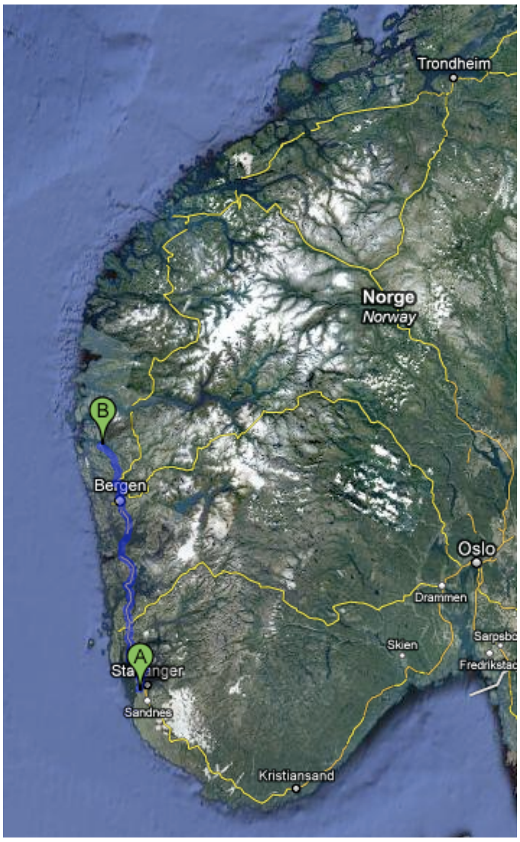
The equipment is usually transported in 10-20 ft containers and baskets (pictures 1 and 2), as general cargo, and should in practice be easy to transfer from road transport to sea transport. However, the containers and baskets used in the oil and gas business is not identical to the ISO containers. This is because the different oil companies have chosen different container designs when constructing the oilrigs. As a result the transport companies must use a lot more effort when securing the cargo for transport. Another issue connected to the non-standardised containers is the cargo handling. Different carriers require different handling equipment and influence the handling efficiency. It can also limit the capacity utilization when different sized cargo carriers are used on the same transport.

Most of the oil equipment suppliers are located in the Stavanger area. The oil companies can rent the equipment, and is charged by the day. After a customer has returned the equipment it must be serviced before the next customer can have it. This means that when the equipment has been used by one of the oilrigs serviced by Mongstad Base it has to be returned to Stavanger for service before an oilrig outside Kristiansund can receive it.

5.3 *Description of the routes*

5.3.1 Stavanger – Mongstad

Stavanger and Mongstad is located on the west coast of Norway, approximately 280 km apart. It takes about 4 hours and 40 minutes to drive from Stavanger to Mongstad, including two ferries on the way[5]. Grieg Logistics has one truck operating a scheduled route travelling this distance each day. This transport must be booked before a preset time, charging a price per tonne. The rest of the transport depends on the demand, and are often express deliveries loaded at any hour.



Picture 3 Stavanger – Mongstad

On average a total 10-15 trucks travels between the supply bases in Stavanger, Mongstad and Kristiansund.

Stavanger-Mongstad is the largest trade route in terms of number of shipments, and the second largest in terms of volumes. For the years 2008 to 2010, 63 181 tonnes where transported by Grieg Logistics between these bases (figure 12). On average, GL provided transport for 21 060 tonnes of oil related equipment from Stavanger to Mongstad, each year, though there has been a slightly decrease in number of shipments over the years. This is due to a decreased activity level at Mongstad Base the past 2-3 years. This reduction is a result of a northern shift in the oilfield, increasing the demand at the supply bases located further north.

[5] Estimated with Google Maps (http://maps.google.com/)

This route is also the route with most loading and unloading of cargo between the supply bases. This is due to the location of other bases between Stavanger and Mongstad, such as the Coast Center Base (CCB) in Ågotnes, Bergen.

40 325 tonnes, equal to 64 % of the total volume, are classified as BB-assignments; shipments transported by truck between the two supply bases.

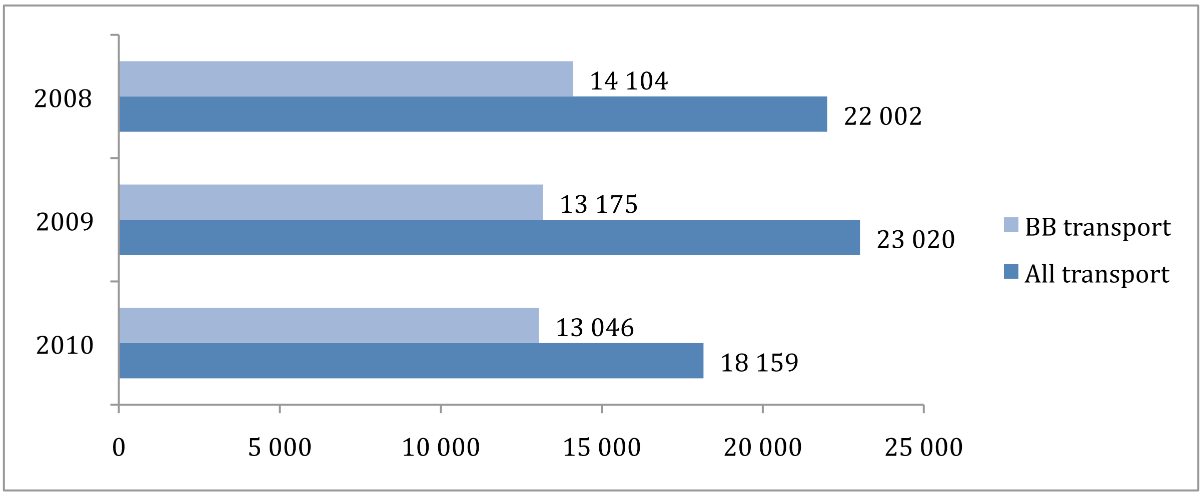


Figure 12 Volumes transported by Grieg Logistics, Stavanger-Mongstad (tonnes)

5.3.2 Mongstad – Stavanger

The cargo flow between Mongstad and Stavanger is the largest one in terms of volume of oil equipment transported in the period 2008 to 2010, with a total of 67 769 tonnes delivered (including co-loadings) (figure 13). There has been a decrease in volumes from 2008 to 2010. The activities at Mongstad Base has decrease as a result of the oilfield activities moving further north, changing the demand for oil related equipment to supply bases located further north.

98 % of all the volume was transported directly from Mongstad to Stavanger (BB-assignments).

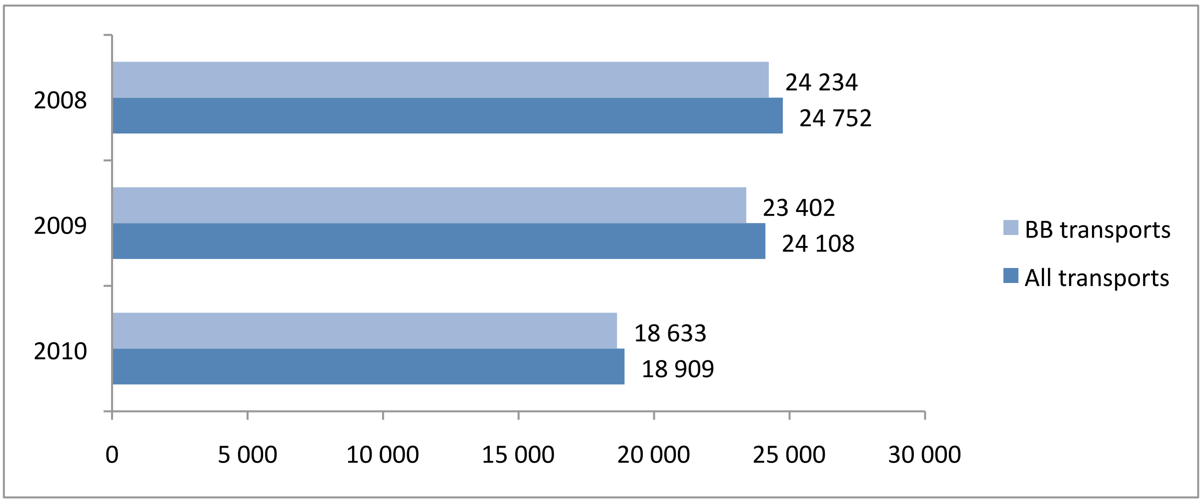
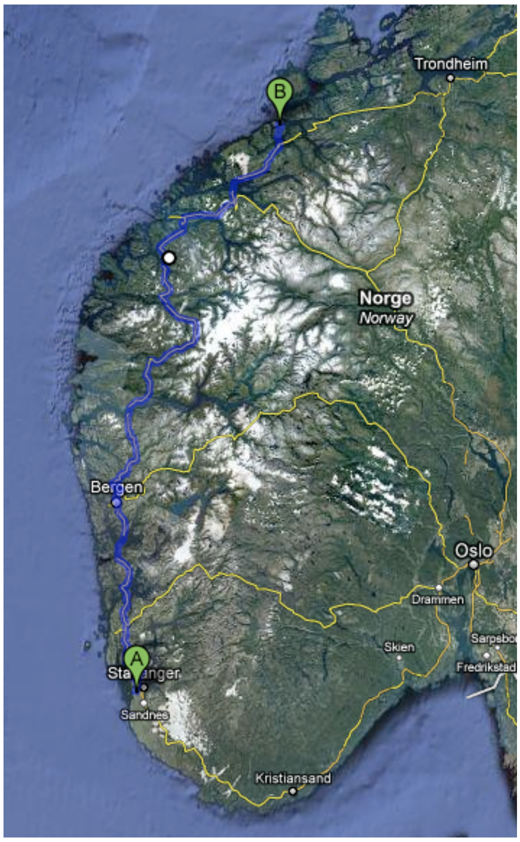


Figure 13 Volumes transported by Grieg Logistics, Mongstad-Stavanger (tonnes)

5.3.3 Stavanger – Kristiansund

The travelling distance between Stavanger and Kristiansund is about 720 km, following E39. The travelling time is about 12 hours driving on E39, including 5 ferries[6].



Picture 4 Stavanger - Kristiansund

Grieg Logistics' flow of oil related equipment between Stavanger and Kristiansund is a medium sized one compared to the six other flows described here. A total of 12 035 tonnes of oil related equipment was delivered from Stavanger and Kristiansund. This route has experienced a growth of over 40 % from 2008 to 2010. This is highly due to the northern shift in the oilfields, increasing the demand for supply base services in Kristiansund. Since the equipment service is performed in Stavanger the transported volumes between these two regions will increase, as the equipment needs service before the next customer gets it.

[6] Estimated with Google Maps (http://maps.google.com/)

10 294 tonnes, equal to 86 % of the transported volume, was classified as BB-assignments over the 3-year period (figure 14).

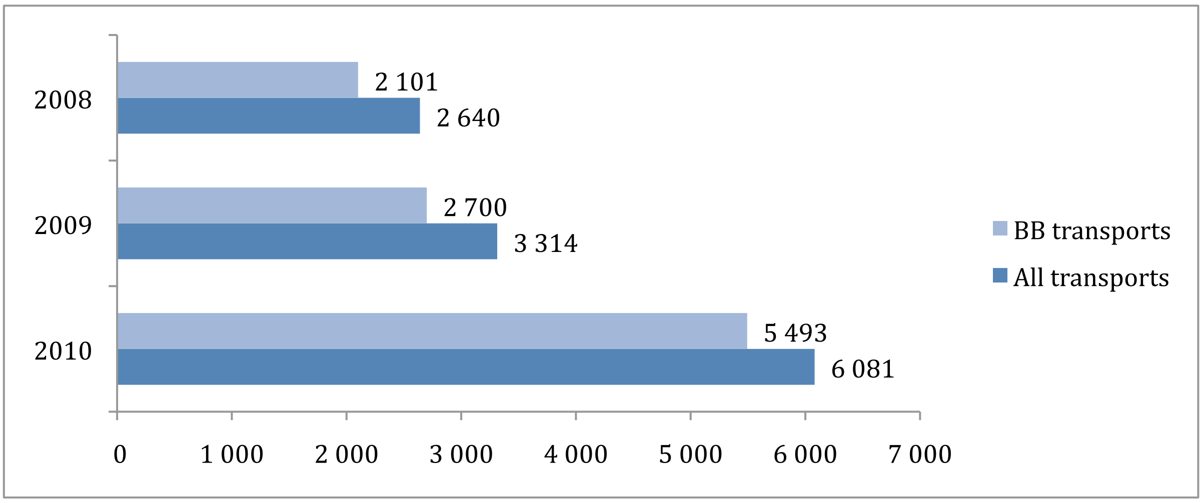


Figure 14 Volumes transported by Grieg Logistics, Stavanger-Kristiansund (tonnes)

5.3.4 Kristiansund – Stavanger

From Kristiansund, a total of 13 817 tonnes were delivered by Grieg Logistics to Stavanger in the period 2008 to 2010 (figure 15). This trade route is the route with the highest increase in weight transported, with an increase of 63 % from 2008 to 2010. Some of this increase can be explained by the geographical shifts of the oilfields. However, some of this volume is also equipment picked up north of Mongstad, which is to be returned to Stavanger via Kristiansund.

Picture 5 Mongstad - Kristiansund

Over the 3-year period, the BB deliveries amounted to 11 388 tonnes, equal to 82 % of total volumes transported between Kristiansund and Stavanger.

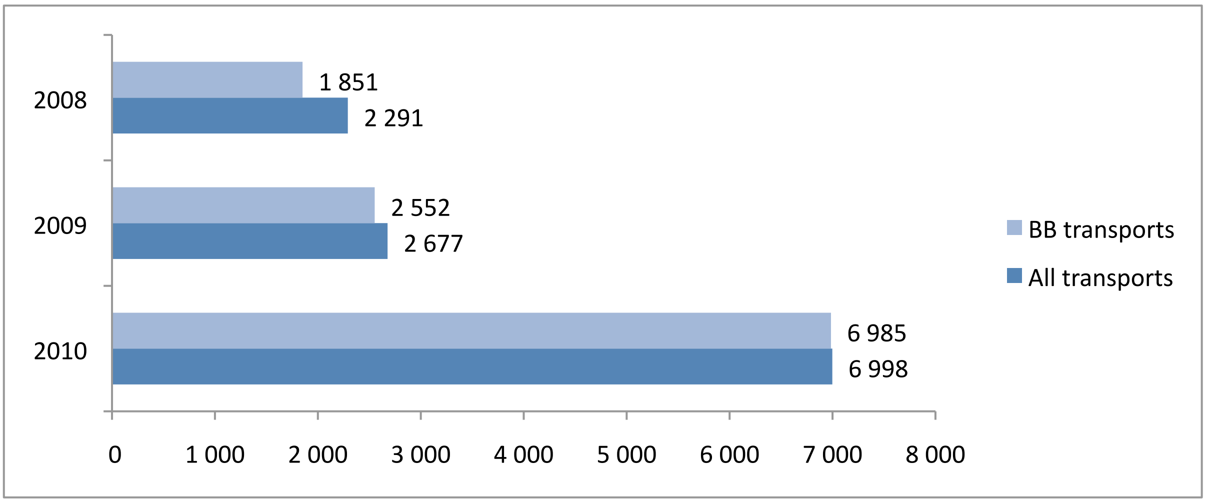


Figure 15 Volumes transported by Grieg Logistics, Kristiansund-Stavanger (tonnes)

5.3.5 Mongstad – Kristiansund

The driving distance between Mongstad Base and Kristiansund is approximately 490 km, and includes 4 ferries when following E39 and Rv60. It takes about 8 hours and 20 minutes to deliver equipment from Mongstad to Kristiansund[7]. The scheduled routes between these supply bases consists of 2 departures per week.

The route between Mongstad and Kristiansund has the second lowest volume transported over the 3-year period, with 2 120 tonnes delivered (figure 16). In addition, the volume transported by Grieg Logistics has more than halved since 2008. As explained above, the demand for oil related equipment has shifted from the south coast to the mid coast. Equipment stored at Mongstad Base has thus been moved permanently to the supply bases in Kristiansund, resulting in lower transport need between these to regions.

2 067 tonnes, equal to 98 %, were direct deliveries from Mongstad Base to Kristiansund Base and Vestbase (BB-transports).

[7] Estimated with Google Maps (http://maps.google.com/)

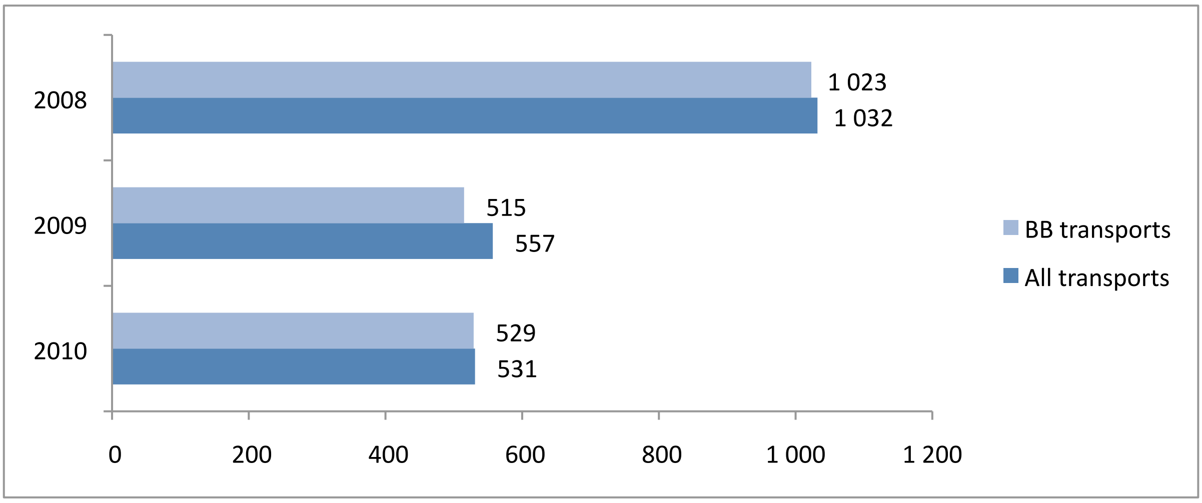


Figure 16 Volumes transported by Grieg Logistics, Mongstad-Kristiansund (tonnes)

5.3.6 Kristiansund – Mongstad

In terms of volume, the cargo flow between Kristiansund and Mongstad is the smallest of Grieg Logistics base-to-base transports, with only 1 481 tonnes transported in the years 2008 to 2010 (table 17).

Similar to the 5 flows described above, most of the transport assignments are BB-assignments (91 %).

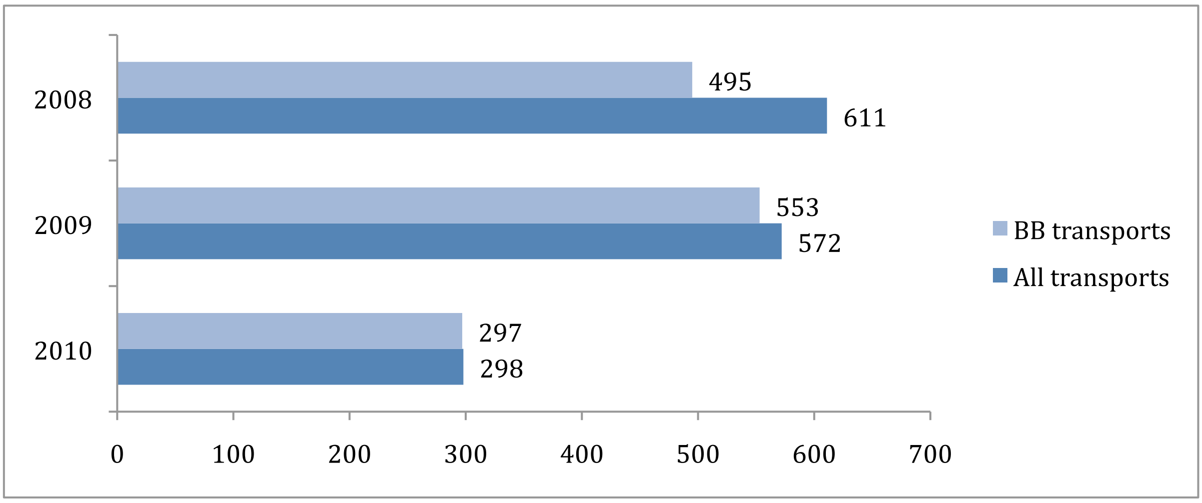


Figure 17 Volumes transported by Grieg Logistics, Kristiansund-Mongstad (tonnes)

The three routes described here represent the largest cargo flows of Grieg Logistics' base-to-base transports. Comparing the three combinations of roundtrips, i.e. Stavanger - Mongstad, Stavanger – Kristiansund and Mongstad – Kristiansund, the cargo volumes transported in each direction is well balanced for all three roundtrips. Much of the cargo transported to a supply base for transportation to offshore installations has to be returned to the supplier when the offshore installation is done with the equipment. As a result, when deliveries are made at the supply bases returning goods are loaded for transport back to its origin. This directional balance in cargo volumes is advantageous in all kinds of transport, and is beneficial when trying to establish a short-sea shipping system.

The volumes transported by Grieg Logistics are relatively high compared to the figures of general and containerised cargo transported on the Norwegian coast, presented in tables 4 and 5 in section 3.3. Grieg Logistics has potentially large enough volumes to successfully establish a short-sea shipping service for their base-to-base transports.

6 Environmental and financial performance of Grieg Logistics base-to-base transport in 2010

Emphasising on environmental and financial performance of the transport, the researcher aspires in this chapter to determine some representational key performance indicators which can be compared with corresponding KPI's for a potential short-sea shipping solution.

The environmental performance is limited to emissions of CO_2, and is measured in emission per tonne-kilometres. The calculations are based on information about the transport assignments performed in 2010 by Grieg Logistics.

Financial performance is presented in NOK and measured in NOK per tonne-kilometres.

The measurement of the environmental performance of the base-to-base transport performed by Grieg Logistics today is initiated on the basis of the Green House Gas Emission and Energy Consumption (GEEC) mapping. GEEC is a tool developed by DNV (Det Norske Veritas), who is a project partner in SHIFT, to map the distribution of emissions and energy consumption in a transport system, giving insight to the problem areas and identifying potential areas of improvement (DNV 2011). The difference between GEEC mapping and other pure carbon emission mappings is the identification and visualisation of the energy cost drivers. However, for the base-to-base case only one transport leg of the supply chain will be mapped; the transport between the supply bases in Stavanger, Mongstad and Kristiansund.

The environmental and economic performance findings in this section will be used as a benchmark for a possible liner route replacing the base-to-base transports on road.

6.1 Calculation emissions of CO2 by burning fuel

On average, the molecular structure of a typical diesel oil is C12H26, i.e.12 carbon atoms and 26 hydrogen atoms connected in a chain. The burning of 1 litre of diesel produces 2,69 kilos of carbon dioxide (CO_2) (Energi Link 2011).

6.1.1 Density

The density of diesel at 15 degrees Celsius = 845 kilos per m_3 (Statoil 2009). Since 1 m_3 is equal to 1000 l, the density is 0,845 kilos per litre diesel.

2,69 kg CO_2/0,845 kg/l diesel = 3,18343 kg CO_2/kg diesel.

6.1.2 Carbon content

The atomic weight of Hydrogen (H) = 1,00794
The atomic weight of Carbon (C) = 12,0107
The atomic weight of Oxygen (O) = 15,9994

When the burned hydrocarbon molecules react with oxygen (O). The reaction between burned hydrocarbon molecules and oxygen creates energy, were one carbon molecule (C) and two oxygen molecules (O) is connected into CO_2. The molecular weight of CO_2 is (12,0107+(2x15,9994)) = 44,0095 g per CO_2. The average amount of CO_2 per carbon atom is 3,664 (44,0095/12,0107=3,664).

The amount of carbon per kg diesel is thus: 3,18343 kg CO_2/kg diesel / 3,664 = 0,8688 kg carbon/kg diesel (= 87 %).

6.2 Information from Grieg Logistics

To conduct the environmental and economic calculations it is necessary with detailed information about the base-to-base transport performed by Grieg Logistics. For simplifications only the transport assignments for 2010 has been included in the analysis. Grieg Logistics has provided an excel file with the necessary information, consisting of almost 10 000 project lines representing a transport relevant to this base-to-base case. Each project consists of one or several assignments, where each assignment is presented with a number of details. The most important details concerning the AS-IS description of the base-to-base transport is:

Origin and destination – the origin and destination is represented by zip codes. This has enabled the researcher to identify the relevant transports and eliminate local transport, i.e. transport loaded and delivered within the same region (Stavanger, Mongstad, Kristiansund). The zip codes used for filtering are 4001-4099 (Stavanger), 5954 (Mongstad), and 6517 and 6530 (Kristiansund).

The assignment classification – each assignment is classified as BB, NM or NS. BB is the direct base-to-base transport delivered by truck. NM (Norge Mottatt) and NS (Norge Sendt) is the road transport of cargo loaded and discharged between the supply bases (i.e. picked up and delivered at other locations than the supply bases), but with the same project number.

Gross weight – the gross weight represents the actual transported volume.

Freight calculation weight – the freight calculation weight is the weight used to calculate the price of the transport. In most cases the freight calculation weight is higher than the gross weight. The deviations in the weight have high fluctuations. Those transports with high deviation in gross and freight calculation weight are transports were the cargo has low weight compared to the transport capacity it consumes. This is especially true for the express transports were the capacity utilization is low but the cost of the transport is equal to a transport of 100% utilization or more. This is to ensure the transporter gets paid the right price.

In addition to the information given in the dataset, Grieg Logistics' employees at the supply base in Ågotnes provided information about the trucks:

The trucks - Grieg Logistics has 40 semitrailer flatbed trucks operating the base-to-base transport. These trucks has no walls or roof, allowing quick and easy loading and unloading of cargo. The load capacity of each truck is 28 tonnes and runs on diesel. The fuel consumption per truck is 0,55 litres per kilometre, and the average fuel price is 12 NOK per litre.

The data provided by Grieg Logistics is sufficient to calculate the number of trucks used for each project, the gross weight and freight calculation weight for each project, as well as the weight ratio for each assignment, tonne kilometres, CO_2 emissions, and prices. A screenshot of the spreadsheet used in calculating the emission is provided in appendix 2. The results of the calculations are presented in section 6.3.

6.3 *Calculating CO_2 emissions from Grieg Logistics' base-to-base transport*

6.3.1 Problems with co-loadings

The base-to-base transport is not always just transport to and from the bases. There are other supply bases located along the way, as well as customers, creating a need for loading and unloading of cargo (co-loading) during the BB-transport. This complicates the calculations of the CO_2 emissions as the load factor is changing during the transport. It would be unrealistic to just ignore these numbers even though they only account for almost 6 000 tonnes in total in 2010, equal to 12 % of the total volume. These co-loading volumes are thus included in the CO_2 emission mapping of the base-to-base transport. Figure 18 depicts the problem in project number 73112434. This is a transport from Stavanger to Kristiansund, and the project consists of 5 separate assignments. Two of these assignments are being transported from Stavanger to Kristiansund, while the other three are loaded or unloaded or both between these supply bases. The emission of CO_2 per tonne kilometre thus consists of the emission of all these assignments combined.

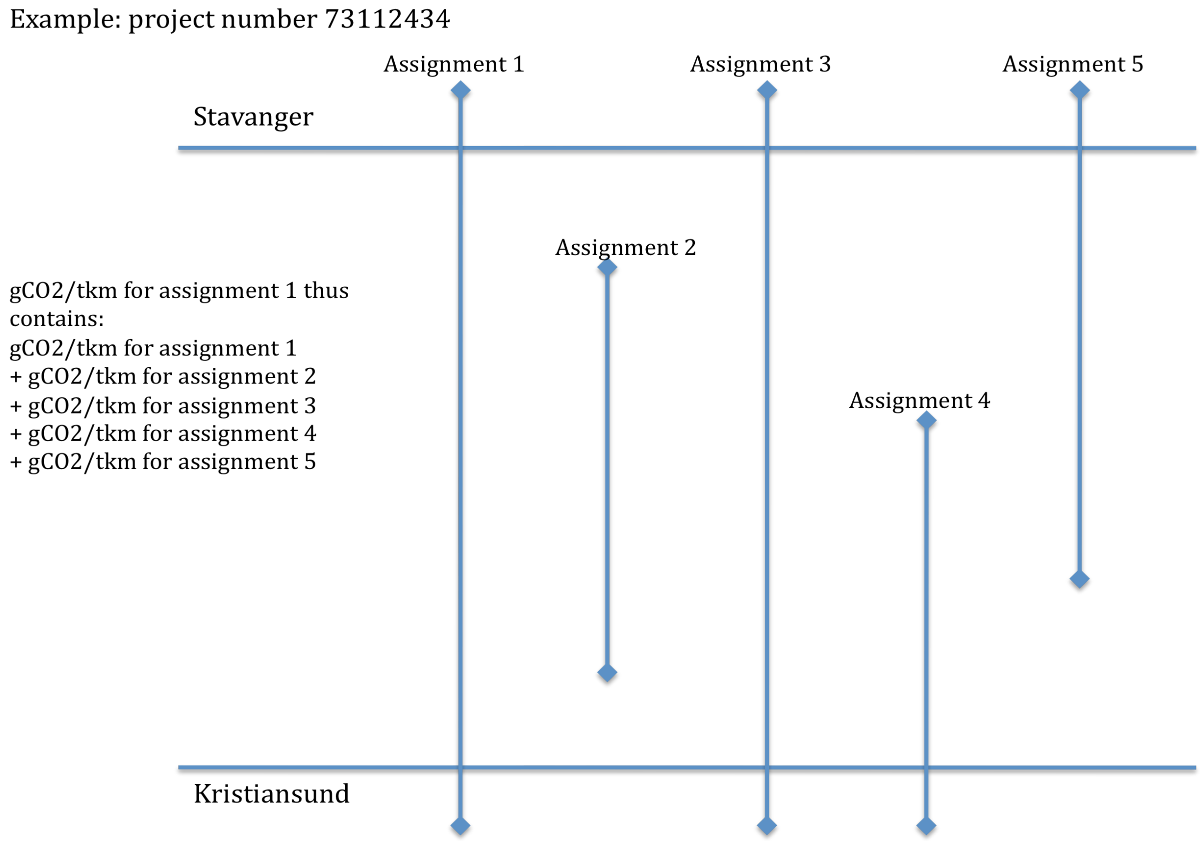


Figure 18 The co-loading problem

The data set provided by Grieg Logistics operates with two different weight measures: gross tonnage and freight calculation weight. Gross tonnage shows the actual transported tonnage. The freight calculation weight is meant to represent the percentage of space used by the cargo and should be a good indication of the capacity utilization. These measurements can however be deceptive. Express deliveries are almost always 100 % utilized regardless of how much space is actually used. The calculation of the freight calculation weight is intended to ensure the transporter receives full payment for his services, which can result in a capacity utilization of over 100 % due to several assignments with high freight calculation weight. As a result, when mapping the CO_2 emissions the gross tonnage is used.

As for the economic performance, the tonne kilometres will only include BB-transports and not the cargo loaded and discharged between the supply bases. However, when calculation the cost the freight calculation weight is used since this is what the customer actually pays for.

6.3.2 The performed transport work

The transport work performed by transporting oil related equipment is calculated using numbers of total transport volumes and the sum of distances between the supply bases.

6.3.2.1 Tonnes transported

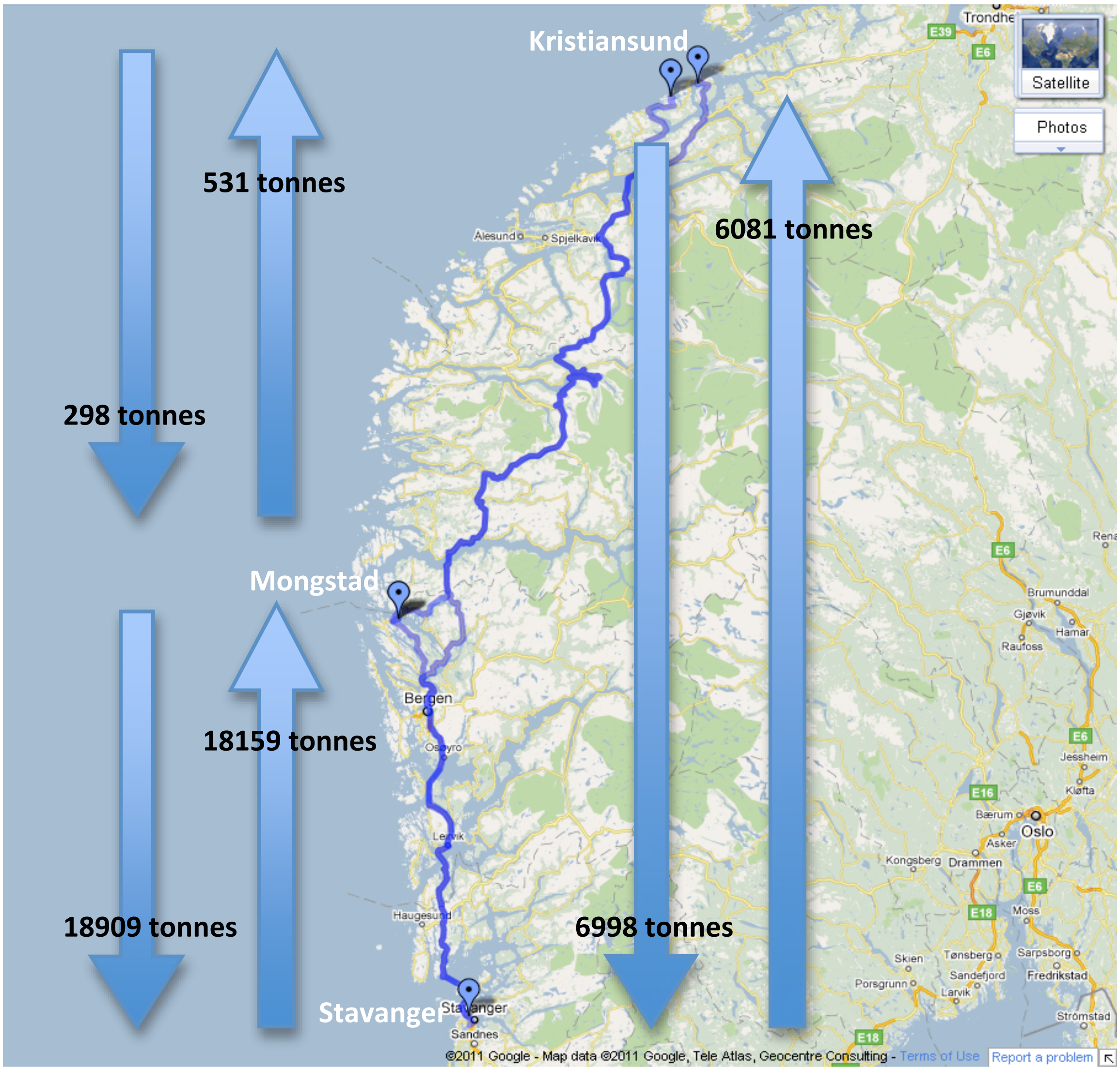


Figure 19 Transported tonnage (gross tonnage) total = 50 976 tonnes

The figure 19 depicts the distribution of the volumes of oil related equipment transported between the three regions explored. The gross tonnage of BB, NM and NS transports are included. The total volume transported in 2010 was 50 976 tonnes.

6.3.2.2 Transport distance (in km)

The distances transported are obtained using Google Maps[8], and is presented for each supply bases. The transported distances in 2010 is equal to 6 504 608 km.

	To	Stavanger	Stavanger	Tananger	Mongstad	Kr.Sund	Kr.Sund
From	Zip Code	4029	4056	4098	5954	6517	6530
Stavanger	4029				271	690	
Stavanger	4056				290	690	690
Tananger	4098				278	690	690
Mongstad	5954	271	290	278		490	490
Kr.Sund	6517	690	690	690	490		
Kr.Sund	6530		690	690	490		

Table 11 Driven distances between the supply bases (in km)

6.3.2.3 Tonne kilometres

The tonne kilometres (tkm) are calculated for all assignments in a project, including the loading and unloading between the supply bases. The tonne-kilometres for each transport distance are shown in table 12.

	TO			
FROM	Stavanger	Mongstad	Kristiansund	Totalt
Stavanger		5 273 922	4 196 221	9 470 144
Mongstad	5 471 048		260 290	5 731 339
Kristiansund	4 828 512	146 025		4 974 537
Totalt	10 299 560	5 419 948	4 456 512	20 176 019

Table 12 Tonne kilometres (including co-loadings)

6.3.3 CO_2 emissions

To establish how much CO_2 is emitted, information about distance, number of trucks, fuel consumption, amount of CO_2 per litre fuel, and load factor of each assignment is necessary. The distances are shown in table 11. The number of trucks used for delivering each project is found by consolidating the projects to identify the total weight. Each truck has a load capacity of 27 tonnes. If the total weight is less than 27 tonnes, one truck is used. If the total weight is between 27 and 54 tonnes, 2 trucks are use, etc. Each truck has a fuel consumption of 0,55 litres per kilometre, and each litre of diesel burned creates 2,69 kg of CO_2. The weight ratio is calculated for each assignment, showing the assignment's percentage of the total weight of the project. gCO_2 is the product of these factors (distance*number of trucks*diesel consumption*CO_2 per litre*load factor). The sum of CO_2 emitted for each distance is shown in table 13.

---

[8] http://maps.google.com/

	TO			
FROM	Stavanger	Mongstad	Kristiansund	Total
Stavanger		496 263 541	518 230 987	1 014 494 528
Mongstad	637 739 430		42 519 918	680 259 348
Kristiansund	619 077 603	24 829 663		643 907 266
Total	1 256 817 033	521 093 204	560 750 905	2 338 661 142

Table 13 gCO_2 emissions for all transports (including co-lodings)

From these calculations, emission of CO_2 per tonne-kilometres can be calculated. The CO_2/tkm is shown in table 14.

	TO		
FROM	Stavanger	Mongstad	Kristiansund
Stavanger		94,10	123,50
Mongstad	116,57		163,36
Kristiansund	128,21	170,04	

Table 14 gCO_2 per tonne kilometre

Total tonnes transported is equal to 50 976 t. The total tonne-kilometres are 20 176 019 tkm and the total CO2 emitted is 2 338 661 142 g. This gives an average emission of 115,91 gCO2/tkm. The results are listed in table 15.

Total volumes transported	50 976 tonnes
Total transport work	20 176 019 tonne-kilometres
Total emissions of CO_2	2 338 661 142 gCO2
Emitted CO_2 per tonne-kilometre	115,9 gCO2/tonne-kilometre

Table 15 Summary of environmental performance of base-to-base transport in 2010

6.3.4 Performance compared to existing CO_2 emission factors

In table 8 in section 3.4.1.2 page 33, IMO's (2009) emission factors was presented, showing an emission range from 80 gCO_2/tkm to 181 gCO_2/tkm, depending on the calculation method and the vehicle type. These numbers show Grieg Logistics' base-to-base transport is average.

Other emission factors exist for benchmarking Grieg Logistics' transport performance. EcoTransIT is a tool for comparison of emission and energy consumption related to the operation of different transport modes, developed by Institute for Energy and

Environmental Research (IFEU 2008). For a Euro 4 truck the total emission of gCO_2 per tonne kilometres ranges from 63 gCO_2/tkm to 107 gCO_2/km (table 16), depending on the type of cargo loaded. For bulk cargo the load factor is equal to 100 %, for average cargo 58 %, and for volume cargo 30 %. The cargo transported in Grieg Logistics' base-to-base service is classified as volume goods in terms of EcoTransIT's cargo description. This gives CO2 emission of 107 g/tkm, which is less than the results for Grieg Logistics.

Emission standard	type of cargo	EC (kJ/tkm)	CO_2 (g/tkm)	NO_X (mg/tkm)	NMHC (mg/tkm)	PM_{dir} (mg/tkm)
Euro 1	bulk	981	65	610	65	19
	average	1.086	72	683	75	21
	volume	1.673	111	1.051	131	37
Euro 2	bulk	946	63	664	47	9
	average	1.044	69	755	55	10
	volume	1.592	106	1.192	91	18
Euro 3	bulk	976	65	492	46	10
	average	1.082	72	553	54	12
	volume	1.665	111	856	93	22
Euro 4	bulk	947	63	314	50	2
	average	1.050	70	353	59	2
	volume	1.616	107	544	102	4
Euro 5	bulk	899	60	184	50	2
	average	996	66	205	58	2
	volume	1.532	102	315	100	4

Table 16 Total emission factors for lorry transport (articulated truck > 34-40 t, motorway, average gradient for hilly countries) (IFEU 2008)

The Network for Transport and Environment (NTM) has established a common base of values for calculating the environmental performance of different transport modes.

Emissions	Gram per tkm Tailpipe	Gram per tkm LCI-data [1]	Gram per tkm Total	Gram per tkm Variation
Carbon dioxide, CO_2 (total)	59	4	**63**	130% - 85%
Carbon dioxide, CO_2 (fossil)	59	4	**63**	130% - 85%
Nitric oxides, NOX	0.50	0.01	**0,51**	130% - 85%
Hydrocarbons, HC	0.02	0	**0,02**	130% - 85%
Methane, CH_4	0	0	**0**	130% - 85%
Carbon monoxide, CO	0.10	0	**0,1**	130% - 85%
Particles, PM	0.01	0	**0,01**	130% - 85%
Sulphur dioxide, SO_2	0	0	**0**	130% - 85%

Table 17 Emission factor for a tractor + semitrailer (NTM 2011)

Using NTM's methodology, the emission of gCO2 per tkm is 63, with variations from 130 % to 85 % (81,9 gCO2/tkm to 53,5 gCO2/tkm) (table 17). The NTM emission factors are based on the following data input:

Max cargo load, ton: 26

Category: (HDV) Tractor + semi-trailer

Vehicle description: Dieseldriven tractor + semi-trailer<26 ton, Euro 3

Cargo quantity, ton: 13

Road category: Motorways

Traffic category: Freeflow

Load factor in %: 50

Fuel consumption in l/km: 0,294

Fuel type: Diesel

Fuel quality: Diesel Europe (low sulphur)

The NTM calculations are based on a higher load factor than the EcoTransIT method, as well as a lower truck standard (Euro 3). It also assumes a free flow of traffic on motorways and a lower fuel consumption, which makes the figures less comparable to the figures of Grieg Logistics' transport. The differences in the emission factors provided by IMO (2009), IFEU (2008), NTM (2011) and Grieg Logistics are connected to differences in load factors, fuel consumptions, vehicle and infrastructure characteristics, and estimation methods. However, given the figures from IMO (2009), IFEU (2008) and NTM (2011) it is reasonable to assume emissions of CO_2 from road transport on average should lie between 63 gCO2/tkm and 181 gCO2/tkm. This gives and average emission factor of 122 gCO2/tkm, which is higher than that of Grieg Logistics (115,9 gCO2/tkm).

6.4 *Financial performance*

The economic performance is based on the prices paid by the transport customers. These prices include fuel costs, toll and ferry costs. On top of the prices comes an 8 % diesel charge due to increased diesel prices. The prices are shown in table 18.

	Per kg				Per tonne				
From Stavanger	**0-25**	**26-100**	**101-500**	**501-1000**	**1001-3500**	**3501-7500**	**7500-**	**Semi**	**Truck**
Mongstad	275	390	620	840	725	725	725	8000	6000
Kristiansund	550	750	950	1300	1400	1350	1300	23000	18000
From Mongstad									
Stavanger	250	380	620	840	550	550	480	8000	6000
Kristiansund	400	650	850	1150	1400	1350	1300	16800	14400
From Kristiansund									
Stavanger	550	750	950	1300	1400	1350	1300	23000	18000
Mongstad	400	650	850	1150	1400	1350	1300	16800	14400

Table 18 Grieg Logistics Price list (plus 8% diesel charge)

6.4.1 Transport work

As explained above, the results will be more realistic if only the tonnage of the BB transports is included, when calculating the tonne kilometres. This is because the prices don't change with the amount of other cargo loaded on the same truck. As a result the tonne-kilometre is slightly lower than for the CO2 emission calculation. The gross tonnage is used since this is the actual transported volume.

6.4.1.1 Transported tonnage

The gross tonnages of the BB-transports are shown in table 19.

	TO			
FROM	Stavanger	Mongstad	Kristiansund	Total
Stavanger		13 046	5 493	18 540
Mongstad	18 633		529	19 162
Kristiansund	6 985	297		7 282
Total	25 618	13 344	6 022	44 984

Table 19 Transported tonnage of oil related equipment (BB-transports)

6.4.1.2 Tonne-kilometres

The tonne kilometres for calculating the economic performance are shown in table 20.

	TO			
FROM	Stavanger	Mongstad	Kristiansund	Total
Stavanger		3 791 197	3 790 281	7 581 478
Mongstad	5 390 896		259 277	5 650 173
Kristiansund	4 819 890	145 600		4 965 490
Totalt	10 210 786	3 936 797	4 049 558	18 197 141

Table 20 Tonne kilometres (BB)

6.4.2 Total costs

If the freight calculation weight is equal to the total weight of a project, then the costs of the transport is the cost of a semi trailer in the cost table (table 18) plus 8% diesel charge, times the number of trucks needed. For all other transports the cost is equal to the freight calculation weight times the cost indicated in table 18 for the given distance, plus 8 % diesel charge. The total costs for each distance is given in table 21.

	TO			
FROM	Stavanger	Mongstad	Kristiansund	Total
Stavanger		17 804 046	14 668 473	32 472 519
Mongstad	18 404 792		1 134 898	19 539 690
Kristiansund	17 021 275	1 550 720		18 571 994
Total	35 426 066	19 354 765	15 803 371	70 584 203

Table 21 Total costs of Grieg Logistics' base-to-base transport

6.4.3 NOK/tkm

The cost per tonne kilometre is shown in table 22.

	TO		
FROM	Stavanger	Mongstad	Kristiansund
Stavanger		4,70	3,87
Mongstad	3,41		4,38
Kristiansund	3,53	10,65	

Table 22 Transport costs per tonne-kilometre

Total tonnes transported to and from the supply bases are 44 984 tonnes. The total tonne kilometres are 18 197 141 tkm and the total cost is 70 584 203 NOK. This gives an average cost of 3,88 NOK per tonne kilometre.

PART IV

7 Establishing a potential short-sea shipping solution

This chapter seeks to establish a potential short-sea shipping solution for the transportation of oil related equipment between supply bases on the Norwegian coast. This work includes the critical success factors established in chapter 4, with a special focus on the first factor: customer satisfaction.

Figure 20 Customer satisfaction criterions

Customer satisfaction is dependent on the reliability of the service, the price, the ability to deliver door-to-door, the lead-time, the number of calls per week, the flexibility of the service, and on how easy it is to buy the short-sea shipping service.

The foundation of the sea-based solution is influenced by Norlines' and Eimskip's existing short-sea shipping service. These two companies represent the transport suppliers in the SHIFT project and they wish to include the base-to-base transport in their current routes, arguing that there is available capacity on these routes and that this will contribute to making the solution(s) as realistic as possible.

In order to make the routes as realistic as possible it is however crucial to take into consideration what the customers of these transports demand from a short-sea shipping service if a modal shift is to be realised. An e-mail correspondence with an informant at one of Grieg Logistics' largest customers of transport of oil related equipment, has provided the researcher with detailed information on what is required from a transport. Information based on this e-mail correspondence will be referred to as 'information from the informant'.

7.1 Information from the transport customer

The following assessment of the critical factors of customer satisfaction is based on information from the informant.

7.1.1 Reliability

Reliability is very important in the transportation of oil related products. The cargo transported is often being transported offshore after arrival at the supply base. The offshore transport service is scheduled and has fixed departures. Equipment needed offshore needs to be delivered at the right supply base within the preset delivery deadline at the supply base. The impact of a delay in delivery can amount to several thousand NOK's in extra costs due to high renting prices on the equipment.

Small deviations in delivery time can be accepted in some cases, but this will require reprioritising of loading and discharging at the supply bases.

7.1.2 Price

Though reasonable transport prices are desirable, it is not the decisive feature when planning the transport. Other factors that are more important include punctuality and environment.

The informant was asked to choose between road and sea transport in different scenarios of price level and environmental impact, assuming all other factors were equal. The scenarios and the informant's choices are presented in table 23. It shows that environmental friendliness has a higher value than lower prices when choosing transport mode. When environmental friendliness is equal for both modes, price is the decisive factor.

Scenario	Informant's choice
Price and environmental impact is equal for both modes	Shipping
Price is equal, shipping has less environmental impact	Shipping
Shipping is more expensive, equal environmental impact	Truck
Truck is cheaper, shipping is more environmentally friendly	Shipping
Shipping is cheaper, environmental impact equal	Shipping
Shipping is cheaper and least environmental friendly	Truck
Road is cheaper and most environmental friendly	Truck

Table 23 Cost vs environment scenarios

7.1.3 Door-to-door deliveries

The informant says that anything other than door-to-door is unacceptable. They do not wish to use resources on procuring transport to and from ports. The transport of oil related equipment is not always subject to intermodal transport as the equipment is delivered at the same port at which the offshore transport is departing from. Rental equipment, which has to be picked up and returned to the supplier located outside a port, requires transport with truck in door-to-door deliveries.

7.1.4 Time

The lead-time requirements vary with the criticality of the equipment being transported, and depend on the different deadlines at each supply base. Express transports of equipment to or from a supplier have to be delivered as quickly as possible. Often there is an offshore vessel waiting for only this particular delivery, before it can departure. Transports of express deliveries take no more than 6-7 hours to deliver from Stavanger to Mongstad.

Transports of less urgency have longer acceptable lead-times. Such transports have to be registered at the transporter within a preset deadline. These deadlines are set to match delivery deadlines at the supply bases.

7.1.5 Frequency

The transport demand is dependent on the offshore operations on the oilrigs. The informant's company is responsible for supplying many rigs, and today's operations require a frequency of 5-7 departures a week. If some of this transport is to be shifted to short-sea shipping, the informant estimates 3-4 ship calls a week is necessary to satisfy the demand.

7.1.6 Flexibility

Flexibility is a highly valued feature of a transport for this company. Changes in operations offshore can take place often and fast, requiring flexible transport solutions to satisfy the demand for equipment offshore. Transport plans made one day can be changed drastically the next day, and logistical 'guards' is available 24 hours a day in case changes should incur.

7.1.7 Easy to buy

The informant's company has agreements with two transport companies for their base-base-transport (including Grieg Logistics). In most cases, the supplier of the equipment procures most of the transport. In these cases, the supplier can buy transport at the same price and terms as the informant's company, and the transport company knows the terms and conditions of the customer.

7.1.8 Environment

In addition to the seven characteristics of a transport presented in figure 20, the informant was asked to comment on the environmental aspect of transport planning. To this, the informant says that the environmental impacts always are considered when planning transport. This is, however, in most cases related to the environmental friendliness of the cargo being transported. Transports of hazardous goods and radioactive materials are transported by sea as a result of restrictions on road transport.

7.2 NorLines

NorLines is a short-sea liner shipping and logistics company with its headquarter located in Stavanger, Norway, and is the largest operator of side port tonnage of scheduled routes within and to/from Norway. Operating 9 general cargo vessels at 1500-4100 DWCC (dead weight cargo capacity) and with more than 600 port calls per week to over 70 ports, NorLines has an established market share within the Norwegian and North-European short-sea shipping market. NorLines is also responsible for all freight transport with Hurtigruten with daily departures from 32 ports along the cost between Bergen and Kirkenes. By offering additional transport by road, rail and air and warehousing, NorLines has the ability and knowledge to offer their customers with a complete system for transport and logistics services.

7.2.1 The vessels

Norlines has three vessels appropriate for a short-sea shipping service of oil related equipment between the supply bases. These are 'Nordkinn', 'Nordvåg' and 'Nordvik'.
Nordkinn is relatively new special purpose container and reefer vessel, built in 2006. She has a deadweight tonnage of 2 737 tonnes and a speed capacity of 16 knots. Nordkinn was purchased by Norlines in 2009 by Eimskip, and was formerly named Storfoss.
Nordvåg and Nordvik were built in 1978 and 1977, respectively. They have similar characteristics, with a deadweight tonnage of 1 450[9].
Complete descriptions of the vessels are provided in appendix 3

7.2.2 The routes

Out of the 9 general cargo vessels operated by NorLines, two of the scheduled routes are suitable for delivering oil related equipment between the supply bases on the Norwegian coast. In the following these routes will be referred to as N1 and N2. The vessels operating these routes are Nordkinn on N1, and Nordvik, Nordvåg and Sunnmøre on N2. Information about the vessels can be found in appendix 1.
The routes operated today by these 4 ships are shown in the table below (table 2). The vessels pass the supply bases at least one time on either the northbound or the southbound trip. In addition it passes several other supply bases (see list of all supply bases along the Norwegian Coast in appendix 3), which offers the possibility of more goods being transferred from road to sea. Table 1 and 2 below shows when the ships are scheduled to be in which port. A complete list of the ports visited on each route is provided in appendix 4.

N1 - Northbound direction		**N1 - Southbound direction**	
Port	*Day*	*Port*	*Day*
Stavanger	Saturday	Kristiansund	Thursday/Friday
Mongstad	Saturday evening	Mongstad	Saturday
Kristiansund	Monday/Tuesday	Stavanger	Saturday evening

Table 24 Scheduled port calls on Norline's route 1 (N1)

[9] http://www.marinetraffic.com/ais/shipdetails.aspx?mmsi=220571000

N2 - Northbound direction		N2 - Southbound direction	
Port	*Day*	*Port*	*Day*
Stavanger	Tuesday	Kristiansund	Saturday
Mongstad	Thursday	Mongstad	Sunday/Monday
Kristiansund	Thursday/Friday	Stavanger	Tuesday

Table 25 Scheduled port calls on Norline's route 2 (N2)

7.3 Eimskip CTG

Eimskip is an Icelandic shipping company founded in 1914, almost 100 years ago. It started offering shipping transport to and from Iceland, and has developed into a total transport solution provider with offices and agents strategically located in North America, Asia and Europe. Focusing on "*forming an unbreakable transport chain from the shipper to the receiver*", Eimskip has a service portfolio consisting of reefer forwarding, general forwarding, warehousing, coldstorage, inland transport, air freight, project services and other logistical activities.

7.3.1 The vessels

Eimskip CTG operates several liner and spot vessels. Three of these vessels are appropriate to consider when establishing a liner service for the base-to-base transport: Holmfoss, Svartfoss and Irafoss. Holmfoss is a liner vessel "*specially developed to operate with general reefer cargoes in exposed sea areas, with relatively high speed and with a high comfort level*" (Eimskip, see appendix 4). Built in 2007, she is the newest vessel included in this research. The deadweight tonnage of Holmfoss is 2 500 tonnes. Svartfoss is also a liner vessel, built in 2005 and has a capacity of 2 750 dwt. Irafoss, built in 1991, has a capacity of 1890 tonnes. See appendix 4 for complete information about the vessels.

7.3.2 The routes

Eimskip operates North Atlantic liner services, connecting Iceland, Norway, Faroe Islands, Newfoundland and Greenland to the continent and the rest of the world. In Norway, Eimskip has six offices, operating liner services with multipurpose reefer vessels sailing from Murmansk, along the Norwegian cost to Holland and the UK (figure 21).

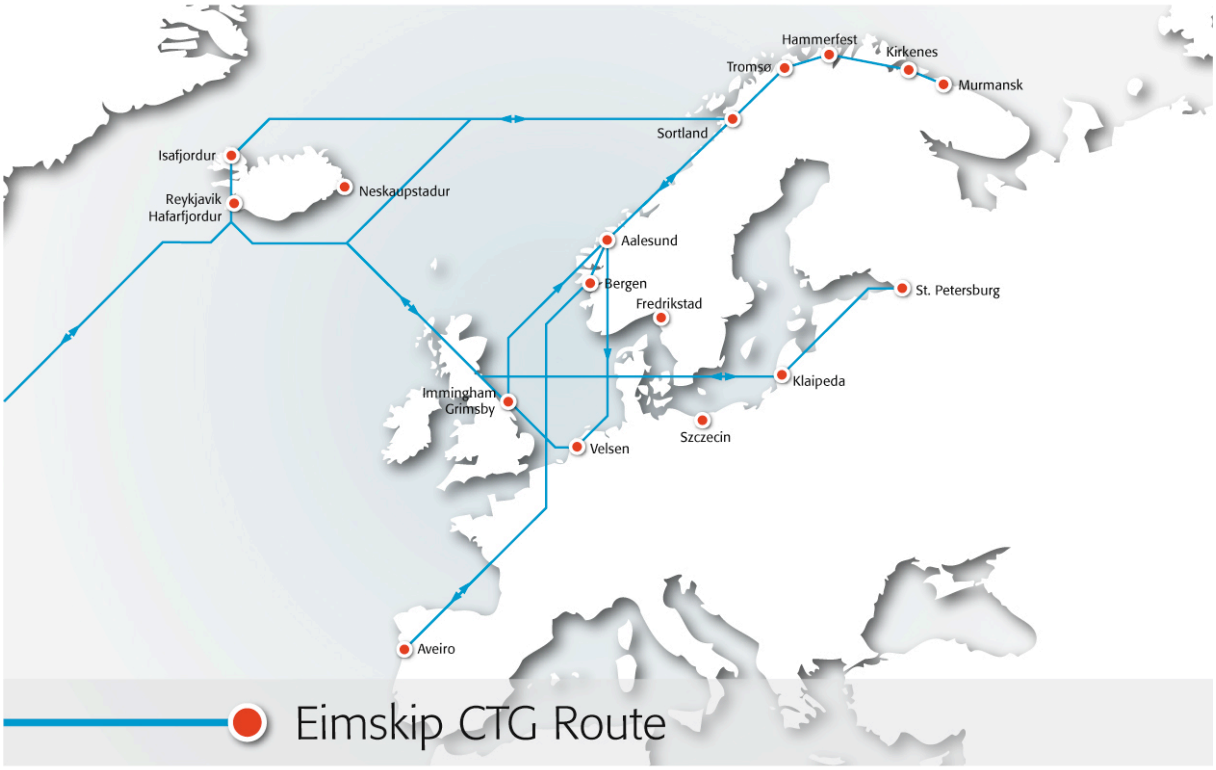


Figure 21 Eimskip CTG Route

Source: http://eimskip.com/no/Liner/Sailing-schedule.html

These vessels visit the supply bases in question as shown in table 26. This route will be referred to as E1.

E1 - Northbound direction		**E1 - Southbound direction**	
Port	*Day*	*Port*	*Day*
Stavanger	Friday	Kristiansund	Thursday
Mongstad	Friday/Saturday	Mongstad	Saturday
Kristiansund	Saturday/Sunday	Stavanger	Saturday evening

Table 26 Scheduled port calls on Eimskip's route (E1)

8 Performance of short-sea shipping

8.1 *Environmental performance*

The extent of air pollution from marine transportation depends on three variables: fuel consumption, distance, and load factor.

8.1.1 Emission of CO2 by burning fuel

On average, the molecular structure of a typical bunker oil is C15H32, i.e. 15 carbon atoms and 32 hydrogen atoms connected in a chain. The emissions of CO_2 are estimated using CO_2 conversion factors provided by IMO (2005) in table 27.

The density of marine gasoil is 890 kg/m^3 (Norsk Petroleumsinstitutt 2009). It is in most cases not necessary to calculate the density of fuel for ships, as the consumption of bunker fuel is expressed in tonnes. The carbon content is listed in table 27.

Type of fuel	ISO Specification	Carbon Content	gCO2/tonne fuel
Diesel/Gasoil	Iso 8217 Grades DMX through DMC	0,875	3 206 000
Light Fuel Oil	Iso 8217 Grades RMA through RMD	0,86	3 151 040
Heavy Fuel Oil	Iso 8217 Grades RME through RMK	0,85	3 114 400
LPG	Butane	0,81	3 030 000
LPG	Propane	0,81	3 000 000
LNG		0,80	2 750 000

Table 27 CO2 conversion factors, gCO2 per tonne of fuel (IMO 2005)

8.1.2 Emissions of NOx

NOx emissions are estimated using a factor of 12,70 g/kWh, provided by Sjödin et.al. (2007). With an energy content of 11 700 kWh/tonne fuel (Lloyd's Register 2008) gives an estimated emission factor of 148 590 gNOx/tonne fuel.

8.1.3 Emissions of SO2

The SO2 emissions are depending on the amount of sulphur in the fuel. For the purpose of this research, a sulphur content of 1,5 % is assumed. One kWh leads to an emission of 5,52 g sulphur (Sjödin et.al. 2007), equal to 64 584 g sulphur/tonne fuel. Since the molar mass of sulphur is half that of SO2, the emission factor for SO2 is thus 129 168 g/tonne fuel (Tiwary and Colls 2009).

8.1.4 Information from Eimskip

Eimskip has provided information about fuel consumption and distances:

Fuel consumption:

- Irafoss - 73 tonnes gasoil per roundtrip (assuming this includes auxiliary machinery fuel consumption).
- Svartfoss - 150 tonnes diesel oil per roundtrip (assuming this includes auxiliary machinery fuel consumption).
- Holmfoss - 140 tonnes HFO and 23 tonnes Ggasoil pr roundtrip.

Distance of roundtrip Murmansk-Bremerhaven: 4 560 km

8.1.5 Information from NorLines

Norlines has provided fuel consumption for Nordkinn. NorlLines has not provided sufficient information about Nordvik and Nordvåg, and the environmental performance of these vessels on route N2 is therefore not included. The distance of the roundtrip is calculated through an online distance calculation service.

Fuel consumption Nordkinn: 142 000 – 148 000 litres per roundtrip. An average of 145 000 litre is assumed. With a density of 890 kg/m^3, fuel consumption is equal to 129 tonnes (Norsk Petroleumsinstitutt 2009). Fuel type is assumed to be heavy fuel oil. Fuel consumption from auxiliary machinery is assume to be equivalent in proportion as for Holmfoss, and equals 21 tonnes of gasoil.

Distance of roundtrip Eemshaven-Kirkenes: 10 576 km[10]

8.1.6 Estimation of environmental performance of short-sea shipping

Given the information presented above, the performance of a short-sea shipping service can be estimated. The results of the environmental performance are presented in table 28.

Neither NorLines nor Eimskip has presented figures for capacity utilization. Estimates are therefore calculated for load factors of 40 %, 50 %, 60 %, 70 % and 100%.

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[10] Calculated at http://www.axsmarine.com/public/

		Holmfoss	Irafoss	Svartfoss	Nordkinn	Nordvik	Nordvåg
Dwt		2 500	1 890	2 750	2 737	1 450	1 450
Load capacity (90% of dwt)		2 250	1 701	2 475	2 463	1 305	1 305
Fuel consumption (tonnes)							
	Diesel/Gasoil	23	73	150	21	UNKNOWN	UNKNOWN
	Heavy Fuel Oil	140			126	UNKNOWN	UNKNOWN
Tonne-kilometres							
	100 %	10 260 000	7 756 560	11 286 000	26 051 861		
	70 %	7 182 000	5 429 592	7 900 200	18 236 303		
	60 %	6 156 000	4 653 936	6 771 600	15 631 116		
	50 %	5 130 000	3 878 280	5 643 000	13 025 930		
	40 %	4 104 000	3 102 624	4 514 400	10 420 744		
Total gCO2		509 754 000	234 038 000	480 900 000	459 740 400		
gCO2/tkm							
	100 %	50	30	43	18		
	70 %	71	43	61	25		
	60 %	83	50	71	29		
	50 %	99	60	85	35		
	40 %	124	75	107	44		
Total gSO2		21 054 384	9 429 264	19 375 200	18 987 696		
gSO2/tkm							
	100 %	2	1	2	1		
	70 %	3	2	2	1		
	60 %	3	2	3	1		
	50 %	4	2	3	1		
	40 %	5	3	4	2		
Total gNOx		24 220 170	10 847 070	22 288 500	21 842 730		
gNOx/tkm							
	100 %	2	1	2	1		
	70 %	3	2	3	1		
	60 %	4	2	3	1		
	50 %	5	3	4	2		
	40 %	6	3	5	2		

Table 28 Results of shipping emissions

8.2 Financial performance

NorLines and Eimskip have not provided sufficient data to estimate costs per tonne-kilometre. The financial performance of short-sea shipping will thus be based on NorLines' price lists available on their web page (Norlines 2011). The prices for transporting cargo batches of different sizes for the different distances are presented in table 29.

	Min. price	1000-1999 kg	2000-4999 kg	5000-9999 kg	10000 kg <
Stavanger-Bergen	2141	1645	1511	1237	1196
Stavanger-Kristiansund	2636	2027	1862	1547	1481
Bergen-Kristiansund	2636	2027	1862	1547	1481

Table 29 Transport prices of short-sea shipping, NOK / tonne (NorLines 2011)

Comparing these prices with the transport prices provided by Grieg Logistics, an estimation of financial performance can be calculated. Table 30 shows the differences in transportation costs assuming a roundtrip delivering 40 tonnes of cargo from each supply base to each supply base, which is the average delivered volume to and from each base given a frequency of 4 deliveries per week, operating 52 weeks per year. The transport costs of road transport is based on the use of two semi trailers one each transport leg.

	Sea	Road
Leg 1 (stv-mon)	47 840	16 000
Leg 2 (mon-kr.s)	59 240	33 600
Leg 3 (kr.s-mon)	59 240	33 600
Leg 4 (mon-stv)	47 840	16 000
Total	214 160	99 200

Table 30 Differences in transport prices per roundtrip

This brief calculation shows that a roundtrip costs NOK 214 160 and NOK 99 200 when transported by sea and road, respectively.

PART V

9 Conclusion

The analysis of Grieg Logistics transport of oil related equipment in their base-to-base segment, provided information about total CO_2 emissions and the performed transport work for 2010. Equivalent numbers has been estimated for a potential short-sea shipping analysis, which is used for comparing the CO_2 efficiency of each of these transport modes.

For comparing NOx and SO_2 emissions, emission factors from table 17 (NTM 2011) is used for road transport.

The emissions for each of the transports are shown in table 31.

	Road	Holmfoss	Irafoss	Svartfoss	Nordkinn
gCO2/tkm	115,9	82,8	50,3	71,0	29,4
gSO2/tkm	0,0	3,4	2,0	2,9	1,2
gNOx/tkm	0,6	3,9	2,3	3,3	1,4

Table 31 Comparing emission factors of road and sea transport

The figures in table 31 shows that when considering CO_2 emissions, short-sea shipping has less emissions, proposing a total reduction of CO_2 emissions of up to 75 %. This result contributes to the environmental benefits of shifting cargo from road to sea.

A roundtrip between Stavanger, Mongstad and Kristiansund by sea is equal to 560 km[11]. Nordkinn emits 43 470 gCO_2 per km. A roundtrip by ship from Stavanger to Kristiansund thus emits a total of 24 343 200 gCO_2. Assuming a 100 % cargo transfer of transport of oil related equipment from road to sea, with a frequency of three departures per week, the average tonnage on each roundtrip is 327 tonnes. This gives a total of 183 120 tkm. Provided these figures, the estimated emission from oil related equipment transported by Nordkinn is equal to 132,9 gCO2/tkm. With an increase in frequency to four departures a week, the emission increases to 177,4 gCO2/tkm. These calculations are presented in table 32.

[11] Calculated using AXS Marine distance table (http://www.axsmarine.com/public/)

NORDKINN	
gCO2 per roundtrip	459 740 400
Distance per roundtrip (km)	10 576
gCO2/km	43 470
Distance of supply base roundtrip (km)	560
gCO2 per supply base roundtrip	24 343 289
Total tonnes transported in 2010	50 976
Scenario 1*	
Tonnes per roundtrip	326,8
Tonne-kilometres	182 991
gCO2/tkm	133,0
Scenario 2**	
Tonnes per roundtrip	245,1
Tonne-kilometres	137 243
gCO2/tkm	177,4

*100% cargo transfer, 3 departures per week, 52 weeks per year

**100% cargo transfer, 4 departures per week, 52 weeks per year

Table 32 Emissions from transporting oil related equipment with Nordkinn

These numbers show that even with a 100 % cargo transfer using the cleanest vessel available, the CO_2 efficiency is much higher for the short-sea shipping solution than for road transport. This does not support a modal shift for transporting oil related equipment between the supply bases.

The analysis and estimates presented in this research does not include oil related equipment to and from other supply bases than Stavanger, Mongstad and Kristiansund. The other supply bases receives and sends transports of oil related equipment, which volumes are not included in this research. Broadening the scope could increase the transported tonnage without increasing the transported distances remarkably and thus reduce the CO_2 emitted per tonne-kilometre.

According to the informant from the transport customer's company, transport agreements were established with two transport companies. If the volume transported by the other company was consolidated with the volume transported by Grieg Logistics and transported together by short-sea shipping, the CO_2 emission results could be improved.

However, CO_2 emissions are not the only pollutants from road and sea transport. Table 31 showed that short-sea shipping had the lowest emissions of CO_2 per tonne-kilometres compared to road, but considering NO_X and SO_2 emissions the table turns.

SO_2 emissions from road are equal to zero (table 17) (NTM 2011). The NOx emissions from short-sea shipping of oil related equipment is presented in table 33.

NORDKINN	
gNOx per roundtrip	21 842 730
Distance per roundtrip (km)	10 576
gNOx/km	2 065
Distance of supply base roundtrip (km)	560
gNOx per supply base roundtrip	1 156 574
Total tonnes transported in 2010	50 976
Scenario 1*	
Tonnes per roundtrip	326,8
Tonne-kilometres	182 991
gNOx/tkm	6,3
Scenario 2**	
Tonnes per roundtrip	245,1
Tonne-kilometres	137 243
gNOx/tkm	8,4

*100% cargo transfer, 3 departures per week, 52 weeks per year

**100% cargo transfer, 4 departures per week, 52 weeks per year

Table 33 NO_X emissions from transporting oil related equipment with Nordkinn

This emission of NO_X per tonne-kilometre is 14 times higher than the estimated emission factor from NO_X emissions per tonne-kilometre for a heavy truck (NTM 2011).

The results presented above suggest that road transport of oil related equipment is more environmentally friendly than short-sea shipping, considering emissions of SO_2, NO_X and CO_2 per tonne-kilometre. Reductions in shipping emissions can be achieved through consolidation of cargo and through new LNG technologies. A modal shift is not financially justified either, with possible higher transport costs for short-sea shipping than for road transport.

In addition to the environmental and financial , the other six critical factors of short-sea shipping success have to be included in the establishment of a short-sea shipping solution. The environmental impact is only a small piece of the picture, and is not an exclusive cause of short-sea shipping success. Customer satisfaction should be the centre of focus, as the demand of the transport customers sets the foundation for how to improve the other success factors and developing a successful short-sea shipping service.

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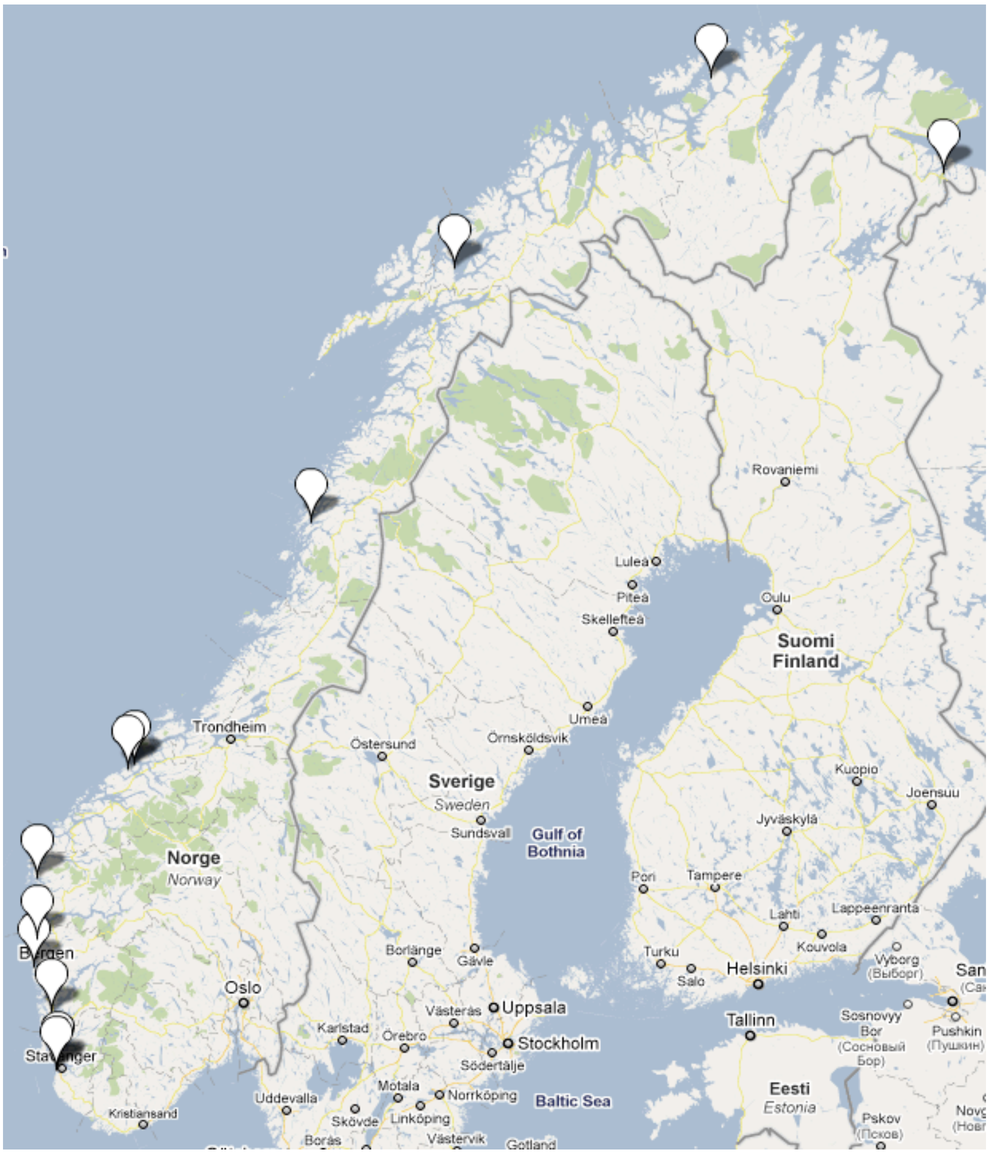
Appendix 1 – Supply bases on the Norwegian Coast[12]

Starting from south:
Norsea AS Tananger, Tananger
Norsea AS Dusavik, Stavanger
AS Stord Base, Stord
Coast Centre Base (CCB), Ågotnes
Mongstad Base, Mongstad
Fjord Base, Florø
Kristiansund Base AS, Kristiansund
Vestbase AS, Kristiansund
Helgelandsbase AS, Sandnessjøen
Nordbase AS, Harstad
Polarbase AS, Hammerfest
Kirkenesbase AS, Kirkenes



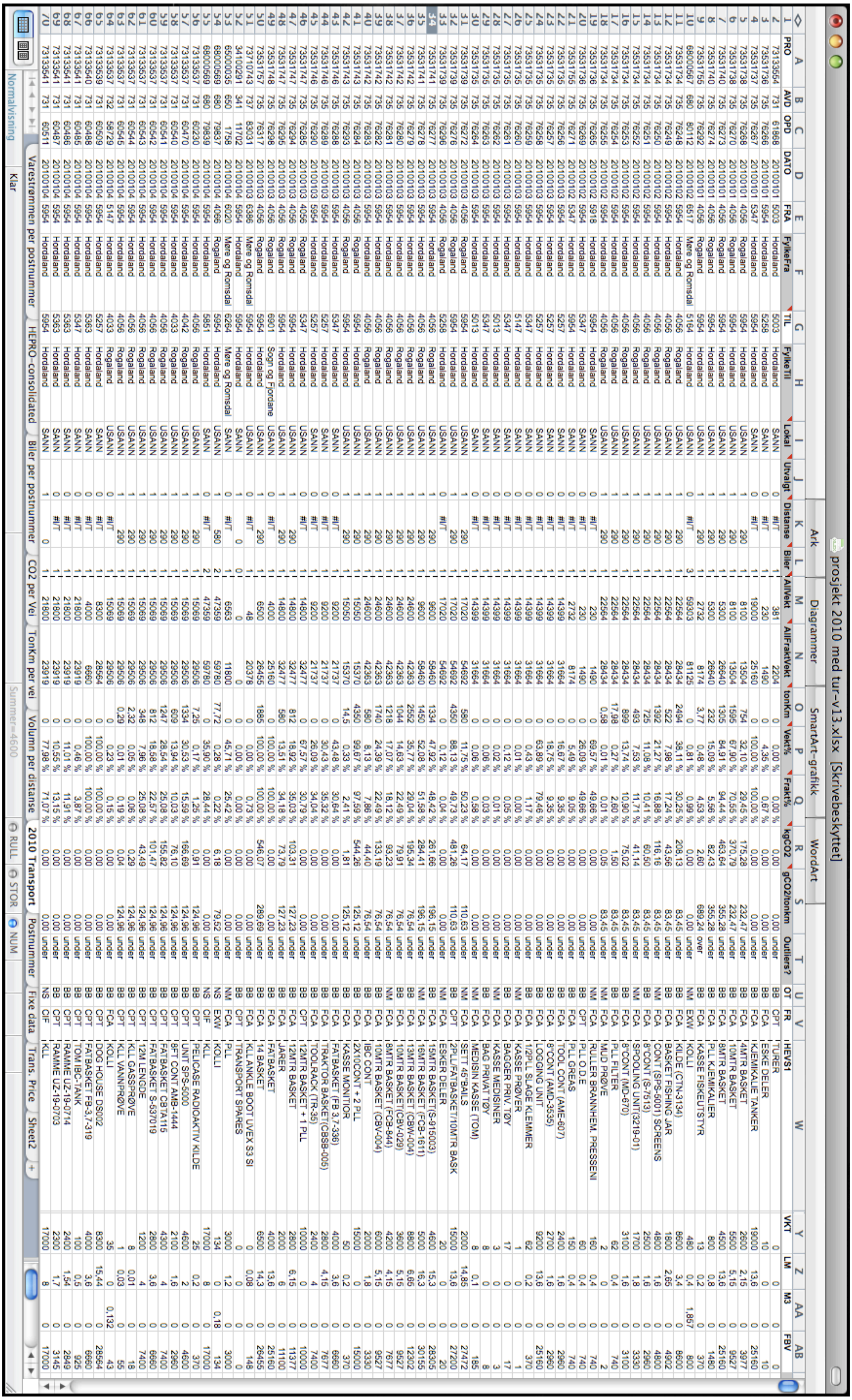
12 http://www.petro.no/maritim/modules/module_123/proxy.asp?C=256&I=13546&D=2

Appendix 2 – Estimates of CO_2 efficiency of cargo ships (IMO 2009)

Type	Size	Average cargo capacity (tonne)	Average yearly capacity utilization	Average service speed (knots)	Transport work per ship (tonne-NM)	Loaded efficiency (g of CO_2/ tonne-km)	Total efficiency (g of CO_2/ tonne-km)
Crude oil tanker	200,000+ dwt	295,237	48%	15.4	14,197,046,742	1.6	2.9
Crude oil tanker	120,000–199,999 dwt	151,734	48%	15.0	7,024,437,504	2.2	4.4
Crude oil tanker	80,000–119,999 dwt	103,403	48%	14.7	4,417,734,613	3.0	5.9
Crude oil tanker	60,000–79,999 dwt	66,261	48%	14.6	2,629,911,081	4.3	7.5
Crude oil tanker	10,000–59,999 dwt	38,631	48%	14.5	1,519,025,926	5.2	9.1
Crude oil tanker	0–9,999 dwt	3,668	48%	12.1	91,086,398	20.7	33.3
Products tanker	60,000+ dwt	101,000	55%	15.3	3,491,449,962	3.3	5.7
Products tanker	20,000–59,999 dwt	40,000	55%	14.8	1,333,683,350	7.2	10.3
Products tanker	10,000–19,999 dwt	15,000	50%	14.1	464,013,471	11.3	18.7
Products tanker	5,000–9,999 dwt	7,000	45%	12.8	170,712,388	14.8	29.2
Products tanker	0–4,999 dwt	1,800	45%	11.0	37,598,072	26.5	45.0
Chemical tanker	20,000+ dwt	32,200	64%	14.7	1,831,868,715	5.7	8.4
Chemical tanker	10,000–19,999 dwt	15,000	64%	14.5	820,375,271	7.3	10.8
Chemical tanker	5,000–9,999 dwt	7,000	64%	14.5	382,700,554	10.7	15.1
Chemical tanker	0–4,999 dwt	1,800	64%	14.5	72,147,958	18.6	22.2
LPG tanker	50,000+ m^3	46,656	48%	16.6	2,411,297,106	5.2	9.0
LPG tanker	0–49,999 m^3	3,120	48%	14.0	89,631,360	27.0	43.5
LNG tanker	200,000+ m^3	97,520	48%	19.6	5,672,338,333	5.4	9.3
LNG tanker	0–199,999 m^3	62,100	48%	19.6	3,797,321,655	8.4	14.5
Bulk carrier	200,000+ dwt	227,000	50%	14.4	10,901,043,017	1.5	2.5
Bulk carrier	100,000–199,999 dwt	163,000	50%	14.4	7,763,260,284	1.8	3.0
Bulk carrier	60,000–99,999 dwt	74,000	55%	14.4	3,821,361,703	2.7	4.1
Bulk carrier	35,000–59,999 dwt	45,000	55%	14.4	2,243,075,236	3.8	5.7
Bulk carrier	10,000–34,999 dwt	26,000	55%	14.3	1,268,561,872	5.3	7.9
Bulk carrier	0–9,999 dwt	2400	60%	11.0	68,226,787	22.9	29.2
General cargo	10,000+ dwt	15,000	60%	15.4	866,510,887	7.6	11.9
General cargo	5,000–9,999 dwt	6,957	60%	13.4	365,344,150	10.1	15.8
General cargo	0–4,999 dwt	2,545	60%	11.7	76,945,792	10.9	13.9
General cargo	10,000+ dwt, 100+ TEU	18,000	60%	15.4	961,054,062	8.6	11.0
General cargo	5,000–9,999 dwt, 100+ TEU	7,000	60%	13.4	243,599,799	13.8	17.5
General cargo	0–4,999 dwt, 100+ TEU	4,000	60%	11.7	120,938,043	15.5	19.8
Refrigerated cargo	All	6,400	50%	20.0	392,981,809	12.9	12.9
Container	8,000+ TEU	68,600	70%	25.1	6,968,284,047	11.1	12.5
Container	5,000–7,999 TEU	40,355	70%	25.3	4,233,489,679	15.2	16.6
Container	3,000–4,999 TEU	28,784	70%	23.3	2,820,323,533	15.2	16.6
Container	2,000–2,999 TEU	16,800	70%	20.9	1,480,205,694	18.3	20.0
Container	1,000–1,999 TEU	7,000	70%	19.0	578,339,367	29.4	32.1
Container	0–999 TEU	3,500	70%	17.0	179,809,363	33.3	36.3
Vehicle	4,000+ ceu	7,908	70%	19.4	732,581,677	25.2	32.0
Vehicle	0–3,999 ceu	2,808	70%	17.7	226,545,399	47.2	57.6
Ro-Ro	2,000+ lm	5,154	70%	19.4	368,202,021	45.3	49.5
Ro-Ro	0–1,999 lm	1,432	70%	13.2	57,201,146	55.2	60.3

Note: "Loaded efficiency" is the theoretical maximum efficiency when the ship is fully loaded at service speed/85% load. Since engine load at the fully loaded condition is higher than the average including ballast and other voyages, the difference between the columns "loaded efficiency" and "total efficiency" cannot be explained by differences in utilization only.

Appendix 3 – Screenshot of Excel Spreadsheet



prosjekt 2010 med tur-v13.xlsx [Skrivebeskyttet]

Ark | Diagrammer | SmartArt-grafikk | WordArt

	AC	AD	AE	AF	AG	AH
1	C-HEPRO	C-Vekt	C-Fvekt	PrisDistanseIdx	TransporPris	Pris+Diesel
2	73133554	0	0	#I/T	#I/T	0
3	73531736	10	10	#I/T	#I/T	0
4	73531737	19000	25160	#I/T	#I/T	0
5	73531738	2600	3977	1	2883,325	3113,991
6	73531738	5500	9527	1	6907,075	7459,641
7	73531740	4500	25160	1	18241	19700,28
8	73531740	800	1480	1	1073	1158,84
9	73531755	13	370	1	620	669,6
10	68000567	480	800	4	1150	1242
11	73531734	8600	8600	5	4128	4458,24
12	73531734	1800	4902	5	2696,1	2911,788
13	73531734	4800	4800	5	2640	2851,2
14	73531734	2500	2960	5	1628	1758,24
15	73531734	1700	3330	5	1831,5	1978,02
16	73531734	3100	3100	5	1705	1841,4
17	73531734	62	740	5	840	907,2
18	73531734	2	2	5	250	270
19	73531736	160	740	#I/T	#I/T	0
20	73531736	60	740	#I/T	#I/T	0
21	73531755	150	740	#I/T	#I/T	0
22	73531735	2400	2960	#I/T	#I/T	0
23	73531735	2700	2960	#I/T	#I/T	0
24	73531735	9200	25160	#I/T	#I/T	0
25	73531735	62	370	#I/T	#I/T	0
26	73531735	1	1	#I/T	#I/T	0
27	73531735	17	17	#I/T	#I/T	0
28	73531735	3	3	#I/T	#I/T	0
29	73531735	8	8	#I/T	#I/T	0
30	73531735	8	185	#I/T	#I/T	0
31	73531739	2000	27472	1	19917,2	21510,576
32	73531739	15000	27200	1	19720	21297,6
33	73531739	20	20	1	275	297
34	73531741	4600	28305	5	13586,4	14673,312
35	73531741	5000	30155	5	14474,4	15632,352
36	73531742	8800	12302	5	5904,96	6377,3568
37	73531742	3600	9527	5	4572,96	4938,7968
38	73531742	4200	7677	5	3684,96	3979,7568
39	73531742	6000	9527	5	4572,96	4938,7968
40	73531742	2000	3330	5	1831,5	1978,02
41	73531743	15000	15000	1	10875	11745
42	73531743	50	370	1	620	669,6
43	73531746	4000	6660	#I/T	#I/T	0
44	73531746	2800	7677	#I/T	#I/T	0
45	73531746	2400	7400	#I/T	#I/T	0
46	73531747	10000	10000	1	7250	7830
47	73531747	2800	11377	1	8248,325	8908,191
48	73531747	2000	11100	1	8047,5	8691,3
49	73531748	4000	25160	#I/T	#I/T	0
50	73531757	6500	26455	1	8000	8640
51	73710743	0	148	4	850	918
52	34100291	0	0	#I/T	#I/T	0
53	65000035	3000	3000	#I/T	#I/T	0
54	68000569	134	134	1	620	669,6
55	68000569	17000	17000	#I/T	#I/T	0
56	73133537	25	370	5	620	669,6
57	73133537	4600	4600	5	2530	2732,4
58	73133537	2100	2960	5	1628	1758,24
59	73133537	4300	7400	5	4070	4395,6
60	73133537	2800	6660	5	3663	3956,04
61	73133537	1200	7400	5	4070	4395,6
62	73133537	8	18	5	250	270
63	73133537	1	55	5	380	410,4
64	73133537	35	43	5	380	410,4
65	73133539	8300	28564	#I/T	#I/T	0
66	73133540	4000	6660	#I/T	#I/T	0
67	73133541	100	925	#I/T	#I/T	0
68	73133541	2400	2849	#I/T	#I/T	0
69	73133541	2300	3145	#I/T	#I/T	0
70	73133541	17000	17000	#I/T	#I/T	0

Varestrømmen per postnummer | HEPRO-consolidated | Biler per postnummer | CO2 per Vei | TonKm per vei | Volumn per distanse | 2010 Transport | Postnummer | Fixe data | Trans. Price | Sheet2

Normalvisning | Klar | Summer= | RULL | STOR | NUM

Appendix 4 – NorLines' vessel operating on N1 and N2

M/V "NORDKINN"
Special Purpose Container / Reefer Vessel

- **Flexible multi purpose cargo/reefer vessel**
- **Very favourable fuel economy**

Contact:
Mobile phone +47 47 48 47 67
Fax +47 47 48 47 70
E-mail: nordkinn@norlines.no

IMO nr: 9333644
Callsign: OZ2080
Flag: Faroe Island
Homeport: Torshavn

Main Dimensions:

LOA	79,99 m
Length between PP	78,15 m
Breadth Moulded	16,00 m
Depth Moulded Shelter Deck	9,10 m
Depth Moulded Main Deck	6,10 m
Scantling Water Line	6,10 m
Design Water Line	5,75 m

Capasities:

Deadweight	2737 t
Gross tonnage	2991 t
Deck Load (conts)	1250 t
Cargo Hold Capasity (4 holds)	4150 m3
Speed	16 knots

Class:
DNV 1A1, Reefer (-27 gr C / +32 gr C)
Container, Ice C, EO
IMO: 9333644
Call sign: OZ 2080
Flag: Faroese (The Faroe Islands, Torshavn)

Tank capacities:

Fuel Oil	303 m3
Fresh Water	52 m3
Water Ballast	1091 m3

Propulsion Machinery:

1x medium speed main eng.	3060 kW
1x reduction Gear with PTO	140 rpm
1x large diameter DP propeller	

Manoeuvring:
1x high lift flap rudder
1x electrohydr. steering gear
1x C.P. sie thruster aft
1x C.P. side thruster forward

Electrical System:
Derric: SWL 75 tons / 19m
2 cargo lifts: SWL 4 tons
4 fork lifts: 2 x 5,0 tons / 4,0 tons / 3,0 tons

Container/deck crane:
50 t - 16 m / 27 t - 21 m / 12,5 t - 24 m

2 cargo lifts:
Platform size: 3,05x1,40 m
Lifting capacity: 4,1 t at 24 m/min.

Net cargo hold areas:

Cargo hold 1	471 m2
Cargo hold 2	252 m2
Cargo hold 3	503 m2
Cargo hold 4	395 m2
Shelter Deck	550 m2
Boat Deck	225 m2

Container capacities:

20' shelter deck	2 (26)
40' shelter deck	20
40' boat deck	8

Accommodation:

Cabins	10

m/s NORDVIK

Contact:
Danish Mobil phone: 30570170
Norwegian mobil: 0047 40448052
Danish Fax: 20371569
Email: Nordvik@seamail.dk
Inmarsat C1 telex: 422057110
Inmarsat C2 telex: 422057111

Description:
Built Norway 1978
Class DNV + 1A1,
Eo kmc Ice-C
Type pallet / sideport vsl with reefer cap.
Imo: 7704837
Call sign: OZBP2
Danish flag
Port of register Nørresundby (DK)

Main particulars:
LOA 88,8
Moulded breadth 14,50
Draft 4,50/5,19m

Tonnage:
Dwat 2,552
GT 2.854 / NT 856

Speed consumption:
abt 12 knots on 8,5t/day

Container capacity:
On deck 53teus
In hold 15teus
Reefer plugs 15pcs
Total deck area 2,336m2
below deck (881m2 t/d, 837m2 m/d, 618m2 t/t)

Crane capacity:
30t on 20m outreach

Refridgerated storage:
abt 780 pallets - 6 temp. regulated holds
-28 to +28dg C. Chilled storage for abt 1,000 pallets

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m/s NORDVÅG

Contact:
Norwegian mobil phone: +47 40448053
Norwegian mobil via satellit: +47 21038073
UK mobil line via satellit: +44 1224672360
Email: nordvaag@seamail.dk
Inmarsat C telex: 42000066@inmc.eik.com

Description:
Built Norway 1977
Class DNV + 1A1, Eo kmc Ice-C
Type pallet / sideport vsl with reefer cap.
Imo: 7704849
Call sign: OZBQ2
Danish flag
Port of register Nørresundby (DK)

Main particulars:
LOA 88,8
Moulded breadth 14,50
Draft 4,50/5,19m

Tonnage:
Dwat 2,552
GT 2.854 / NT 856

Speed consumption:
abt 12 knots on 8,5t/day

Container capacity:
On deck 53teus
In hold 15teus
Reefer plugs 15pcs
Total deck area 2,336m2
below deck(881m2 t/d, 837m2 m/d, 618m2 t/t)

Crane capacity:
30t on 20m outreach

Refridgerated storage:
abt 1000 pallets - 7 temp. regulated holds
-28 to +28dg C.
Chilled storage for abt 850 pallets

Appendix 5 – EIMSKIP CTG's ships operating on the Norwegian coast

HOLMFOSS – liner vessel (http://eimskip.com/no/About/Vessels/H%C3%B3lmfoss.html)

Picture 6 Holmfoss Source:

GENERAL INFORMATION

- **Port of registry** St John's
- **Flag state** Antigua and Barbuda

The vessel has been specially developed to operate with general reefer cargoes in exposed sea areas, with relatively high speed and with a high comfort level.

Some features of the vessel:

- Handle dry cargoes with individual temperature in each cargo hold, totally 5 holds on three decks
- Transport containers and refrigerated containers on open deck
- Loading/unloading by using forklifts in the cargo holds and two cargo lifts operating between cargo deck levels and quay level

Owner – Eimskip, Iceland
Builder – Myklebust Verft AS, Norway
Design – MM 80 Reefer MK II, Multi Maritime AS, Norway

CLASSIFICATION
DNV +1A1, Reefer (-270C/+320C), Container, Ice 1A, EO

MAIN DIMENSIONS
Length over all - 79,99 m
Length between p.p. - 78,15 m
Breadth moulded - 16,00 m
Depth to shelter deck - 9,10 m
Scantling water line - 6,10 m
Design water line - 5,75 m
Service speed - 15 knots

HOLDS DIMENSIONS
Hold 1: 463 m2
Hold 2: 355 m2
Hold 3: 497 m2
Hold 4: 390 m2
Hold 5: 475 m2
Total m2: 2,180 m2
Total cft: 190,716 cubic feet

MAX PERMISSIBLE LOADS
Tween deck and 3rd deck: 2 tons per m2
Tanktop: 1,5 tons per m2

CAPACITIES
Dead weight at dwl. 2500 t
Gross tonnage international: 3500 GRT
Net register tons: 2092 NRT

LIFESAVING & PROTECTION
MOB-boat 6 persons, 40 hp outboard engine
Life rafts 2 x 12 men on each side

CONTAINER CAPACITY - BOAT DECK
40 ft containers 14

ACCOMMODATION
Capacity 11 persons
- 1 man cabins 9
- 2 men cabins 1

Facilities: Mess/saloon, smoker's saloon, change room, trim room, sauna, galley, freezing- and refrigerating room for provisions and laundry.

REFRIGERATION CAPACITY
Net capacity pr. Hold:
- 1 1,330 m3
- 2 865 m3
- 3 1198 m3
- 4 976 m3
- 5 1199 m3

Net volume, total 5568 m3
Hold temperature -27 Celsius

REFRIGERATION PLANT
The cargo holds are cooled by means of gravity air circulationg cooling coils installed under the deck. The coils are designed for pump curculation of $CaCl_2$. The refrigerating machinery system consists of two automatic Brine Chiller Units. Each York unit is equipped with a screw compressor, an electric motor (for frequency control), a shell and tube condenser, and a plate type brine chiller with separator for flooded operation of the chiller. The refrigerant is R717.

SIDE LOADING SYSTEM
One watertight side door (TTS) located Port side
- port size 6,6 x 9 m

Two separate operated cargo lines
- elevator platform size 3,05 x 1,4 m
- elevator capacity 2 x 4,1 t SWL
- elevator speed 24 m/min
- lifting height 12,0 m
- quay heights 5,3 to 12,1 m ab. base line

MACHINERY
Main engine
- 3000 kW at 600 RPM
- HFO at 380 CSt/500C
- reduction gear with PTO for shaft generator

Propeller 4000 mm, CP, 133 RPM
Rudder Hinze Flap Rudder
Steering gear 2 x 450
Side thruster, forward 500 kW
Side thruster, aft 350 kW

POWER PRODUCTION
Diesel generator
- 2 x 738 kVA, 1800 RPM, 450V, 60 Hz

Shaft generator
- 1200 kVA, 1200 RPM, 3 x 440V, 60 HZ

NAVIGATION & ELECTRONICS
Two radars (3/10 cm), ARPA, DGPS, GPS, AIS, eletronic chart system, voyage recorder, gyro compass, magnetic compass, autopilot, echo sounder, speed log and TV monitoring system.

COMMUNICATION
GMDSS radio, GMDSS VHF, VHF, Navtest receiver, telefax, GMS phones, UHF and TV satellite antenna.

ALARM and MONITORING
Standard automation (E0) system for monitoring, alert and control of machinery and systems.

SVARTFOSS – liner vessel (http://eimskip.com/no/About/Vessels/Svartfoss.htm

Picture 7 Svartfoss
Source: http://www.marinetraffic.com/ais/shipdetails.aspx?MMSI=304882000

GENERAL INFORMATION

Tonnage / Capacities:

DWT 2750 mts
GT 2995 mts
NT 1332 mts
DWCC 2550 mts

MAIN PARTICULARS

Built Vaagland Båtbyggeri AS 2005
Class DNV*1A1 Reefer / Container, Ice C, E0, World Wide
LOA 79,90 m
LPP 78,10 m
Beam 16,00 m
Draft Summer 6,45 m

CRANES

1 crane: 50 tonn - 23 meter / 12,5 tonn - 25 meter

SIDEDOORS

1 sidedoor on port side
Beam 6,40 meters
2 lifts a 4,1 tons
Tide: high water 1 meter – low water 7 meters.
Forklifts:
3 x 2,5 tonns + 1 x 2,0 tonns electric forklifts.

MACHINERY

Main engine Alpha 3060 kW
Propeller Diameter 4,0 m turnable
Rudder Becker
Bowthursters Brunvoll 2 electric 350+500 kW
Aux. engine 2 x 600 kW
Shaftgenerator 1 x 1000 kW
Service speed loaded 16.0 knots
Service speed ballast 17.5 knots

CARGO CAPACITY

Holds	*Sq.m.*	*Height*	*Volume*
Tanktop	474 m^2	2,79 m	1327 m^3
Main deck	370 m^2	2,35 m	870 m^3
Main deck	500 m^2	2,35 m	1175 m^3
Shelterdeck	395 m^2	2,50 m	988 m^3
Total	1739 m^2		4366 m^3

Weatherdeck: 680 m2

Temperature can be runned seperatly for each compartment, –27° C / +32C

CONTAINER CAPACITY
Deck 28 x FEU + 2 x TEU (58 teus)
30 reefers plug

IRAFOSS – semi spot/liner vessel
(http://www.marinetraffic.com/ais/shipdetails.aspx?MMSI=304637000)

Vessel's Details

Ship Type: Cargo
Year Built: 1991
Length x Breadth: 82 m X 11 m
DeadWeight: 1890 t
Speed recorded (Max / Average): 11.3 / 9.8 knots
Flag: Antigua Barbuda [AG]
Call Sign: V2PC2
IMO: 8919233, **MMSI:** 304637000

Picture 8 Irafoss
Source: http://www.marinetraffic.com/ais/shipdetails.aspx?MMSI=304637000