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Route Planning

-Performance improvements for short sea container feeder lines in the Oslo fjord

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Abstract

In this study the focus will be on the short sea container feeder lines in the area of the Oslo fjord and its ports, and how to make it more competitive against other modes of transport. This was tested by looking at the already planned and running routes that have regular port calls in the seven ports of the Oslo fjord, and improving them in two scenarios. In the scenarios three factors where changed: time in port, transit time and the average speed on the sea legs. For calculating the port times and transit times in the two scenarios, a benchmark approach was used. The scenario results were looked at with the use of three parameters for making sea transport a more attractive choice of transport: lead time, cost and flexibility. This showed that with the improvements the sea transport can become a more attractive mode of transport. The findings show that the feeder lines can reduce their route trip time, with the improvements in the three factors. However, there might be some weaknesses in the benchmark approach for some of the studied routes. This is because the benchmarked port times, might be out of reach for some of the port calls.

Keywords: route planning, container feeder lines, benchmark, lead time

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Introduction

Container carriers operate in an environment that is market-driven and increasingly competitive. Their aim is to lower shipping cost and enhance the service to increase the competitiveness. Therefor is decision-making on the routing, ship size sailing frequency, shipping interval, and market demand essential issues when planning the shipping services. The operating effectiveness of the carriers and the service quality provided to the shipper, are directly influenced by the route planning decisions (Chuang, Lin, Kung, & Lin, 2010; Hsu & Hsieh, 2007).

Feeders that operate in short-sea shipping are in direct competition with other modes of transport and especially road transport (Christiansen, Fagerholt, Nygreen, & Ronen, 2007). In a survey performed by Institute of Transport Economics (TØI), the reasons for why customers choose road transport over sea transport was enlightened. The main reasons that was found where the price and frequency, followed by routes and time. Some of the enlighten ways for sea transport to become more competitive against road are by, reduced prices, improved sea transport offer, reduced lead time and reduced costs in ports (Haram, Hovi, & Caspersen, 2015).

TØI's results corresponds with Paixão and Marlow (2002) findings for why customers choose road transport over other transport modes. They say that, road transport has a large market share, and the reason for this is that it fulfills the customer requirements to a higher degree than other modes. The customer requirements are transit times, flexibility, frequency and cargo safety. In addition, the purpose for selecting road transport is often based on economic thinking, like costs, time, flexibility, quality and reliability (Paixão & Marlow, 2002).

The routing and scheduling problem for ships are different form the other transportation modes. The reason for this is that ships operate under other conditions (Christiansen, Fagerholt, & Ronen, 2004). For liner ships the design of scheduling models is difficult problem, because they have a certain instinctive feature (Ting & Tzeng, 2003).

This thesis will be focusing on liner traffic of regular scheduled container transport in the Norwegian area of the Oslo fjord and its ports, and how to make it more competitive. The study will be on route planning on these vessels and the parameters for making it an attractive choice of transport. The study's objective will be to improve the schedules of the already existing routes that operate in the Oslo fjord. The improvements from the new routes will be measured with the use of the parameters.

The parameters that will be of focus are lead time, cost and flexibility. According to the findings form Haram et al. (2015), Paixão and Marlow (2002) and Berg and Aarland (2010), these three parameters have been selected.

The structure of the study is as following, introduction and a problem formulation of the study comes first, then there will be a literature review where the three focused parameters will be described. In the methodology the used method will be described. In the analysis and the diagnosis sections the operating routes will be looked at and how they will be improved will be explained. The results from the improvement of the routes will be presented in the results section, while in the discussion section the findings will be looked at in connection to theory. Last there will be a conclusion to the study and the research questions.

Background

“The Norwegian government has a political objective of safe, environmentally friendly and cost effective freight transport” (Haram et al., 2015, p. I). To be able to achieve this, there is a goal in both the EU and Norway to transfer more goods form road over to sea- and train transport (Haram et al., 2015).

“NØKS II - short sea shipping in Øresund, Kattegat and Skagerrak” is one of the projects that are working on the strengthening the short sea shipping's position. The projects vision is that the “Sea route will be developed into an attractive, green, safe and sustainable link for goods flow in and between Denmark, Sweden and Norway” (Vestfold fylkeskommune, 2015). Their aim is to transfer more goods form road to sea (Kulberg, 2015).

This thesis research question is initiated by NØKS, who also have provides the resources in terms of access to Marine traffic data. Therefore will this thesis, focus on the short sea container feeder lines in the geographical area of the Oslo fjord, and its ports, Borg, Moss, Oslo, Drammen, Larvik, Grenland and Kristiansand.

Why is This Important to Investigate?

For feeder vessels to be able to compete with other modes of transport, especially road, and to achieve the objective of transferring more goods from road- to sea, the competitiveness of sea transport has to be strengthened (Haram et al., 2015). In addition they have to meet the customers with the same advantages that road transport offers, which is cost, reliability, flexibility and quality (Berg & Aarland, 2010).

By creating a route that can meet the customer requirements and make the short sea shipping of containerized goods more attractive in relation to the customers, the aim of transferring more goods from road to sea transport can be met.

Research Questions

1-How can the route trip of a vessel be reduced?

2-How can the short sea container feeder lines performance in the Oslo fjord be improved based on benchmark?

Hypothesis

H_1: Can the lead time be reduced for the ship to e.g. four days?

H_2: Can the ship time schedule be reduced?

H_3: Can the service frequency be increased?

Problem Formulation

In this study the focus will be on regular scheduled container vessels routes. The routes that will be of focus are the routes that serve the seven ports of the Oslo fjord, Moss, Borg, Oslo, Drammen, Larvik, Grenland and Kristiansand. The objective with this study is to improve the already planned and operating routes in the Oslo fjord, so that they can become more competitive against road transport by fulfilling more of the customer requirements. By improving the routes so that the customer's interests and requirements are withheld, the Government and NØKS's aim of transferring more goods form road to sea transport can become more attractive.

The study wants to solve the research questions regarding if the route trip can be reduced on the vessels, and if the short sea container feeder lines performance in their service in the Oslo fjord can be improved based on a benchmark approach.

Benchmarking can be defined as, "*an ongoing process of measuring and improving products, services and practices against the best that can be identified worldwide*" (Codling, 1995, p. 7). In this study the benchmark will be found in each route, so that the best observed transit time on each sea leg and the port with the lowest standard deviation in the port time will be set as the routes benchmarks. With the best practice benchmarking the shipping company can gain competitive strength and create customer value, because this is the bottom line benefits of benchmarking (Camp, 2003).

To reduce the route trip on the already planned and running routes in the Oslo fjord, there will be performed two scenarios in a model that has been made based on the downloaded vessel route information In these two scenarios there are three factors that will be changed, transit time, time in port and the average speed on the sea legs. For the scenarios there will be used a benchmark approach on the time in port and the transit time, and based on the produced results from the model, one can see if the performance can be improved based on a benchmark approach. In addition, the three hypotheses will with the help of the model be tested.

The improvements from the two scenarios will thereafter be tested by looking at them up against the parameters, lead time, cost and flexibility. By testing the results in this way, it can become clear if the short sea container feeder lines performance can be improved based on a benchmark, if the new routes can improve the sea transports competitiveness against road transport and if the customer requirements can be fulfilled.

Literature Review

In this section there will be a literature review of the tree focused parameters, lead time, cost and flexibility and they will be explained in further detail. In addition, to understand how these parameters fit into the route planning, the liner shipping and route planning will be briefly explained.

Container Transport

Liner shipping mainly involves the transportation of manufactured products, food and garments that have been containerized (Wang, Alharbi, & Davy, 2015). The liner shipping service for container ships' characteristics are fixed ports, fixed routs, and fixed time service (Chuang et al., 2010).

Route planning

Since feeders services are often in direct competition with other transportation modes to be able to compete with them, it may be necessary to offer more frequent services (Christiansen et al., 2007).

The service frequency is defined by Wang and Meng (2012a) as "The headway (days) between two adjacent ships on a ship route, or the round-trip time if there is only one ship deployed on the ship route".

For liner shipping, decisions are made at three planning levels, strategic, tactical and operational. The levels involve decisions that have to be made at different planning horizons, the decisions made one planning level affects the other levels (Agarwal & Ergun, 2008).

At the strategic planning level the long term decisions are made, which involves acquiring resources and determining fleet size and mix. The tactical planning level is where the route planning is done. Some of the decisions at this level are frequency, number of vessels, port selection and rotation, planned arrival time at each port of call, the planned maximum speed, etc. At the operational planning level, the decisions are regarding cargo, which paths to use, cruising speed selection, ship loading and environmental routing (Agarwal & Ergun, 2008; Christiansen et al., 2007; Song, Li, & Drake, 2015; Wang et al., 2015).

Lead Time

Notteboom (2006, p. 25) defines the transit time, lead time, in both a narrow and a broad approach. The narrow approach, defines the transit time “As the number of sailing days on a port-to-port basis”. In this study this approach will be primary used.

A competitive factor for liner shipping is to offer short transit time. This is even more important when the goods that are being transported are time sensitive. Goods that are time sensitive goods are often perishable- and consumer goods that have short life cycles or high economic/technical depreciation. For the goods concerned, increased sailing time creates opportunity costs linked to fixed capital, which can lower their economic value (Notteboom, 2006).

Liners usually have weekly services, this means that the round trip journey time, i.e. weeks, of a ship route is equal to the number of ships deployed on the route. If the ship sails at a higher speed, it can result in reductions in the number of ships needed to withhold a weekly service, the operating cost and the lead time. In addition it can also lead to shorter transit time for the customer's goods, thus lower inventory cost (Wang et al., 2015).

Slow steaming has been employed to most container vessels since 2009. The slow steaming strategy reduces the bunker fuel consumption and extends the round-trip time. With an increase in the duration of the round-trip time, more vessels are needed deployed to withhold the weekly frequency. This is an option for shipping lines to reduce the operational costs and utilizing available vessels (Reinhardt, Plum, Pisinger, Sigurd, & Vial, 2016).

The downside with slow steaming is unattractive service for the customers, because of extended lead time. For the customers when choosing carriers, transit time and freight rates are crucial criteria's. Therefore, slow steaming's negative impact on the transit time could lead to loss of customers. Consequently, the lowering of the speed is a trade-off between bunker fuel consumption and customer satisfaction (Reinhardt et al., 2016).

If the ship slows down their speed, then the lead time for the customer's goods will increase. This can be seen in relation to Little's law, when the cycle time (average time on the ship) increases then there will be more goods in work in progress (average number of units on board), since the throughput (customer demand) is constant. This will have a negative effect for the customers and they might chose to use other modes of transport with shorter cycle time to reduce their work in progress (Little, 2011).

Cost

There are three main categories that shipping costs can be divided into, these are capital and operating costs, fuel costs and port charges (Hsu & Hsieh, 2007). In the design of the routes, these costs are influential factors for the shipping company (Wang et al., 2015).

Capital and operating costs

The first group, capital and operating costs are the total expenses paid for the daily use of the ship. These expenses are costs like the cost of owning the ship, crew wages and meals, ship repair and maintenance, insurance, materials and supplies (Hsu & Hsieh, 2007).

Bunker fuel cost

Bunker fuel costs are the cost of bunker fuel consumption of the ship, both when sailing and when dwelling in port (Hsu & Hsieh, 2007). Of the total operating cost, the bunker fuel cost accounts for about 20-60 % (Wang & Meng, 2012a). This percentage is dependent on the bunker price and the general economic environment (Karsten, Brouer, Desaulniers, & Pisinger). Since this cost consists of such a large share, a reduction in the bunker fuel consumption would lead to considerable cost reductions (Reinhardt et al., 2016).

Bunker fuel cost and ship cost has a direct implication on the ship route schedule. A shorter inter-arrival time between port calls results in higher speed. Even though the sailing speed is just increased with a couple of knots, it may lead to an increase in the bunker fuel consumption and cost. However, if there is a longer inter-arrival time between the ports it would result in longer round-trip time, and to withhold the weekly frequency there would be a need for more deployed ships. So there needs to be a trade-off between the bunker fuel cost and the ship cost (Wang & Meng, 2012a).

Port charges

Port charges, is the cost for ship dwelling in port (Hsu & Hsieh, 2007). This cost is one of the differences between ship and truck transport. Trucks do not pay port fees but ships do (Christiansen et al., 2004). The costs that occur at a port call can be divided into three main groups, private, municipal and governmental costs (Eidhammer, 2004).

The largest cost for a port call is the costs for loading and unloading the cargo, and the cost varies depending on when the operation is done, e.g. daytime, afternoon, night, weekend and holidays (Eidhammer, 2004).

Inventory cost

Another cost that is central when planning the route and that influences the route decision is the inventory cost (Hsu & Hsieh, 2007). The carrier is only indirectly concerned with the commodities inventory cost, the cost is borne by the shipper. Nevertheless this cost should be taken into account regardless of who pays for the incurred costs. By taking it into consideration, the carrier can make better decisions and the shipper may become more willing to send his cargo with the carrier (Hsu & Hsieh, 2007; Karsten et al.).

For the customer, the cost represents the loss of opportunity cost or value, since the goods cannot be sold or used while being shipped (Hsu & Hsieh, 2007). For many manufacturers and retailers this cost represent a major logistics cost (Rushton, Croucher, & Baker, 2006).

By taking the inventory cost into account in the routing decision the quality of service to the customer can be enhanced. The shipping service can be enhanced by higher sailing frequency, using faster container ships and by planning routs so the time is shortened, which resulting in lowered waiting cost for the customer (Hsu & Hsieh, 2007). To achieve a balance between fleet operation cost and level of service, the inventory cost should be included in the liner network design (Christiansen, Fagerholt, Nygreen, & Ronen, 2013).

Shipping companies often want to minimize shipping costs and the costumer wants to minimize the inventory cost, these objectives are in conflict. Therefor is it important to find a trade-off. Between shipping cost and inventory cost there exist an trade-off which is linked by the sailing frequency (Hsu & Hsieh, 2007).

Uncertainty Factors

Regular scheduled vessels, even though they are on fixed schedules, often arrive one or two days behind schedule (Wang & Meng, 2012b). Liner shipping services are subject to a variety of uncertainty factors, which can be classified into two groups, uncertainty at sea and uncertainty at port. In the tactical planning level these factors that influence the route fulfillment should be taken into consideration in the planning process (Christiansen et al., 2007).

Most container shipping lines have developed or have an aim to develop liner service networks that are characterized by low operating cost, high frequencies, fast transit times and both tight and reliable voyage schedules. However, it is not an easy task to managing the time factor in the design and operation. Many factors can disrupt the schedule and have a negative effect on the schedule reliability. For both the shipping lines and their customers, lost minutes results in lost money, time is money (Notteboom, 2006).

"The reliability of a liner service network can be defined as the probability that one or more of its links does not fail to function, according to a set standard of operating variables" (Notteboom, 2006, p. 32). When the link does not function according to the set standards then there will be imposed costs on the shipping line and their customers.

Uncertainty at sea

Uncertainties at sea are adverse weather conditions such as rain, snow, low visibility, tornado, hurricane and thunderstorm. Uncertainties at sea are coped with by build in some buffer time for each voyage leg (Wang & Meng, 2012a).

Uncertainties at port

Uncertainties at ports are lack of navigation experience of the ship master, insufficient berth planning system, fluctuation of quay crane handling efficiency, and variation of the number of containers handled in each week (Wang & Meng, 2012a).

Uncertainties at port affects the time the ship spends in port and therefore also the available sailing time for the subsequent voyage leg. Therefore needs the sailing speed function for the subsequent leg to be adjusted accordingly. Due to this, needs the sea contingency and uncertain time in port to be considered in the schedule design (Wang & Meng, 2012a).

For the shipping companies to reduce their costs, reduction in the port turnaround time is an important factor (Zeng & Yang, 2009). A ship only creates value when it is moving cargo. The time a container vessel spends in port consists of many different operations that take time, however the most significant time component in port are the time for handling containers, loading and unloading. Therefore, the time a ship uses in port depends to a large extent on the ports container handling efficiency (Wang et al., 2015).

Ships have a high dependence on weather conditions, and it can lead to high operation uncertainty. The weather conditions are one of the most important unpredictable factors that influence the fulfillment of plans, and should be considered in the planning process. However, this problem could be managed by building in enough slack, but often the built in slack is low because of the high costs (Christiansen et al., 2007).

Flexibility and Buffer

Because of these uncertainty factors that lead to delays and unreliable services for the customers which imposes costs on both the carrier and shipper there is a need for more flexible services and buffer time in the carriers schedule. There are a number of ways that the shipping line can lower the risk of low schedule and transit time reliabilities. Buffers are one of the key decision variables in the design of liner service, by introducing sufficient buffer time in the service, reliability is generally attained (Notteboom, 2006) (Brouer, Dirksen, Pisinger, Plum, & Vaaben, 2013). Reliability can be dealt whit in different ways, some companies have implemented buffer time, while others manages these loops and vessels in a more creative ways, speeding up the vessel, port skipping or swamping (Notteboom, 2006).

One of the ways of dealing with delay is to speed up as much as possible, with the aim of reducing or eliminating the delay at the immediate next port (Qi, 2015). However, often liners are not willing to speed up beyond a certain level, even though the delay could be fixed with a higher speed. Shipping line are often reluctant to speed up further because of the rapidly increase in the bunker fuel consumption and cost (Song et al., 2015).

Methodology

Applied research has an aim of finding solutions for an immediate problem that is facing a society or an industrial/business organization. The findings form this kind of research can be applied to related problems (Bickman & Rog, 2009).The purpose of the study is to develop a model to optimize the regular scheduled containers lines lead time. Based on the research question and hypothesis, this study can be categorized as applied research.

Research Design

The research design is a description of how the research process will be conducted. The research design includes all the stages in the research process. The design chosen is dependent on the researcher's knowledge on the topic and the drafted research question (Gripsrud & Olsson, 1999; Jacobsen, 2000). There are three main types of design, these are explorative-, descriptively- and causal design (Gripsrud & Olsson, 1999).

The causal design is used to explain the cause- effect relationship. This design is a type of experiment where one manipulates the independent variables to then see the effect on the dependent variable (Gripsrud & Olsson, 1999).

Casual design is appropriate in relation to the purpose of the study and to answer the study's research question and hypothesis. The parameters that influence the vessels time on a voyage was changed and improved, so one will be able to see how this affect the lead time and the competitiveness.

Method

Mixed methods are research that in one single research project combines alternative approaches. It is when the research strategy crosses boundaries of the conventional paradigms, by combining methods drawn from other tradition, easily said combining qualitative and quantitative methods (Denscombe, 2007).

The method of combining approaches can be defined as between-method. This approach uses different methods in relation to the same objective of study, there has here been used a pre-eminence of quantitative data over the qualitative data, where the qualitative data has been used in the interpretation and clarification of the quantitative data. Here the qualitative data has been used at an early stage to look at what the customers want when choosing transport and at the end to speculate about the findings from the quantitative data (Brannen, 1995).

It is often said that a quantitative researcher looks through a wide lens and is searching for patterns of inner-relationships between a previously unspecified set of concepts, while the qualitative researcher looks through a narrow lens at a specific set of variables (Brannen, 1995). In quantitative methods the researcher mostly work with numbers while in qualitative methods the main form of work that the researcher uses is text (Thagaard, 2011).

Quantitative data is the main source of information in this study, and will come in the form of dates and times of the vessels that operate in the regular scheduled liner traffic. This data will be the main source for improving the routes. The qualitative research will be through secondary data in the form of research articles and reports. This will shed light on how the route planning is conducted, how uncertainties can influence the planned route and how the route can be improved in relation to the three parameters lead time, cost and flexibility.

This method is used because it gives the research improved accuracy in the way that the findings from the quantitative method can be checked up against the findings from the qualitative method. By the use of these two methods on the subject the findings can be presumed to be more precise, it can provide a fuller and more complete picture of the route planning and short sea transport by enhancing the findings. The qualitative data can be strengthened by the use of qualitative data to see the relation between the customer requirements and the improvements of the routes. The qualitative data can also be used to build on the initial data and shed light on how the new model of route planning can become a more attractive option for the customers (Denscombe, 2007).

The method shall give the approach that is used for mapping the reality. There are two approaches that can be used, inductive and deductive. Deductive approach is when the researcher goes from theory to empery, and is a more closed approach to look at an objective side of reality (Jacobsen, 2000). The research approach is a deductive approach that tests the validity of assumptions, theories or hypothesis at hand. This approach was conducted in the way that there was made research questions and hypothesis based on different theory. These questions and hypothesizes will then be tested in the model and confirmed or unconfirmed, with the help literature.

Secondary Data

Secondary data is data that is collected by others. This kind of data can be either quantitative or qualitative. Qualitative secondary data can be categorized as texts, while quantitative secondary data can be statistics, accountings, annual reports and others. Different types of data can be used for control of each other, support and strengthen the results and create contrasts (Jacobsen, 2000).

The collected quantitative secondary data was downloaded from Marine Traffics database (Marine Traffic, n.d.). This is AIS data for the regular scheduled container traffic in the Oslo fjord. Statistics Norway also been used to collect historical container traffic data for the Norwegian ports of interest (Statistics Norway, n.d.). The collected qualitative data was books, scientific articles and reports from library or databases. These were used to fulfill the quantitative data, to be able to understand how the route planning is conducted, how it affects the customer's choice of transport.

The use of documentary sources gives a great advantage in several ways. First of all the accessibility is relative easy. The vast amount of information that is available is often without cost, delay or need for appointments or authorization. The likelihood of ethical problems is also very low. Therefore, do often documents pose fewer problems than when there are people as sources (Denscombe, 2007).

Population and Samples

Population is "The complete set of relevant units of analysis" (Frankfort-Nachmias & Nachmias, 2008, p. 163). The population in this study is all the regular scheduled container line routes that have port calls in the Oslo fjord. Because the population contains a countable number of sampling units, the population can be defined as a finite population, and will all be included in the sample (Frankfort-Nachmias & Nachmias, 2008).

A sampling problem for this study can be incomplete frames. This problem arises when there are found sampling units in the population that are missing from the list (Frankfort-Nachmias & Nachmias, 2008). For this study this can happen by incomplete lists of vessels operating on regular scheduled routes in the Oslo fjord, if the company changes the vessel that operates on the route, or if the found information is wrongful.

Data Analysis

The official statistics that is used in this study can be categorized as interval data. The interval data is data that are ranked on a scale, which means that the distance between the data are a known factor (Denscombe, 2007). The data comes in dates and times that the vessels arrive and depart the ports on their voyage.

Raw data is not always easy to make sense of, therefore is the first stage in the analysis to organize the raw data in a way that makes it more understandable (Denscombe, 2007). The data was downloaded and the relevant ships were grouped together in routes and voyages.

To describe the frequency and the distribution of the observed voyage times there was calculated an average and a spread of the time spent in transit between ports, the speed on the different sea legs and time spent at port. This was done by the use of average and standard deviation.

Validity

Validity can be defined as, the extent to which an instrument measured what it claimed to measure (Ary, Jacobs, Snorensen, & Walker, 2014). There are two categories of validity, internal and external validity (Jacobsen, 2000).

Internal validity relates to the accuracy and precision of the data, in addition to the data appropriateness in respect to the investigated research question. There are two basic questions that needs to be asked in relation to the internal validity; "Are the data the right kind for investigating the topic and have they been measured correctly?" (Denscombe, 2007, p. 296). External validity refers to the generalizability, meaning if the findings can be applied to other instances of the phenomenon (Denscombe, 2007).

With the use of mixed methods the validity can be enhanced. This is because the use of more than one method can enhance the findings (Denscombe, 2007). In relation to the study's internal validity, the needed quantitative data was downloaded in a satisfying manner. For the qualitative data, the needed data was attained. The generalization of the findings in the study, i.e. the external validity, would be for other regular scheduled containers in another area or other regular scheduled vessels that could adapt this form for their route.

Official statistics will appear to provide documents that are authoritative, objective and factual (Denscombe, 2007). However, one should always be careful when using documents and statistics that is collected by others because their purpose with the research might have been different and the once who produced the statistics might have something to gain or lose on the basis of what the results reveal (Denscombe, 2007; Jacobsen, 2000). The collected quantitative data is from impartial sources, and has not been inflicted by what the data reveals. The site can be regarded as a trustworthy source and therefore the statistics will be regarded as valid sources.

In this study there has been used a benchmark approach across the ports. This was done in the way that the average port time for the port with the lowest standard deviation on port time from the observations, was selected as a benchmark for the use as port time for all the ports on the route in the two scenarios. This was done on all the ten routes. By using this approach there can and will be some uneven distribution in the times. The port with the lowest standard deviation was often the port with the lowest average port time observations. A consequence of this approach is that it will give a reduction in the port time that may be too low for many of ports, and decreases the external validity.

However, at two of the routes the lowest standard deviation has not been used. The reason for this were that for one of the routes the port with lowest variation had an average port time of 3,80 hours, which were considered to be too low for the rest of the ports. The port with the next lowest standard deviation was used, which also where low but where considered to be a better option. For the other route, the port with the lowest standard deviation had an average port time of 30,42 hours, so instead the next lowest port where used. This is because the objective is to improve the route and with such long time in port the route would not have been improved. With these two small adjustments to the port time the method becomes more valid.

Reliability

Reliability focuses on whether the research instrument used has a neutral effect and if it is consistent across multiple occasions. An often asked question to the reliability would be, "Would the research instrument produce the same results on different occasions (all other things being equal)?" (Denscombe, 2007, p. 296). So the reliability refers to if the instrument of measure has variable errors (Frankfort-Nachmias & Nachmias, 2008).

An important factor to keep in mind when operating with secondary data, in the form of qualitative and quantitative data, is that the researcher loses the control over the conditions that lead to reliability of the data. Meaning that the way the research is collected, measurement methods and who have registered the data is not known (Jacobsen, 2000). To replicate the study at a different occasion and getting the same results can be difficult. This is because the routes might change port of calls and rotation, there might be different uncertainty factors in port and at sea that influence the routes, and seasonal fluctuations that affects the cargo quantity and weather. So to replicate with exactly the same results would be hard, nevertheless, since there was used average times and standard deviation to get the results, this enhances the reliability of the study and there would be possibilities to get similar results.

The qualitative data was downloaded and exported to the used Excel spreadsheet. The use of this method reduces the chances of the data being wrongfully recorded. However, there might appear errors in the grouping of the data which could lead to wrong results and impaired reliability. However, the groupings where checked more than once for errors, so the chance for errors is decreased, and can therefore be regarded as reliable.

Analysis and Diagnose

In this section, there will first be an analysis of the routes that are operating the regular scheduled liner traffic in the Oslo fjord and an explanation of the observations from the downloaded data. Then in the diagnosis section the two improvement scenarios will be explained in further detail.

Analysis

The routes

There are ten regular scheduled container routes, which are operated by fourteen vessels that have regular calls in the ports of the Oslo fjord. These routes are either operated by one, two or four vessels. Nine of these routes are weekly schedules, thus arrive the Norwegian ports once a week.

The route that does not have weekly frequency is the route that is operated by four vessels. For the ships 1, 2, 3 & 4 their route takes four weeks, so they do not have a weekly schedule to the Norwegian ports, but they have frequently calls to the ports. Their route, which here has been set to start in Bremerhaven starts in the weeks 4, 5, 7, 8, 9, 10, 11 and 14. As can be seen there is a few gaps in the weeks, however this can maybe be explained by the different downloading dates. In table 1, the frequency of all the ships can be found.

The collected data is Automatic Identification System (AIS) data which has been downloaded from Marine traffic's database. Here the vessel activity has been downloaded for the last 60 days.

The vessels that operate the routes in the Oslo fjord are all small container ships, thus feeder vessels. Their TEU capacity, range between 658 and 1036 TEU's, in table 1 vessel particulars can be found for all the ships that operate the routes.

Table 1

Vessel particulars on the vessels that operate regular scheduled routes in the Oslo fjord and their frequency.

Ship	Service Speed, kn	TEU Capacity	Frequency
Ship 1	19,00	1036	4 weeks
Ship 2	18,00	868	4 weeks
Ship 3	18,50	868	4 weeks
Ship 4	18,30	880	4 weeks
Ship 5	18,30	880	weekly
Ship 6	18,50	868	weekly
Ship 7	18,50	862	2 weeks
Ship 8	18,30	880	2 weeks
Ship 9	18,30	750	weekly
Ship 10	18,30	880	weekly
Ship 11	17,90	850	weekly
Ship 12	18,00	658	weekly
Ship 13	17,90	801	weekly
Ship 14	17,00	658	weekly
Ship 15	17,00	750	weekly
Ship 16	19,30	1036	weekly
Ship 17	18,50	1008	weekly

Adapted from (Marine Traffic, n.d.)

The number of port calls in the Oslo fjord on each route, range from one to five ports. The port of Oslo is visited most frequently, by six routs. The port of Larvik follows with five regular routs that call the port. Grenland's port Brevik is the port that has fewest regular port calls and is visited by two routes. In the table 2, are the vessels that have regular scheduled port calls to these seven ports. During the looked upon period some routes changed ships. The ships that got replaced where ship 5 with ship 6, ship 13 with 14, and ship 16 with 17.

Table 2

The regular scheduled container vessels that have port calls in the ports of the Oslo fjord.

Fredrikstad - Borg port	Moss	Oslo	Drammen	Larvik	Grenland - Brevik port	Kristiansand
Ship 1, 2, 3 & 4	Ship 1, 2, 3 & 4		Ship 1, 2, 3 & 4	Ship 1, 2, 3 & 4		
		Ship 5 / 6				
Ship 7 & 8		Ship 7 & 8		Ship 7 & 8	Ship 7 & 8	Ship 7 & 8
Ship 9		Ship 9		Ship 9		
		Ship 10		Ship 10		Ship 10
	Ship 11	Ship 11			Ship 11	
			Ship 12			
		Ship 13 / 14				
	Ship 15		Ship 15	Ship 15		
						Ship 16 / 17

Adapted from (Marine Traffic, n.d.)

All the ports that the different routes visit on their voyage can be seen in table 3. Some of the routes have many ports of call on their voyage. Mostly this is for the routes that are operated by more than one vessel, and have a longer round trip time. The routes of the vessels sometimes change and sometimes the port call order is changed in the observations. Therefore to be able to make the calculations for the voyages, the route order that is most observed is used in the calculations. The found time tables of the routes have also been checked so that the calculated routes are as correct as possible (Seago Line, n.d.; Unfeeder, n.d.). The ports in italic are the port calls that change order many times in the observations.

Table 3

The routes of the regular scheduled container vessels, that operates in the Oslo fjord.

Ship 1, 2, 3 & 4	Ship 5 /6	Ship 7 & 8	Ship 9	Ship 10	Ship 11	Ship 12	Ship 13 / 14	Ship 15	Ship 16 / 17
Bremerhaven	Rotterdam Maasvlakte	Hamburg	Rotterdam Maasvlakte	Antwerp	Rotterdam Maasvlakte	Hamburg	Hamburg	Rotterdam Waalhaven	Rotterdam Maasvlakte
Kronshtadt	Oslo	Bremerhaven	Rotterdam Waalhaven	Oslo	Rotterdam Waalhaven	Szczecin	Bremerhaven	Drammen	*Aarhus*
Rauma	Goteborg	Aarhus	Oslo	Larvik	Oslo	Drammen	Oslo	Moss	Goteborg
Hamburg		Kristiansand	Larvik	Kristiansand	Moss		Goteborg	Larvik	Kristiansand
Bremerhaven		Oslo	Fredrikstad	*Antwerp*	Brevik		Helsingborg	Immingaham	
Fredrikstad		Fredrikstad	Rotterdam Waalhaven	*Berendrecht*	Rotterdam Waalhaven			Rotterdam Maasvlakte	
Larvik		Brevik		*Antwerp*					
Dramme		Larvik		*Tess*					
Moss		Kristiansand							
Aarhus		Bremerhaven							
Hamburg		Hamburg							
Bremerhaven		*Aarhus*							
Wilhelmshaven		*Fredericia*							
Helsingborg		*Kalundborg*							
Copenhagen									
Tyne									

Note. Ports in italic are the ports that have not been improved in scenario one and two.

Adapted from (Marine Traffic, n.d.)

Transit time

The transit time on the routs and on the different sea legs, varies from trip to trip. There are many variables that can be the reason for this. The observation period is the winter months, January to the beginning of April. In the winter months, the weather is changing and unstable, and this can also be seen in the routes. For many of the routes they have deviations on the same dates, which can be linked to weather data. In the looked upon period the wind has been over 15 meters per second at more than ten occasions at Færder (Yr, n.d).

For liner ships, the port of departure is the port of destination. Thus, voyage is complete when the ship arrived at the port of departure (Chuang et al., 2010). Therefore, when the routes lead time is calculated it is form the ship leaves the port of departure and until it arrives back at the same port which is then the port of destination. The first port, port of departure/destination has been chosen based on what the time table says is the first port and/or based on the port with the longest average port stay.

Time in port

In the observations, the port stays is calculated from the vessels actual time of arrival (ATA) to the actual time of departure (ATD) in the AIS data, then there has been calculated an average time in port for all calculated port calls and a standard deviation on the time to see how large the time variation is.

In table 4, the average time in port and the standard deviation for the port time observations is shown. As can be seen, there is large deviation in the time used in the different ports, and the standard deviation in some of them is high. These variations can be influenced by the amount of containers that are going to be loaded and unloaded, uncertainties at port and the weather. For the port time the weather has had a visible effect at some occasions.

The quantity of containers that are loaded and unloaded for each port and by each vessel is not known. However, historical data gives an indication on how much cargo the Norwegian ports loads and unloads.

Table 4

Overview of the observed average time use in port and the standard deviation of the port time for the vessels in the calculated ports.

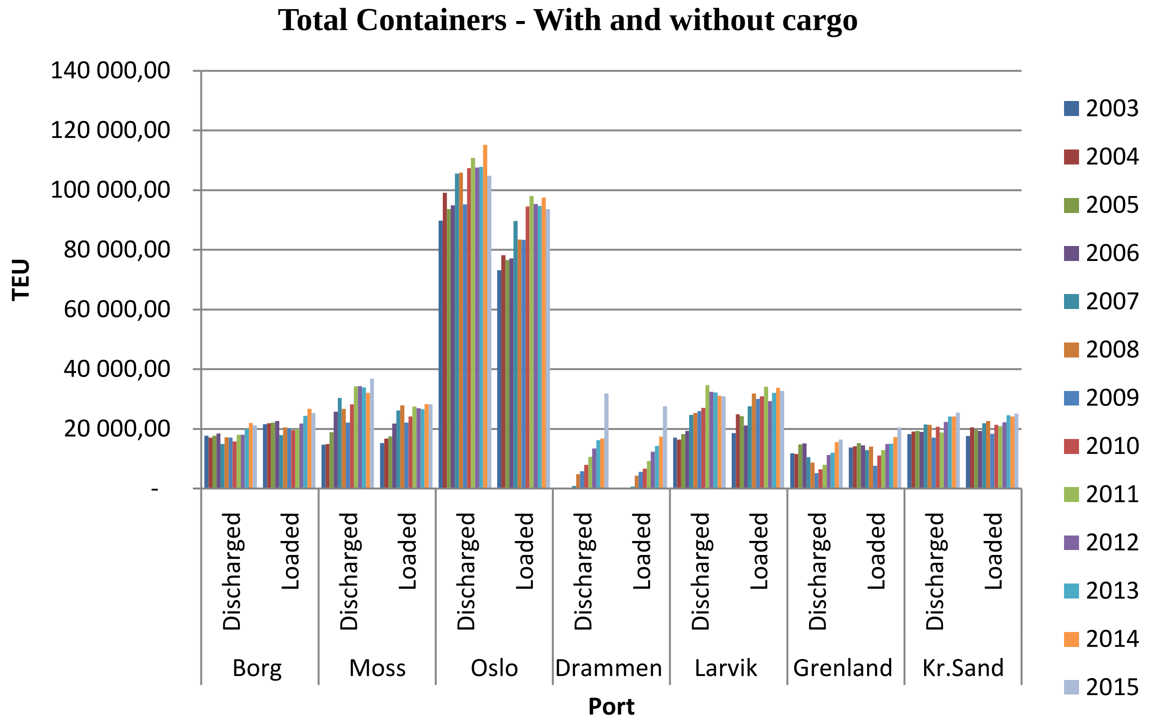
		Port 1	Port 2	Port 3	Port 4	Port 5	Port 6	Port 7	Port 8	Port 9	Port 10
Ship 1, 2, 3 & 4	Average port time	28,89	17,44	19,57	13,51	16,98	12,83	**5,37**	6,63	30,97	3,80
	Standard deviation	19,08	7,26	8,03	3,04	9,33	7,78	**1,61**	2,93	19,62	0,46
Ship 5 / 6	Average port time	40,39	**13,28**	24,09							
	Standard deviation	7,13	**4,36**	8,50							
Ship 7 / 8	Average port time	32,57	19,45	10,72	15,47	11,33	9,74	**5,01**	17,45	13,93	34,13
	Standard deviation	4,11	5,51	6,64	3,55	3,11	3,92	**2,14**	5,49	3,26	7,68
Ship 9	Average port time	25,62	11,12	15,49	**8,58**	9,90	8,54				
	Standard deviation	9,35	1,75	2,89	**1,45**	2,68	1,97				
Ship 10	Average port time	30,42	**18,36**	19,33	14,26						
	Standard deviation	2,16	**4,58**	4,75	6,70						
Ship 11	Average port time	18,22	18,03	19,25	7,70	10,73	**11,12**				
	Standard deviation	6,13	2,62	5,31	4,08	1,39	**0,55**				
Ship 12	Average port time	**24,20**	42,37	8,95							
	Standard deviation	**2,76**	15,48	5,43							
Ship 13 / 14	Average port time	26,93	13,05	**7,65**	17,22	10,01					
	Standard deviation	13,69	4,60	**3,85**	5,58	5,69					
Ship 15	Average port time	15,95	15,20	**6,91**	7,20	12,74	7,22				
	Standard deviation	3,04	4,22	**1,43**	2,15	4,73	2,11				
Ship 16 / 17	Average port time	49,86	24,03	**20,99**							
	Standard deviation	21,28	6,96	**4,94**							

Note: Numbers in bold are the port times that have been used in scenario one and two.

Cargo volume to the ports

As the collected historical data shows in the graph below, the port of Oslo is the one with the greatest TEU quantity both loaded and discharged, followed by Larvik port. Oslo and Larvik are also the ports that are most frequently visited. Grenland and Drammen are the ports with the lowest cargo quantity in the form of TEU's, which can explain the few port calls.

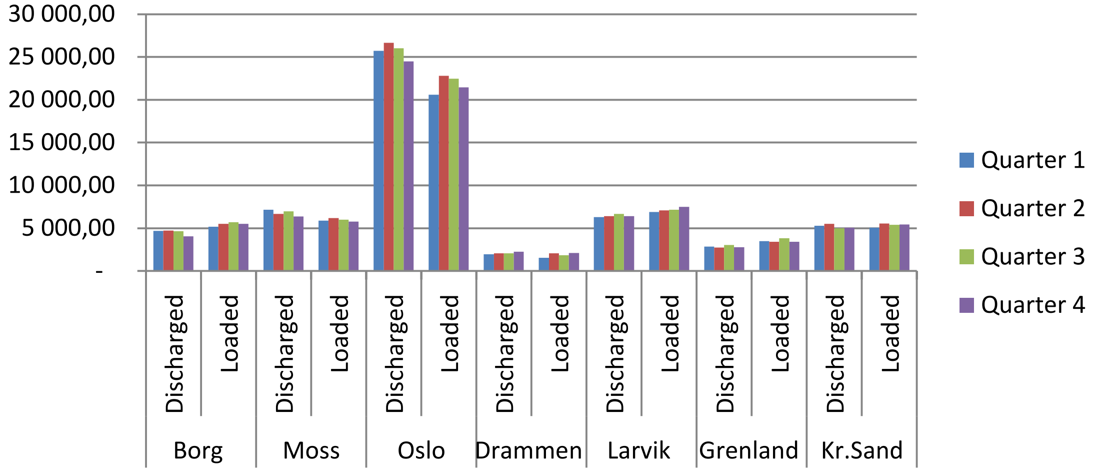
Figur 1



Adapted from (Statistics Norway, n.d.)

There is a seasonal variation in the TEU quantity that are being loaded and discharged in the ports, graph 2 shows the total average TEU quantity per quarter for the years 2003-2015. In all the quarters the port of Oslo is the one with largest quantity. There is a small seasonal variation in all the ports. Variation between the quarters means that the need for sea transport varies between seasons and in some periods the need for sea transport can be larger or smaller than others.

Figur 2



Adapted from (Statistics Norway, n.d.)

Diagnosis

From the observations it can be found that the vessels transit time varies between the observations and that the average speed on the sea legs rarely is close to the vessels service speed. That the speed of the vessels is low can be because of reasons like slow steaming or uncertainties at sea. Since the speed is an average of the whole sea leg, it does not give the true speed on the routes. However it gives an indication that the speed can be increased.

The average speed on the legs are calculated after the time between the ATD and ATA from the AIS data, on the different legs and then divided on the length between the ports.

For the ports, it is observed that in some ports and at some occasions the port stays are many hours and sometimes even days before the vessel proceed on the route.

These variations in the route can lead to delays, unreliable services to the customers and increased costs for both parties. Therefore, will this study look at the route with the use of two scenarios, best practice approach and best practice with increased speed approach. In these two scenarios the parameters that will be changed is the time in port, transit time and the average speed on the transit.

The scenarios

The objective with the two approaches is to improve the routes transit time, test if the lead time can be reduced to e.g. four days and test if the frequency can be improved. For the routes that are operated by more than one vessel, the objective is to improve the route to 16 days for the route with four operating vessels and 8 days for the route that are operated by two vessels.

With a shorter transit time on the routes, the vessels can take more round trip voyages per year, resulting in a higher service frequency of the routes. For the frequency, there is not calculated in any slack for maintenance and repairs of the vessels. This is because it is assumed that if a vessel has to be taken out of service for a period, another will take over to withhold the service frequency.

The routes that will be calculated on can be found in the table 3. The ports in italic are the once that has changed the port order frequently in the observations, this made them hard to calculate on and therefor are they not improved.

The routes with the occurrence of this changing port call order are the routes that are operated by the ships 1, 2, 3 & 4, ship 7 & 8, and ship 10 and ship 16/17. For these routes, the average time that is used between and in these ports is included in the total lead time.

For all the routes there have been made simulation trips, for the average trip and the two improvement scenarios. These trips will show how the routes will look like going with the improvements up against the average route. The trips have been calculated with a high and low variation and a 95 % confidence level. For the variation the standard deviation from the observations has been used. The 95 % confidence level is used to make the trips more robust and so that they can handle if there are some variations on the route.

Scenario 1 – Best practice

For the scenario 1 -best practices routes, the parameters that have been changes are the vessels time in port «Port Time» and the vessels sailing time from one port to another «transit time». This will be done to improve the route and minimize the variation. By improving these time factors, the total route time can be improved and the service frequency can be increased.

For each route the best observed transit time between each port will be selected and used in the best practice route, this will be done for all the different routes.

For the port time, there have been used a benchmark approach. The average port time of the port with the lowest standard deviation has been used as a benchmark on all the port calls on the route. This has been performed on all the routes. In table 4, the benchmark ports are highlighted by the use of bold numbers.

For two routes the port with the lowest standard deviation on the port time was not used. For the route of the ship 10, the average of the next best standard deviation was used. The reason for this is that the port with the lowest standard deviation had a high average that would not improve the rout and it was much higher than the average in the other ports calls on the route. For the route operated by the four vessels, the port with the lowest standard deviation had a very low average port time, so to get a more representative port time the next best standard deviation was used.

Scenario 2 – Best practice with speed increase

For the scenario 2 – best practice with speed increase routes, average speed on the sea legs is the variable that has been changed. Here the speed on the transits will be further improved by using the best practice route and increase the average speed on the different sea legs with 10 %. The service speed of the ships that operates on the looked upon routes, range between 17 and 19 knots. Therefore, will the speed not be increased more than the stated service speed, from table 1.

So for the sea legs that with a 10 % increase goes a bow the service speed, will be corrected and increased with a lower percentage or not increased at all. Since there is a high focus on slow steaming and keeping the costs down for the vessels bunker consumption the average speed has not been increased more than 10 %.

By increasing the speed, the transit time decreases and thus the total round trip voyage time is reduced. Which leads to that the service frequency can be even more increased.

In the results part, the effects of these scenarios on every route are displayed up against the average routes.

Results

In this section the found results from the two improvements approaches “Beat practice” and “Best practice with speed increase” will be presented. These results will be presented up against the average trip form the observations. For both the scenarios there will also be an example of the improvements and a simulation trip for one of the routes displayed. The simulation trips for all the routes can be found in Appendix A.

Scenario 1 - Best Practice

Time improvements

For all the routes there were improvements with the best practice approach. In table 5 are the total time usage in transit, port and on the total route summed up, for both the average route and the best practice route, in addition to the improvement in percentage. The lowest total route improvement is for the route operated by ship 12, with an improvement of 7.31 %

from the average route. The highest total route improvement is for the ships 5 and 6 and the route they are operating. This route had an improvement of 44.21 % in the total route time.

Table 5

Total time usage in days for the average routes and the best practice routes and time improvements in percent.

	Average Route			Best Practice Route			Improvents in percent		
Routes	Total transit time	Total time in port	Total route time	Total transit time	Total time in port	Total route time	Total transit time	Total time in port	Total route time
Ship 1, 2, 3 & 4	23,75	5,59	28,86	23,32	1,79	21,23	1,81 %	67,99 %	26,43 %
Ship 5 / 6	3,81	3,24	7,05	3,02	1,66	4,68	20,81 %	48,76 %	33,65 %
Ship 7 & 8	6,81	7,50	14,31	5,69	2,30	7,98	16,52 %	69,36 %	44,21 %
Ship 9	3,77	3,30	7,07	3,22	2,15	5,36	14,67 %	35,03 %	24,17 %
Ship 10	3,67	3,43	7,10	3,43	3,06	6,49	6,51 %	10,82 %	8,59 %
Ship 11	3,42	3,54	6,97	3,13	2,78	5,91	8,63 %	21,52 %	15,19 %
Ship 12	3,72	3,15	6,87	3,34	3,02	6,37	10,22 %	3,86 %	7,31 %
Ship 13 /14	4,09	3,12	7,21	3,33	1,59	4,92	18,53 %	48,88 %	31,67 %
Ship 15	4,16	2,72	6,15	3,62	1,73	5,01	12,84 %	36,41 %	18,47 %
Ship 16 /17	3,46	3,95	7,42	2,58	2,62	5,20	25,50 %	33,64 %	29,84 %

As can be seen in the table a bow, the largest improvements lies in the time in port, except for ship 12 where the largest improvement is in the transit time. With, a reduction in the port time and the transit time the route can be improved and the total voyage shortened.

With best practice only one of the routes was improved to the objective lead time. Ship 7 and 8 sails the same route so to improve them they need to use 8 days on the voyage, this has been achieved with the best practice route where they now use 7.98 days (191. 64 hours). All the other routes use more than four days to complete the route, and needs to be further improved to be able to take the trip in four days. This means that the hypothesis 1, where accepted for one route.

The speed

With an improvement in the transit time there is also an improvement in the average speed on the routes. All the routes average speed increases in a range between 1.27 – 3.10

knots. The route that has the lowest average speed and best practice speed is the route operated by the four vessels. However, they have the largest improvement in percent from average route to best practice route, with a speed increase of 25.57 %. In table 6 the speed improvements for all the routes can be found.

Table 6

The average speed in knots on the average routes and best practice routes and the speed improvements in percent.

Routes	Average route	Best practice	Improvement in average speed
Ship 1, 2, 3 & 4	11,41	14,32	25,57 %
Ship 5 / 6	13,78	16,53	20,02 %
Ship 7 & 8	13,51	15,63	15,69 %
Ship 9	12,20	14,61	19,77 %
Ship 10	14,78	16,04	8,57 %
Ship 11	13,15	14,62	11,17 %
Ship 12	13,09	14,48	10,65 %
Ship 13 /14	12,48	14,50	16,19 %
Ship 15	12,85	14,83	15,38 %
Ship 16 /17	13,76	16,86	22,49 %

Service frequency

With a shorter transit time on the round trip voyages, the sailing frequency can also be improved. With the best practice approach, the total number of trips a year can be increased with 170, 43 overall against the average routes. Resulting in 700.21 round trip routes per year, which is an improvement of 32.17%. The table below presents the number of trips per year that the routes can take with the average- and best practice. With this result, hypothesis 3, is accepted for all routes.

Table 7

The number of trips per year that can be performed for the average routes and the best practice routes.

	Ship 1, 2, 3 & 4	Ship 5 / 6	Ship 7 & 8	Ship 9	Ship 10	Ship 11	Ship 12	Ship 13 / 14	Ship 15	Ship 16 / 17	Total
Average route	50,63	51,79	51,04	51,63	51,45	52,44	53,17	50,68	59,41	49,24	521,49
Best practice	68,82	78,06	91,48	68,09	56,28	61,83	57,36	74,17	72,86	70,19	699,16

Best practice simulation trip

Here the simulation trip of the average route and the best practice route for route that ship 12 operates is presented with high and low variation. In Appendix A the simulation trip for the other routes can be found.

Table 8

Best practice, time used with high and low variation for the ship 12

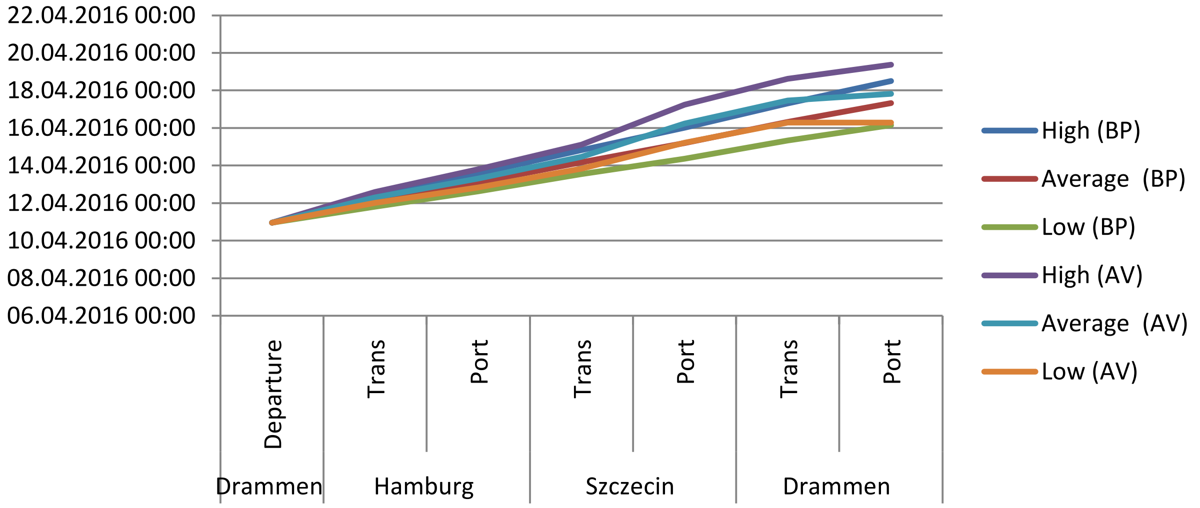
	Hamburg		Szczecin		Drammen	
Best practice	Transit	Port	Transit	Port	Transit	Port
High	34,24	28,75	29,74	28,75	30,89	28,75
Average	27,33	24,20	25,87	24,20	27,02	24,20
Spread	4,20	2,76	2,36	2,76	2,36	2,76
Low	20,43	19,65	21,99	19,65	23,14	19,65
Average trip						
High	39,31	28,75	31,54	51,30	33,15	17,88
Average	32,40	24,20	27,67	42,37	29,28	8,95
Spread	4,20	2,76	2,36	5,43	2,36	5,43
Low	25,50	19,65	23,79	33,43	25,40	0,01

Table 9

Simulation of ship 12 time use for the the best practice route and the average route with high and low variation

EX trip	Drammen	Hamburg		Szczecin		Drammen	
	Departure	Transit	Port	Transit	Port	Transit	Port
High (BP)	10.04.2016 23:00	12.04.2016 09:14	13.04.2016 13:59	14.04.2016 19:43	16.04.2016 00:28	17.04.2016 07:22	18.04.2016 12:06
Average (BP)	10.04.2016 23:00	12.04.2016 02:20	13.04.2016 02:32	14.04.2016 04:24	15.04.2016 04:36	16.04.2016 07:37	17.04.2016 07:49
Low (BP)	10.04.2016 23:00	11.04.2016 19:25	12.04.2016 15:04	13.04.2016 13:04	14.04.2016 08:43	15.04.2016 07:51	16.04.2016 03:31
High (AV)	10.04.2016 23:00	12.04.2016 14:18	13.04.2016 19:03	15.04.2016 02:35	17.04.2016 05:54	18.04.2016 15:03	19.04.2016 08:56
Average (AV)	10.04.2016 23:00	12.04.2016 07:24	13.04.2016 07:36	14.04.2016 11:16	16.04.2016 05:38	17.04.2016 10:54	17.04.2016 19:51
Low (AV)	10.04.2016 23:00	12.04.2016 00:29	12.04.2016 20:09	13.04.2016 19:56	15.04.2016 05:22	16.04.2016 06:46	16.04.2016 06:47

Figur 3



Best Practice with Speed Increase

In this approach, the speed has been the parameter that has been changed. Not all the sea legs could be increased with 10% because of the service speed, these legs where then either increased with 6%, 5 %, 2 % or not increased at all to keep the vessels average speed below the service speed.

Speed

With these speed increments, the average speed on the routes is increased in an rage between 2.53 knots and 4.49 knots from the average routes. In the table 10, the differences in the average speed on the routes, for the average routes and the best practice with speed increase can be found. The route that has the lowest improvement in speed against the average route is the route the ship 10 is operating, which is improved with 17.13 %. For the other routes, the improvements where more than 20 %.

Table 10

The average speed on the average routes and best practice with speed increase routes and the speed improvements in percent.

Routes	Average route	Best practice w. Speed inc.	Improvement in average speed
Ship 1, 2, 3 & 4	11,41	15,55	36,30 %
Ship 5 / 6	13,78	17,36	26,02 %
Ship 7 & 8	13,51	16,59	22,81 %
Ship 9	12,20	15,90	30,33 %
Ship 10	14,78	17,31	17,13 %
Ship 11	13,15	15,94	21,24 %
Ship 12	13,09	15,93	21,72 %
Ship 13 /14	12,48	15,63	25,24 %
Ship 15	12,85	15,96	24,19 %
Ship 16 /17	13,76	18,25	32,66 %

Time improvements

With a higher speed, there is an improvement on the routes time as can be found in table 11. The lowest improvement against the average route time is for ship 10, which has an improvement of 11.36 %. Also here the ships 7 and 8 have the highest improvement in the total route time, which is improved with 44.93 % against the average total route time. Then hypothesis 3 is accepted for one of the ten routes.

Table 11

Total time usage in days for the average routes and the best practice routes with speed increase and time improvements in percent.

	Average Route			Best Practice w. Speed Inc. Route			Improvents in percent		
Routes	Total transit time	Total time in port	Total route time	Total transit time	Total time in port	Total route time	Total transit time	Total time in port	Total route time
Ship 1, 2, 3 & 4	23,75	5,59	28,86	21,17	1,79	20,84	10,86 %	67,99 %	27,78 %
Ship 5 / 6	3,81	3,24	7,05	2,87	1,66	4,54	24,58 %	48,76 %	35,69 %
Ship 7 & 8	6,81	7,50	14,31	5,58	2,30	7,88	18,03 %	69,36 %	44,93 %
Ship 9	3,77	3,30	7,07	2,93	2,15	5,08	22,30 %	35,03 %	28,24 %
Ship 10	3,67	3,43	7,10	3,23	3,06	6,29	11,86 %	10,82 %	11,36 %
Ship 11	3,42	3,54	6,97	2,90	2,78	5,68	15,15 %	21,52 %	18,39 %
Ship 12	3,72	3,15	6,87	3,04	3,02	6,06	18,38 %	3,86 %	11,73 %
Ship 13 /14	4,09	3,12	7,21	3,05	1,59	4,65	25,29 %	48,88 %	35,50 %
Ship 15	4,16	2,72	6,15	3,34	1,73	4,73	19,76 %	36,41 %	23,08 %
Ship 16 /17	3,46	3,95	7,42	2,40	2,62	5,02	30,76 %	33,64 %	32,30 %

Even with increased speed, are the largest improvements for most of the routes in the time in port. Only for the two routes which the ship 10 and ship 12 are operating is the transit time the most improved.

For the route that ship 7 and 8 operate, the objective to get the route down to eight days is achieved and even further improved. However, as also can be seen in table 11, for the other routes the objective to get the transit time down to four days, or 16 days for one of the routes, has not been achieved.

Service frequency

These improvements on the route transit times means that the vessels can sail the route more frequently than they do, at the moment, see table 12. With the use of the best practice with increasing of speed, the route frequency can be improved with an overall of 37.05 % against the average rout, meaning 196.30 more round trips per year. Against the best practice the improvement is 3.67 %, resulting in 25.73 more trips. This result accepts the hypothesis 3.

Table 12

The number of trips per year that can be performed for the average routes and the best practice with speed increase routes.

	Ship 1, 2, 3 & 4	Ship 5 / 6	Ship 7 &8	Ship 9	Ship 10	Ship 11	Ship 12	Ship 13 / 14	Ship 15	Ship 16 / 17	Total
Average route	50,63	51,79	51,04	51,63	51,45	52,44	53,17	50,68	59,41	49,24	521,49
Best practice w. Speed increace	70,11	80,54	92,68	71,95	58,04	64,26	60,24	78,58	77,23	72,73	726,36

Best practice with speed increase simulation trip

There have also been made simulation trips for the best practice routes with speed increase, with high and low variation. In the tables and graph below, an example trip for the route operated by ship 12 is shown. In Appendix A, the simulations for all the other scenario 2 routes can be found.

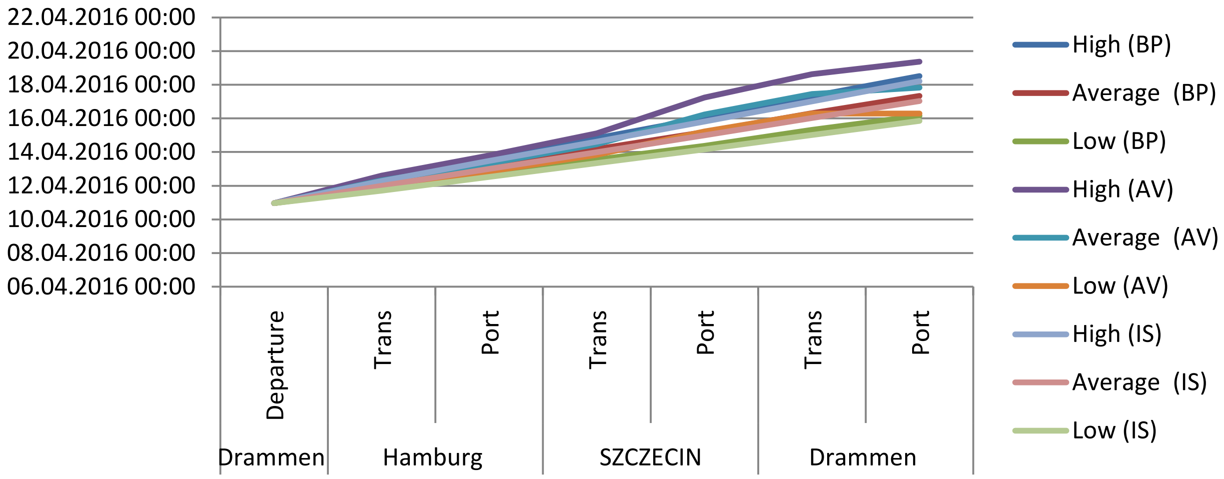
Table 13

Best practice with speed increase, time use with high and low variation for the ship 12						
	Hamburg		Szczecin		Drammen	
Best trip	Transit	Port	Transit	Port	Transit	Port
High	34,24	28,75	29,74	28,75	30,89	28,75
Average	27,33	24,20	25,87	24,20	27,02	24,20
Spread	4,20	2,76	2,36	2,76	2,36	2,76
Low	20,43	19,65	21,99	19,65	23,14	19,65
Average trip						
High	39,31	28,75	31,54	51,30	33,15	17,88
Average	32,40	24,20	27,67	42,37	29,28	8,95
Spread	4,20	2,76	2,36	5,43	2,36	5,43
Low	25,50	19,65	23,79	33,43	25,40	0,01
Increased speed						
High	31,75	28,75	27,39	28,75	28,44	28,75
Average	24,85	24,20	23,52	24,20	24,56	24,20
Spread	4,20	2,76	2,36	2,76	2,36	2,76
Low	17,94	19,65	19,64	19,65	20,68	19,65

Table 14

Simulation of ship 12, time use for the the route with high and low variation							
EX trip	Drammen	Hamburg		Szczecin		Drammen	
	Departure	Transit	Port	Transit	Port	Transit	Port
High (BP)	10.04.2016 23:00	12.04.2016 09:14	13.04.2016 13:59	14.04.2016 19:43	16.04.2016 00:28	17.04.2016 07:22	18.04.2016 12:06
Average (BP)	10.04.2016 23:00	12.04.2016 02:20	13.04.2016 02:32	14.04.2016 04:24	15.04.2016 04:36	16.04.2016 07:37	17.04.2016 07:49
Low (BP)	10.04.2016 23:00	11.04.2016 19:25	12.04.2016 15:04	13.04.2016 13:04	14.04.2016 08:43	15.04.2016 07:51	16.04.2016 03:31
High (AV)	10.04.2016 23:00	12.04.2016 14:18	13.04.2016 19:03	15.04.2016 02:35	17.04.2016 05:54	18.04.2016 15:03	19.04.2016 08:56
Average (AV)	10.04.2016 23:00	12.04.2016 07:24	13.04.2016 07:36	14.04.2016 11:16	16.04.2016 05:38	17.04.2016 10:54	17.04.2016 19:51
Low (AV)	10.04.2016 23:00	12.04.2016 00:29	12.04.2016 20:09	13.04.2016 19:56	15.04.2016 05:22	16.04.2016 06:46	16.04.2016 06:47
High (IS)	10.04.2016 23:00	12.04.2016 06:45	13.04.2016 11:30	14.04.2016 14:53	15.04.2016 19:38	17.04.2016 00:04	18.04.2016 04:49
Average (IS)	10.04.2016 23:00	11.04.2016 23:50	13.04.2016 00:02	13.04.2016 23:33	14.04.2016 23:45	16.04.2016 00:19	17.04.2016 00:31
Low (IS)	10.04.2016 23:00	11.04.2016 16:56	12.04.2016 12:35	13.04.2016 08:14	14.04.2016 03:53	15.04.2016 00:34	15.04.2016 20:13

Figur 4



Benchmark

As can be seen from the results from the two scenarios, and table 15, the routes could be improved by doing some changes, to the time in port, transit and the speed. The amount of change that each rout has in the two scenarios varies. Ship 7 and 8 operate the route that has the best improvements in the total route time on both scenarios and are the only route that was improved to the objective route time.

With the improvements in the service frequency of the routes the vessels could carry more containers yearly, and consequently increase their earnings. In the table below the amount of containers that the vessels could carry yearly with the use of the two scenarios can be found. As can be seen the number of containers transported could be increase with 35-40 percent with the improvements. With more frequent routes the vessels could carry more containers yearly without having to increase the vessel size.

Table 15

Summary of the improvements from the scenarios

	Average route		Beat Practice route			Best Practice w. Speed Inc.		
	Total route	Frequency	Total route	Improvement	Frequency	Total route	Improvement	Frequency
Ship 1, 2, 3 & 4	28,86	50,63	21,23	26,43 %	68,82	20,84	27,78 %	70,11
Ship 5 / 6	7,05	51,79	4,68	33,65 %	78,06	4,54	35,69 %	80,54
Ship 7 & 8	14,31	51,04	7,98	44,21 %	91,48	7,88	44,93 %	92,68
Ship 9	7,07	51,63	5,36	24,17 %	68,09	5,08	28,24 %	71,95
Ship 10	7,10	51,45	6,49	8,59 %	56,28	6,29	11,36 %	58,04
Ship 11	6,97	52,44	5,91	15,19 %	61,83	5,68	18,39 %	64,26
Ship 12	6,87	53,17	6,37	7,31 %	57,36	6,06	11,73 %	60,24
Ship 13 /14	7,21	50,68	4,92	31,67 %	74,17	4,65	35,50 %	78,58
Ship 15	6,15	59,41	5,01	18,47 %	72,86	4,73	23,08 %	77,23
Ship 16 /17	7,42	49,24	5,20	29,84 %	70,19	5,02	32,30 %	72,73

Table 16

The yearly TEU capacity for the vessels with the average route and the two improvement scenarios.

	Average route	Best Practice route	BP w. speed increase
	TEU capacity	TEU capacity	TEU capacity
Ship 1	13 113	17 824	18 157
Ship 2	10 987	14 934	15 213
Ship 3	10 987	14 934	15 213
Ship 4	11 139	15 140	15 423
Ship 5 / 6	44 957	67 757	69 905
Ship 7	21 822	39 430	39 947
Ship 8	22 277	40 253	40 781
Ship 9	38 725	51 067	53 966
Ship 10	45 274	49 530	51 075
Ship 11	44 573	52 558	54 619
Ship 12	34 986	37 744	39 635
Ship 13 / 14	33 350	48 806	51 709
Ship 15	44 554	54 647	57 920
Ship 16 / 17	49 637	70 750	73 316
Total yearly TEU capacity	426 381	575 374	596 878
Total improvement in Percent		34,94 %	39,99 %

Note : for the routes that changes vessels, the capacity has been calculated for the vessel that have taken over the route.

Discussion

This thesis has looked at already running routes of regular scheduled container vessels that are operating in the Oslo fjord. These routes have been improved in a model where two scenarios have been conducted. With the use of these two improvements it was found that the routes can reduce their total lead time by improving the transit time, time in port and transit speed.

These improvements will be looked at in the light of the found parameters, lead time, cost and flexibility. By doing this, one can see how the changes meet the customer requirements and thus can make the sea transport more attractive. In addition, the effects on the shipping company will also be looked at.

Lead Time

In the results the lead time of the route where decreased in both scenarios. The decrease in the lead time can result in a competitive edge for the carriers that are operating the route. This is because the lead time is an important competitive factor for the carrier (Notteboom, 2006).

For the route operated by four ships, the lead time in both the scenarios are improved enough to be able to reduce the number of vessels that are operating. To withhold a weekly schedule, there is in the new routes need for three vessels, which can lead to reduction in the operation cost, but increase in the bunker fuel cost (Wang et al., 2015). However, the objective is not to reduce the number of vessels that operate in the area, because this would reduce the frequency form the scenarios.

The lead time's improvement will have an effect on the customers inventory cost, which represent a major logistics cost for many manufacturers and retailers (Rushton et al., 2006). When the customer can get their goods quicker than they can start to use or sell the transported goods sooner, which means that the opportunity cost is reduced and they can start making money on their products/goods (Hsu & Hsieh, 2007).

For the customer the lead time is especially important when the goods that are being shipped are perishable goods or consumer goods with a short life cycle or high/technical depreciation, i.e. time sensitive goods. With a reduced lead time will the risk of opportunity costs and lowered economic value for the customers be reduced (Notteboom, 2006).

Transit Time

At sea the uncertainty factors that can influence the transit is adverse weather (Wang & Meng, 2012a). In the observations there where noticed on several occasions and several routes deviations in the transit times. It can be assumed that these deviations are because of uncertainty factors, but several of these deviations can be linked to the weather conditions in the area (Yr, n.d).

Weather conditions have an influence on the sailing time because the speed of the vessel often has to be reduced in bad weather (Christiansen et al., 2007). In the presence of waves, the ships course-keeping ability and maneuvering performance can be affected, and as a result of maintain the desired heading they may experience involuntary speed reduction (Skejic & Faltinsen, 2008).

These uncertainties at sea are often tackled by build in some buffer in each voyage leg. At the beginning of the voyage the ship sails at a higher speed and when approaching the destination port the ship can slow down due to short residual voyage distance and less possibility of uncertainties (Wang & Meng, 2012a).

As a result of the lower speed, there might be late arrival for the next planned cargo and rescheduling of the whole fleet (Christiansen et al., 2007). When a ship is delayed to a port, cost for both parties can occur in the form of inventory and production cost for the shipper, and for the carrier operation cost and damage to their reputation in relation to customer satisfaction (Song et al., 2015).

The speed

In scenario two the speed where increased with 10 %, however in both scenarios the average speed on the sea legs rose. When the speed is increased with just a few knots it may lead to an increase in the bunker fuel consumption and cost (Wang & Meng, 2012a).

The bunker fuel cost accounts for a large percentage of the total operating cost, therefor by increasing the speed, and consequently the bunker fuel consumption and cost, the new routes in the scenarios can lead to higher costs for the shipping company.

Since the two scenarios increases the speed, the slow steaming strategy, that many vessels employ, are not followed in the new routes. However, slow steaming has a negative impact on the lead time which can lead to loss of customers, and since there is a trade-off between bunker fuel consumption and customer satisfaction. One can assume that increasing the speed can lead to more customers and more customer satisfaction (Reinhardt et al., 2016). So the new routes may lead to higher bunker fuel cost but also more and satisfied customers.

Time in Port

For all the routes the port time was reduced in the scenarios. Nine of the ten routes had a reduction of more than 10 % against the average port time.

This reduction in the turnaround time is an important factor for reducing the shipping companies costs (Zeng & Yang, 2009). A ship only creates value when it is moving cargo, hence when the ship stands still at port it does not create value. Therefore, with the reduced time the vessels will be able to use more time moving cargo and thereby creating value. To be able to reduce the time in port, the largest time component, which is container handling, needs to be reduced. This operation can be reduced by more efficient loading and discharging activities (Wang et al., 2015).

In the port times there were found some large deviations in the observations. The reasons for deviations are thus not known, but it can be assumed that these came because of different port uncertainties. However, some of the deviations could be linked to the weather, so it could seem like the vessel may have waited for it to pass.

For a ship, the longer the port time, either because of uncertainties or other reasons, the sailing time is shortened, and therefor has to speed up and the bunker fuel cost increases. In addition, the number of ships needed to deploy the rout, to withhold the weekly service, also increases. This means that by improving the port efficiency and making the port time more robust and shorter, can reduce the total cost for the shipping company (Wang et al., 2015).

Since the cargo handling is the largest cost for a port call, one way of reducing it is to plan the arrival and schedule the container handling operations to a time of day that there are no extra charges for the operation, often on the afternoon, night, weekends and on holidays the operation costs extra (Eidhammer, 2004).

Frequency

The inventory costs of the customer should be taken into account in the route planning. By taking the cost into account the quality of service that is offered to the customer and their satisfaction can be enhanced. The level of service can be enhanced by sailing frequency, faster ships and by planning routes so that the lead time is shortened. This will lead to a lowered waiting cost for the customer (Hsu & Hsieh, 2007).

With the two scenarios the lead time was shortened, and the speed of the vessel increased. As a reaction the service frequency of the routes can be increased, resulting in enhanced customer service.

Liner service often has weekly services, and each port is visited on the same day of the week, if a service has been missed there will be waiting time for the next service, which will lead to longer lead time and higher inventory cost (Jiang, Lee, Chew, & Gan, 2015; Wang & Meng, 2012b). With the higher service frequency in the scenarios, the customer can send and/or receive goods more often and if a service is missed it will be a shorter waiting time for the next service, hence lower the inventory cost. This can open up for more customers since they will then have a greater choice of days to ship their goods.

With the increased frequency form the scenarios, the vessels can carry more containers yearly, without having to increase the vessel or fleet size, see table 16, and consequently also increase their earnings, from the freight. Since the objective of the government and NØKS is to transfer more goods to sea, this result shows that the already running tonnage can handle an increase in the goods, if they increase the frequency of the routes and then there would not be a need for more operating tonnage, depending on the amount of course.

When the service frequency is decreased the shipping cost, i.e. capital and operating, bunker fuel cost and port charges, is reduced while the inventory cost increases. Thus with a higher frequency, the shipping cost will increase and the inventory cost will decrease. Therefore should there to be a trade-off between the objectives of the shipper and customer since both parties wants to reduce their costs, this trade-off is linked by the service frequency. With the two scenarios the shipping cost will increase due to the increased frequency, this is because the speed is increased and more frequent port calls and port charges (Hsu & Hsieh, 2007).

Higher service frequency will thus impose more costs on the shipping company, but to be able to compete with other modes of transport, like road, the increased service frequency can be necessary to increase the customer satisfaction (Christiansen et al., 2007).

Flexibility and Buffer

Uncertainty factors influence the route execution and lead to unreliable services (Notteboom, 2006). In the observed routes there where deviations in several of the routes, these can be assumed to be connected with uncertainties at sea and in port. Several of the deviations occurred at dates with a lot of wind and bad weather in the Oslo fjord (Yr, n.d). This shows that the uncertainties are important to take into consideration in the planning and completion of the route.

When delays occur either from uncertainties in port or transit, it can have cascading effects on the whole loop. Such as late arrival to the next port of call and it can impact the round trip voyage of other vessels in the same loop (Notteboom, 2006).

Unreliable services will lead to different costs for the company and the customer. For the shipping line these costs occur in the loss of time, additional operating cost, which can be linked to unproductive vessel time and rescheduling of vessels, or other costs as a result of delay and diversions. For the customers it can result in loss of value, in the form of additional inventory cost and in some cases additional production costs (Notteboom, 2006).

Because of these occurring effects and costs that uncertainties and unreliability leads to, it is important to take them in to consideration in the route planning both at the tactical and operational planning level. They can be handled either by build enough slack in the route planning or to handle them in more creative ways at the operational level (Christiansen et al., 2007; Notteboom, 2006; Song et al., 2015; Wang & Meng, 2012a).

One of the ways of securing a reliable service is to build in buffer time in the schedule, but buffer usually comes with a price. A high buffer time decreased the chance for delays, but to have buffers in the schedule is costly, and can lead to higher freight rates for the customers (Notteboom, 2006). This means that the customers have to choose between high reliability and high freight rates, or more uncertain reliability and lower rates.

In the two scenarios there has been built in some robustness. By the use of the average and standard deviation in the calculation of the route will the route gain some robustness, and the route can become more reliable even with the risk of uncertainties at sea and in port.

One of the ways of dealing with delays are to speed up the vessel, with the aim of reducing or completely eliminating the delay (Qi, 2015). However, this option will be less attractive when the planned maximum speed is close to the vessels maximum speed limit and because often shipping lines are reluctant to speed up further because of the rapidly increasing bunker fuel consumption (Qi, 2015; Song et al., 2015). With the two scenarios, where the speed of the vessel already have been more increased, the shipping line, might become even more reluctant to speed up the vessels when they are delayed.

Reshuffling the order of the port calls or port swapping, is a common way of handling delays, and this might be the reason for the port call order in the observations often change. Cancelling port calls is also a way to get the ship back on schedule. However if these method become more of a rule than an exception, the customer satisfaction might decrease (Notteboom, 2006).

The level of service to the customers is affected by the elements of, and interaction between the service frequencies, deployed vessels and the sailing speed on the route. In the planning process of the routes, the ship operating cost, bunker fuel cost and inventory cost are important factor that needs to be taken into consideration, and there should be made a trade-off between them so that the interests of the carrier and the shipper are withheld (Wang et al., 2015) (Christiansen et al., 2013).

Limitations of the Study

The study has some limitations that can be taken into account in further research. First, the distance between port in the calculations is a standard distance, which either have been collected from the ports web site or the internet have been used (Port of Oslo, n.d; Sea-Distance.org, n.d.). This will not give the true sailing distance of the vessels on the different sea legs. Because of this will the average speed on the vessels, the speed in the two scenarios, and the speed improvements in the results will only be an indication of the speed and improvements. Secondly, the used benchmark approach to calculate the port time for all the ports in the different routes, might give unrealistic port times. This is because, not all the port calls on the route are the same size, have the same handling equipment, and the loaded and discarded quantity in each port may differ. Therefore, to generalize the ports might not give the right or needed port time for all the ports on the route. Another approach that can be used in a further study is to look at all the ports individually and reduce the port time in each port, e.g. with a specific percentage, or hours. Also, in a further study, one could cooperate with the shipping company or the port to get the bill of leading quantity for each port call. In this way one could calculate the port time depending on the port efficiency or the handling equipment efficiency. This was the initial plan of the study, however this was not achieved and therefore where the studies approach adapted to the information that was obtainable.

Conclusion

Based on the AIS data on the short sea container feeder lines, that has been used for benchmark in two scenarios. The benchmark shows that the routes can be improved. The improvements are based on the assumption that all the ports on a route can use the same port time. However, given the results for the benchmark it can be discussed whether this is feasible, since the deviations in transit time and standard deviation that is used has some weaknesses. These weaknesses are that the benchmark for the port time might not be within reach for all the port call on the routes.

In relation to the findings in the study, it is showed that for the feeder lines that operate routes in the Oslo fjord can reduce their route trip time, by improving the port time, transit time and speed of the vessels. The improvements in the study might not be reachable because of the benchmark approach used in the port time, but the results show that a reduction in the port and transit time can have substantial improvement effect on the time used on the route trip.

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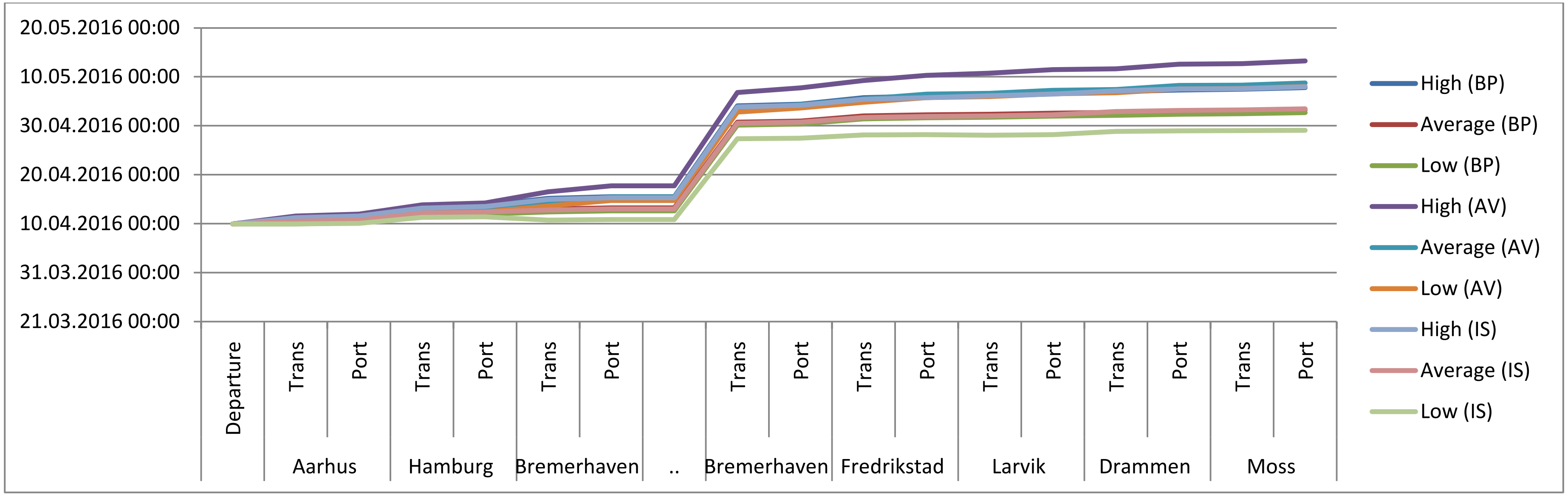
Appendix A

Simulation trips of the average, best practice and best practice with speed increase routes.

Ship 1, 2, 3 & 4

	Aarhus		Hamburg		Bremerhaven		..	Bremerhaven		Fredrikstad		Larvik		Drammen		Moss	
Best trip	Trans	Port	Trans	Port	Trans	Port		Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High	31,67	8,32	42,00	8,32	34,75	8,32		445,32	8,32	31,69	8,32	8,61	8,32	4,52	8,32	2,71	8,32
Average	14,70	5,36	37,70	5,36	9,80	5,36		420,98	5,36	24,55	5,36	2,75	5,36	4,27	5,36	2,08	5,36
Spread	10,31	1,80	2,61	1,80	15,17	1,80		14,79	1,80	4,34	1,80	3,56	1,80	0,16	1,80	0,38	1,80
Low	-2,27	5,36	37,70	5,36	9,80	5,36		420,98	5,36	24,55	5,36	2,75	5,36	4,27	5,36	2,08	5,36
Average trip																	
High	39,05	8,32	46,40	8,72	54,28	29,59		458,18	22,34	35,35	26,39	10,46	16,90	4,78	22,09	2,99	12,87
Average	22,08	5,36	42,10	5,76	29,33	26,63		433,85	19,38	28,21	23,43	4,61	13,94	4,52	19,13	2,36	9,91
Spread	10,31	1,80	2,61	1,80	15,17	1,80		14,79	1,80	4,34	1,80	3,56	1,80	0,16	1,80	0,38	1,80
Low	5,11	5,36	42,10	5,76	29,33	26,63		433,85	19,38	28,21	23,43	4,61	13,94	4,52	19,13	2,36	9,91
Increased speed																	
High	30,33	8,32	38,57	8,32	33,86	8,32		445,32	8,32	29,46	8,32	8,36	8,32	16,76	8,32	2,52	8,32
Average	13,36	5,36	34,27	5,36	8,91	5,36		420,98	5,36	22,32	5,36	2,50	5,36	16,50	5,36	1,89	5,36
Spread	10,31	1,80	2,61	1,80	15,17	1,80		14,79	1,80	4,34	1,80	3,56	1,80	0,16	1,80	0,38	1,80
Low	-3,60	2,40	29,97	2,40	-16,04	2,40		396,65	2,40	15,17	2,40	-3,36	2,40	16,24	2,40	1,27	2,40

EX trip		Aarhus		Hamburg		Bremerhaven		..	Bremerhaven		Fredrikstad		Larvik		Drammen		Moss	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port		Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High (BP)	09.04.2016 23:00	11.04.2016 06:40	11.04.2016 14:59	13.04.2016 08:59	13.04.2016 17:18	15.04.2016 04:03	15.04.2016 12:23		04.05.2016 01:42	04.05.2016 10:01	05.05.2016 17:43	06.05.2016 02:02	06.05.2016 10:39	06.05.2016 18:58	06.05.2016 23:30	07.05.2016 07:49	07.05.2016 10:32	07.05.2016 18:51
Average (I	09.04.2016 23:00	10.04.2016 13:42	10.04.2016 19:03	12.04.2016 08:45	12.04.2016 14:07	12.04.2016 23:55	13.04.2016 05:17		30.04.2016 18:16	30.04.2016 23:38	02.05.2016 00:11	02.05.2016 05:33	02.05.2016 08:18	02.05.2016 13:39	02.05.2016 17:55	02.05.2016 23:17	03.05.2016 01:22	03.05.2016 06:44
Low (BP)	09.04.2016 23:00	09.04.2016 23:00	10.04.2016 04:21	11.04.2016 18:03	11.04.2016 23:25	12.04.2016 09:13	12.04.2016 14:35		30.04.2016 03:34	30.04.2016 08:56	01.05.2016 09:29	01.05.2016 14:51	01.05.2016 17:36	01.05.2016 22:57	02.05.2016 03:13	02.05.2016 08:35	02.05.2016 10:40	02.05.2016 16:02
High (AV)	09.04.2016 23:00	11.04.2016 14:02	11.04.2016 22:22	13.04.2016 20:46	14.04.2016 05:29	16.04.2016 11:46	17.04.2016 17:21		06.05.2016 19:32	07.05.2016 17:52	09.05.2016 05:13	10.05.2016 07:37	10.05.2016 18:05	11.05.2016 10:59	11.05.2016 15:46	12.05.2016 13:51	12.05.2016 16:51	13.05.2016 05:43
Average (/	09.04.2016 23:00	10.04.2016 21:04	11.04.2016 02:26	12.04.2016 20:32	13.04.2016 02:18	14.04.2016 07:38	15.04.2016 10:15		03.05.2016 12:06	04.05.2016 07:29	05.05.2016 11:41	06.05.2016 11:07	06.05.2016 15:43	07.05.2016 05:40	07.05.2016 10:11	08.05.2016 05:19	08.05.2016 07:41	08.05.2016 17:36
Low (AV)	09.04.2016 23:00	10.04.2016 04:06	10.04.2016 09:28	12.04.2016 03:34	12.04.2016 09:20	13.04.2016 14:40	14.04.2016 17:17		02.05.2016 19:08	03.05.2016 14:31	04.05.2016 18:43	05.05.2016 18:09	05.05.2016 22:45	06.05.2016 12:42	06.05.2016 17:13	07.05.2016 12:21	07.05.2016 14:43	08.05.2016 00:38
High (IS)	09.04.2016 23:00	11.04.2016 05:19	11.04.2016 13:39	13.04.2016 04:13	13.04.2016 12:33	14.04.2016 22:24	15.04.2016 06:43		03.05.2016 20:02	04.05.2016 04:22	05.05.2016 09:50	05.05.2016 18:09	06.05.2016 02:31	06.05.2016 10:50	07.05.2016 03:35	07.05.2016 11:55	07.05.2016 14:26	07.05.2016 22:46
Average (I	09.04.2016 23:00	10.04.2016 12:21	10.04.2016 17:43	12.04.2016 03:59	12.04.2016 09:21	12.04.2016 18:16	12.04.2016 23:38		30.04.2016 12:37	30.04.2016 17:58	01.05.2016 16:18	01.05.2016 21:39	02.05.2016 00:09	02.05.2016 05:31	02.05.2016 22:01	03.05.2016 03:23	03.05.2016 05:17	03.05.2016 10:38
Low (IS)	09.04.2016 23:00	09.04.2016 23:00	10.04.2016 01:24	11.04.2016 07:22	11.04.2016 09:46	10.04.2016 17:44	10.04.2016 20:08		27.04.2016 08:47	27.04.2016 11:11	28.04.2016 02:22	28.04.2016 04:46	28.04.2016 01:24	28.04.2016 03:48	28.04.2016 20:03	28.04.2016 22:27	28.04.2016 23:43	29.04.2016 02:07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10.05.2016 00:00
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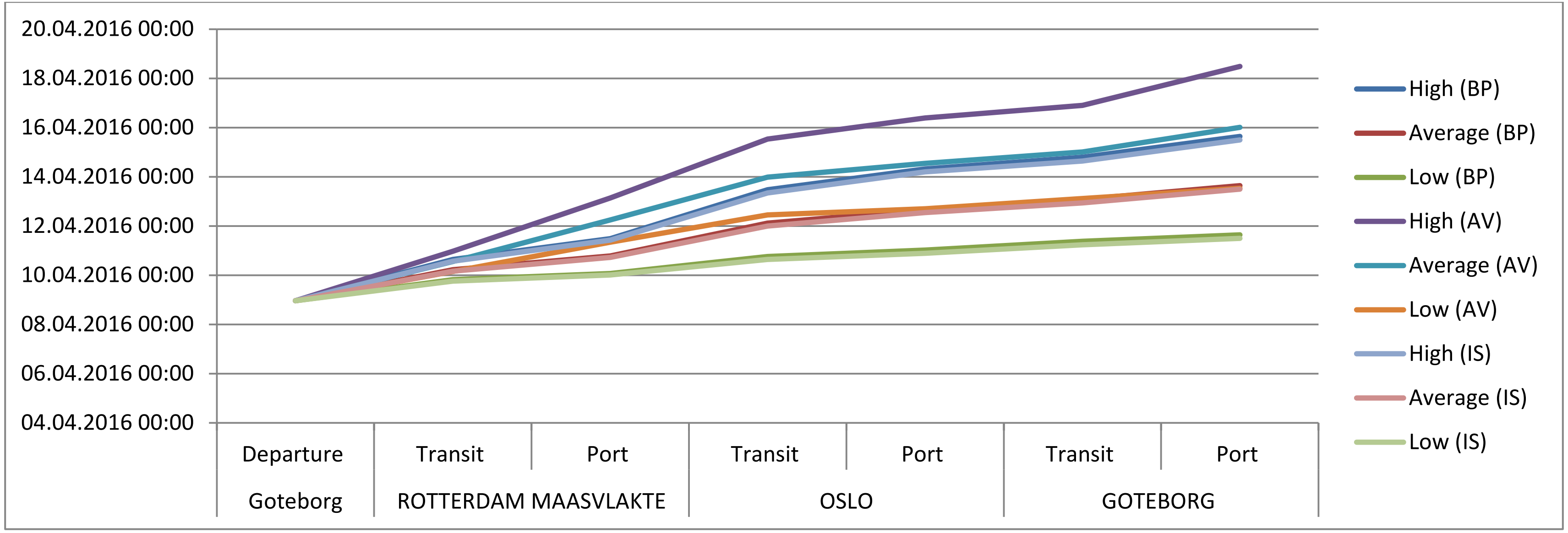
Departure
Trans
Port
Aarhus
Hamburg
Bremerhaven
..
Bremerhaven
Fredrikstad
Larvik
Drammen
Moss
High (BP)
Average (BP)
Low (BP)
High (AV)
Average (AV)
Low (AV)
High (IS)
Average (IS)
Low (IS)

Ship 4 / 5

	ROTTERDAM MAASVLAKTE		OSLO		GOTEBORG	
Best trip	Transit	Port	Transit	Port	Transit	Port
High	40,17	20,46	47,61	20,46	11,19	20,46
Average	30,37	13,28	32,08	13,28	10,00	13,28
Spread	5,96	4,36	9,44	4,36	0,72	4,36
Low	20,56	6,11	16,56	6,11	8,81	6,11
Average trip						
High	48,21	52,11	57,46	20,46	12,34	38,07
Average	38,40	40,39	41,93	13,28	11,15	24,09
Spread	5,96	7,13	9,44	4,36	0,72	8,50
Low	28,60	28,66	26,40	6,11	9,97	10,10
Increased speed						
High	38,73	20,46	46,08	20,46	10,71	20,46
Average	28,92	13,28	30,56	13,28	9,52	13,28
Spread	5,96	4,36	9,44	4,36	0,72	4,36
Low	19,11	6,11	15,03	6,11	8,34	6,11

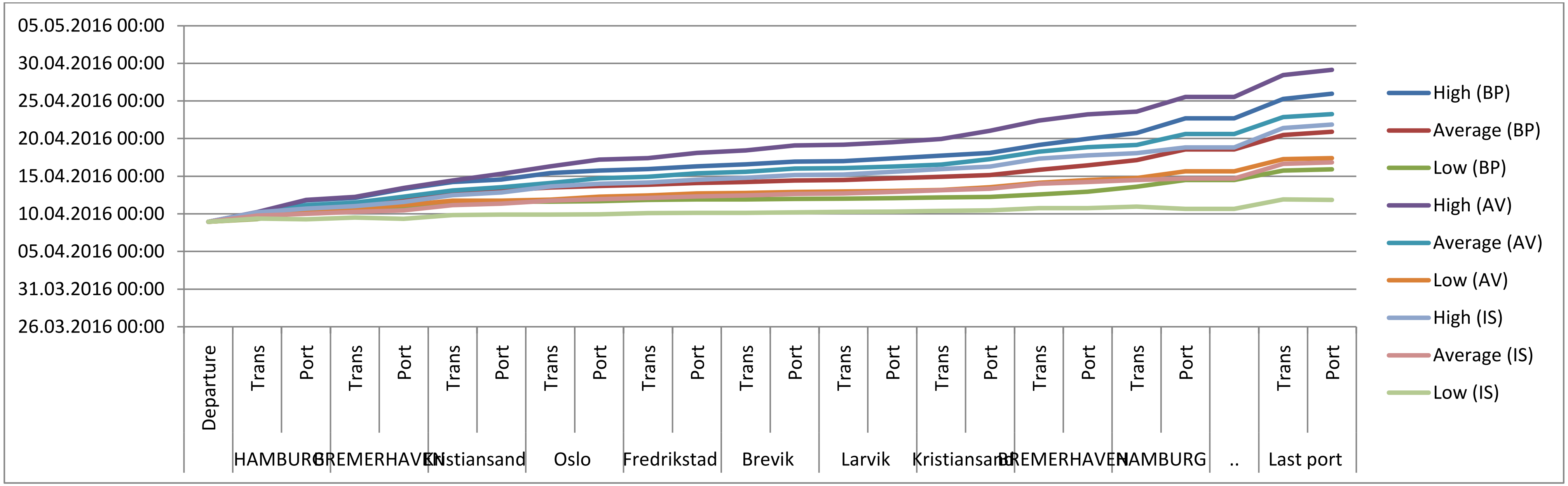
Ex trip	Goteborg	ROTTERDAM MAASVLAKTE		OSLO		GOTEBORG	
	Departure	Transit	Port	Transit	Port	Transit	Port
High (BP)	08.04.2016 23:00	10.04.2016 15:10	11.04.2016 11:37	13.04.2016 11:14	14.04.2016 07:41	14.04.2016 18:53	15.04.2016 15:20
Average (BP)	08.04.2016 23:00	10.04.2016 05:22	10.04.2016 18:38	12.04.2016 02:43	12.04.2016 16:00	13.04.2016 02:00	13.04.2016 15:17
Low (BP)	08.04.2016 23:00	09.04.2016 19:33	10.04.2016 01:39	10.04.2016 18:13	11.04.2016 00:19	11.04.2016 09:08	11.04.2016 15:14
High (AV)	08.04.2016 23:00	10.04.2016 23:12	13.04.2016 03:19	15.04.2016 12:46	16.04.2016 09:14	16.04.2016 21:34	18.04.2016 11:38
Average (AV)	08.04.2016 23:00	10.04.2016 13:24	12.04.2016 05:47	13.04.2016 23:43	14.04.2016 13:00	15.04.2016 00:09	16.04.2016 00:14
Low (AV)	08.04.2016 23:00	10.04.2016 03:35	11.04.2016 08:15	12.04.2016 10:39	12.04.2016 16:46	13.04.2016 02:44	13.04.2016 12:50
High (IS)	08.04.2016 23:00	10.04.2016 13:43	11.04.2016 10:11	13.04.2016 08:16	14.04.2016 04:43	14.04.2016 15:26	15.04.2016 11:53
Average (IS)	08.04.2016 23:00	10.04.2016 03:55	10.04.2016 17:12	11.04.2016 23:45	12.04.2016 13:02	12.04.2016 22:33	13.04.2016 11:50
Low (IS)	08.04.2016 23:00	09.04.2016 18:06	10.04.2016 00:13	10.04.2016 15:14	10.04.2016 21:21	11.04.2016 05:41	11.04.2016 11:47



Ships 7 & 8

	HAMBURG		BREMERHAVEN		Kristiansand		Oslo		Fredrikstad		Brevik		Larvik		Kristiansand		BREMERHAVEN		HAMBURG		..	Last port	
Best trip	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port		Trans	Port
High	28,58	39,33	7,87	28,51	22,11	8,54	20,00	8,54	4,47	8,54	6,73	8,54	1,67	8,54	8,64	8,54	25,84	19,29	18,25	46,77		62,13	16,67
Average	18,48	32,57	6,52	19,45	17,50	5,01	9,62	5,01	4,05	5,01	3,47	5,01	1,40	5,01	5,38	5,01	17,00	13,93	17,08	34,13		46,22	10,19
Spread	6,14	4,11	0,82	5,51	2,81	2,14	6,31	2,14	0,25	2,14	1,98	2,14	0,16	2,14	1,98	2,14	5,38	3,26	0,71	7,68		9,67	3,94
Low	8,39	25,81	5,17	10,38	12,89	1,49	-0,77	1,49	3,63	1,49	0,20	1,49	1,13	1,49	2,12	1,49	8,16	8,57	15,92	21,49		30,31	3,71
Average trip																							
High	30,31	39,33	9,33	28,51	23,77	21,65	23,42	21,31	4,95	16,45	8,15	16,19	1,94	8,54	9,97	26,48	32,41	19,29	8,90	46,77		69,91	16,67
Average	20,22	32,57	7,98	19,45	19,15	10,72	13,03	15,47	4,53	11,33	4,88	9,74	1,67	5,01	6,71	17,45	23,56	13,93	7,74	34,13		54,00	10,19
Spread	6,14	4,11	0,82	5,51	2,81	6,64	6,31	3,55	0,25	3,11	1,98	3,92	0,16	2,14	1,98	5,49	5,38	3,26	0,71	7,68		9,67	3,94
Low	10,12	25,81	6,63	10,38	14,54	-0,21	2,65	9,62	4,11	6,20	1,62	3,30	1,40	1,49	3,45	8,41	14,72	8,57	6,57	21,49		38,09	3,71
Increased speed																							
High	29,92	11,77	7,74	14,08	21,12	8,54	19,46	8,54	4,10	8,54	6,41	8,54	1,54	8,54	8,64	8,54	24,88	10,37	7,63	17,65		62,13	11,49
Average	19,83	5,01	6,39	5,01	16,51	5,01	9,07	5,01	3,68	5,01	3,15	5,01	1,27	5,01	5,38	5,01	16,04	5,01	6,46	5,01		46,22	5,01
Spread	6,14	4,11	0,82	5,51	2,81	2,14	6,31	2,14	0,25	2,14	1,98	2,14	0,16	2,14	1,98	2,14	5,38	3,26	0,71	7,68		9,67	3,94
Low	9,73	-1,75	5,04	-4,05	11,89	1,49	-1,31	1,49	3,26	1,49	-0,11	1,49	1,00	1,49	2,12	1,49	7,19	-0,35	5,30	-7,63		30,31	-1,46

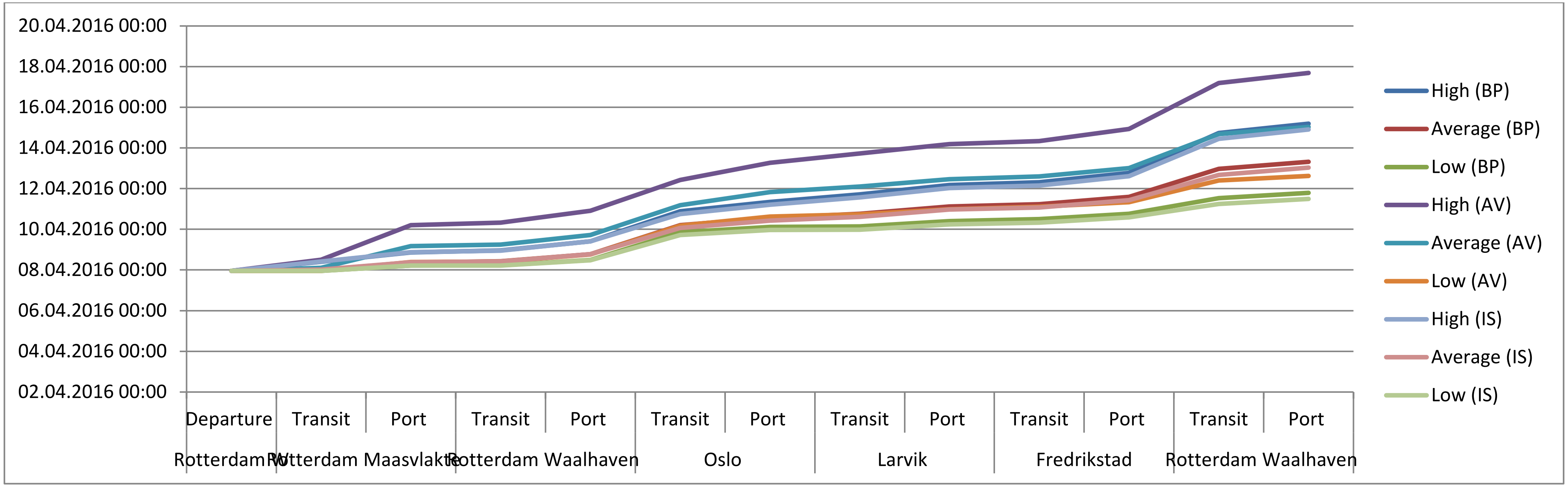
EX trip		HAMBURG		BREMERHAVEN		Kristiansand		Oslo		Fredrikstad		Brevik		Larvik		Kristiansand		BREMERHAVEN		HAMBURG		..	Last port	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port		Trans	Port
High (BP)	08.04.2016 23:00	10.04.2016 03:34	11.04.2016 18:54	12.04.2016 02:46	13.04.2016 07:17	14.04.2016 05:23	14.04.2016 13:56	15.04.2016 09:56	15.04.2016 18:28	15.04.2016 22:56	16.04.2016 07:28	16.04.2016 14:12	16.04.2016 22:44	17.04.2016 00:24	17.04.2016 08:57	17.04.2016 17:35	18.04.2016 02:08	19.04.2016 03:58	19.04.2016 23:16	20.04.2016 17:31	22.04.2016 16:17		25.04.2016 06:24	25.04.2016 23:05
Average (BP)	08.04.2016 23:00	09.04.2016 17:29	11.04.2016 02:03	11.04.2016 08:34	12.04.2016 04:00	12.04.2016 21:30	13.04.2016 02:31	13.04.2016 12:08	13.04.2016 17:09	13.04.2016 21:12	14.04.2016 02:13	14.04.2016 05:41	14.04.2016 10:42	14.04.2016 12:06	14.04.2016 17:06	14.04.2016 22:29	15.04.2016 03:30	15.04.2016 20:30	16.04.2016 10:26	17.04.2016 03:31	18.04.2016 13:39		20.04.2016 11:52	20.04.2016 22:03
Low (BP)	08.04.2016 23:00	09.04.2016 07:23	10.04.2016 09:11	10.04.2016 14:21	11.04.2016 00:44	11.04.2016 13:37	11.04.2016 15:06	11.04.2016 15:06	11.04.2016 16:36	11.04.2016 20:14	11.04.2016 21:43	11.04.2016 21:55	11.04.2016 23:25	12.04.2016 00:33	12.04.2016 02:02	12.04.2016 04:10	12.04.2016 05:39	12.04.2016 13:48	12.04.2016 22:23	13.04.2016 14:18	14.04.2016 11:47		15.04.2016 18:06	15.04.2016 21:48
High (AV)	08.04.2016 23:00	10.04.2016 05:18	11.04.2016 20:38	12.04.2016 05:58	13.04.2016 10:29	14.04.2016 10:15	15.04.2016 07:54	16.04.2016 07:19	17.04.2016 04:37	17.04.2016 09:34	18.04.2016 02:01	18.04.2016 10:10	19.04.2016 02:21	19.04.2016 04:17	19.04.2016 12:49	19.04.2016 22:48	21.04.2016 01:16	22.04.2016 09:41	23.04.2016 04:59	23.04.2016 13:53	25.04.2016 12:39		28.04.2016 10:34	29.04.2016 03:14
Average (AV)	08.04.2016 23:00	09.04.2016 19:13	11.04.2016 03:47	11.04.2016 11:46	12.04.2016 07:12	13.04.2016 02:22	13.04.2016 13:05	14.04.2016 02:07	14.04.2016 17:35	14.04.2016 22:06	15.04.2016 09:26	15.04.2016 14:19	16.04.2016 00:04	16.04.2016 01:44	16.04.2016 06:44	16.04.2016 13:27	17.04.2016 06:54	18.04.2016 06:28	18.04.2016 20:24	19.04.2016 04:08	20.04.2016 14:16		22.04.2016 20:16	23.04.2016 06:28
Low (AV)	08.04.2016 23:00	09.04.2016 09:07	10.04.2016 10:55	10.04.2016 17:33	11.04.2016 03:56	11.04.2016 18:28	11.04.2016 18:28	11.04.2016 21:07	12.04.2016 06:45	12.04.2016 10:51	12.04.2016 17:04	12.04.2016 18:41	12.04.2016 21:59	12.04.2016 23:23	13.04.2016 00:52	13.04.2016 04:19	13.04.2016 12:44	14.04.2016 03:28	14.04.2016 12:02	14.04.2016 18:36	15.04.2016 16:06		17.04.2016 06:11	17.04.2016 09:54
High (IS)	08.04.2016 23:00	10.04.2016 04:55	10.04.2016 16:41	11.04.2016 00:26	11.04.2016 14:30	12.04.2016 11:38	12.04.2016 20:10	13.04.2016 15:38	14.04.2016 00:10	14.04.2016 04:16	14.04.2016 12:48	14.04.2016 19:13	15.04.2016 03:45	15.04.2016 05:18	15.04.2016 13:50	15.04.2016 22:28	16.04.2016 07:01	17.04.2016 07:54	17.04.2016 18:16	18.04.2016 01:54	18.04.2016 19:33		21.04.2016 09:41	21.04.2016 21:10
Average (IS)	08.04.2016 23:00	09.04.2016 18:49	09.04.2016 23:50	10.04.2016 06:13	10.04.2016 11:14	11.04.2016 03:45	11.04.2016 08:45	11.04.2016 17:50	11.04.2016 22:51	12.04.2016 02:32	12.04.2016 07:32	12.04.2016 10:41	12.04.2016 15:42	12.04.2016 16:59	12.04.2016 21:59	13.04.2016 03:22	13.04.2016 08:23	14.04.2016 00:26	14.04.2016 05:26	14.04.2016 11:54	14.04.2016 16:55		16.04.2016 15:08	16.04.2016 20:09
Low (IS)	08.04.2016 23:00	09.04.2016 08:43	09.04.2016 06:59	09.04.2016 12:01	09.04.2016 07:58	09.04.2016 19:51	09.04.2016 21:21	09.04.2016 21:21	09.04.2016 22:50	10.04.2016 02:06	10.04.2016 03:36	10.04.2016 03:36	10.04.2016 05:05	10.04.2016 06:05	10.04.2016 07:35	10.04.2016 09:42	10.04.2016 11:11	10.04.2016 18:23	10.04.2016 18:02	10.04.2016 23:20	10.04.2016 15:43		11.04.2016 22:01	11.04.2016 20:33



Ship 9

	Rotterdam Maasvlakte		Rotterdam Waalhaven		Oslo		Larvik		Fredrikstad		Rotterdam Waalhaven	
Best trip	Transit	Port	Transit	Port	Transit	Port	Transit	Port	Transit	Port	Transit	Port
High	10,58	10,97	2,39	10,97	35,29	10,97	9,09	10,97	3,30	10,97	47,14	10,97
Average	1,20	8,58	1,37	8,58	34,07	8,58	4,88	8,58	2,85	8,58	32,88	8,58
Spread	5,70	1,45	0,62	1,45	0,74	1,45	2,56	1,45	0,27	1,45	8,67	1,45
Low	-8,18	6,19	0,34	6,19	32,84	6,19	0,68	6,19	2,40	6,19	18,63	6,19
Average trip												
High	12,95	41,00	2,80	14,00	36,48	20,24	10,95	10,97	3,64	14,30	54,26	11,78
Average	3,57	25,62	1,77	11,12	35,25	15,49	6,74	8,58	3,19	9,90	40,00	8,54
Spread	5,70	9,35	0,62	1,75	0,74	2,89	2,56	1,45	0,27	2,68	8,67	1,97
Low	-5,80	10,25	0,75	8,24	34,03	10,73	2,53	6,19	2,74	5,49	25,75	5,29
Increased speed												
High	10,90	10,97	1,94	10,97	32,19	10,97	8,65	10,97	3,04	10,97	44,15	10,97
Average	1,52	8,58	0,92	8,58	30,97	8,58	4,44	8,58	2,59	8,58	29,89	8,58
Spread	5,70	1,45	0,62	1,45	0,74	1,45	2,56	1,45	0,27	1,45	8,67	1,45
Low	-7,86	6,19	-0,11	6,19	29,75	6,19	0,23	6,19	2,14	6,19	15,64	6,19

EX trip	Rotterdam W	Rotterdam Maasvlakte		Rotterdam Waalhaven		Oslo		Larvik		Fredrikstad		Rotterdam Waalhaven	
Best trip	Departure	Transit	Port	Transit	Port	Transit	Port	Transit	Port	Transit	Port	Transit	Port
High (BP)	07.04.2016 23:00	08.04.2016 09:34	08.04.2016 20:32	08.04.2016 22:56	09.04.2016 09:54	10.04.2016 21:11	11.04.2016 08:09	11.04.2016 17:15	12.04.2016 04:13	12.04.2016 07:31	12.04.2016 18:29	14.04.2016 17:37	15.04.2016 04:36
Average (BP)	07.04.2016 23:00	08.04.2016 00:12	08.04.2016 08:46	08.04.2016 10:08	08.04.2016 18:43	10.04.2016 04:47	10.04.2016 13:22	10.04.2016 18:15	11.04.2016 02:50	11.04.2016 05:41	11.04.2016 14:16	12.04.2016 23:09	13.04.2016 07:44
Low (BP)	07.04.2016 23:00	07.04.2016 23:00	08.04.2016 05:11	08.04.2016 05:32	08.04.2016 11:43	09.04.2016 20:34	10.04.2016 02:46	10.04.2016 03:26	10.04.2016 09:38	10.04.2016 12:02	10.04.2016 18:13	11.04.2016 12:51	11.04.2016 19:03
High (AV)	07.04.2016 23:00	08.04.2016 11:57	10.04.2016 04:56	10.04.2016 07:44	10.04.2016 21:44	12.04.2016 10:13	13.04.2016 06:27	13.04.2016 17:24	14.04.2016 04:22	14.04.2016 08:01	14.04.2016 22:19	17.04.2016 04:34	17.04.2016 16:21
Average (AV)	07.04.2016 23:00	08.04.2016 02:34	09.04.2016 04:11	09.04.2016 05:58	09.04.2016 17:05	11.04.2016 04:20	11.04.2016 19:49	12.04.2016 02:34	12.04.2016 11:08	12.04.2016 14:20	13.04.2016 00:14	14.04.2016 16:14	15.04.2016 00:46
Low (AV)	07.04.2016 23:00	07.04.2016 23:00	08.04.2016 09:14	08.04.2016 09:59	08.04.2016 18:13	10.04.2016 04:15	10.04.2016 14:59	10.04.2016 17:31	10.04.2016 23:43	11.04.2016 02:27	11.04.2016 07:57	12.04.2016 09:42	12.04.2016 14:59
High (IS)	07.04.2016 23:00	08.04.2016 09:54	08.04.2016 20:52	08.04.2016 22:48	09.04.2016 09:46	10.04.2016 17:58	11.04.2016 04:56	11.04.2016 13:35	12.04.2016 00:33	12.04.2016 03:36	12.04.2016 14:34	14.04.2016 10:43	14.04.2016 21:41
Average (IS)	07.04.2016 23:00	08.04.2016 00:31	08.04.2016 09:06	08.04.2016 10:01	08.04.2016 18:36	10.04.2016 01:34	10.04.2016 10:09	10.04.2016 14:35	10.04.2016 23:10	11.04.2016 01:46	11.04.2016 10:20	12.04.2016 16:14	13.04.2016 00:49
Low (IS)	07.04.2016 23:00	07.04.2016 23:00	08.04.2016 05:11	08.04.2016 05:11	08.04.2016 11:23	09.04.2016 17:08	09.04.2016 23:19	09.04.2016 23:33	10.04.2016 05:45	10.04.2016 07:53	10.04.2016 14:05	11.04.2016 05:43	11.04.2016 11:55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Rotterdam Waalhaven
Oslo
Larvik
Fredrikstad
Rotterdam Waalhaven
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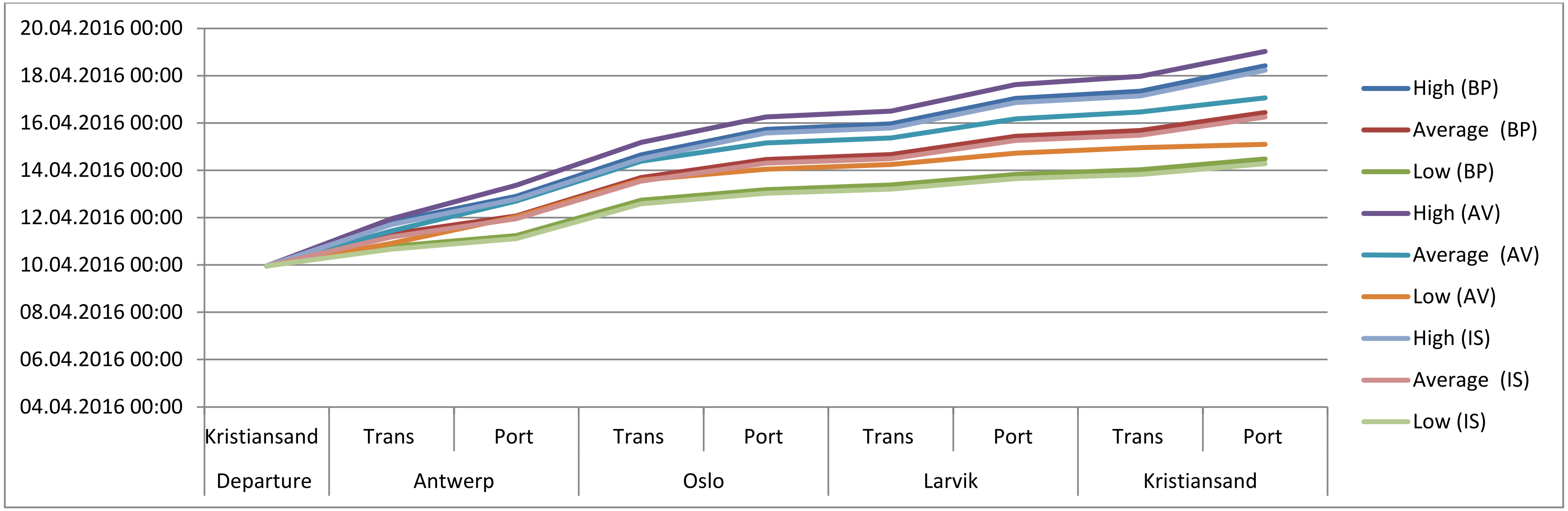
Average (IS)
Low (IS)

Ship 10

	Antwerp		Oslo		Larvik		Kristiansand	
Best trip	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High	44,85	25,90	41,86	25,90	5,49	25,90	7,36	25,90
Average	32,40	18,36	38,85	18,36	5,02	18,36	6,02	18,36
Spread	7,57	4,58	1,83	4,58	0,29	4,58	0,81	4,58
Low	19,95	10,83	35,84	10,83	4,55	10,83	4,68	10,83
Average trip								
High	47,92	33,97	43,39	25,90	5,70	27,14	8,26	25,27
Average	35,48	30,42	40,38	18,36	5,23	19,33	6,92	14,26
Spread	7,57	2,16	1,83	4,58	0,29	4,75	0,81	6,70
Low	23,03	26,88	37,37	10,83	4,76	11,52	5,58	3,24
Increased speed								
High	41,90	25,90	41,10	25,90	5,03	25,90	6,81	25,90
Average	29,45	18,36	38,09	18,36	4,56	18,36	5,47	18,36
Spread	7,57	4,58	1,83	4,58	0,29	4,58	0,81	4,58
Low	17,01	10,83	35,08	10,83	4,09	10,83	4,13	10,83

EX trip	Departure	Antwerp		Oslo		Larvik		Kristiansand	
Best trip	Kristiansand	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High (BP)	09.04.2016 23:00	11.04.2016 19:50	12.04.2016 21:44	14.04.2016 15:36	15.04.2016 17:29	15.04.2016 22:59	17.04.2016 00:52	17.04.2016 08:14	18.04.2016 10:08
Average (BP)	09.04.2016 23:00	11.04.2016 07:24	12.04.2016 01:45	13.04.2016 16:36	14.04.2016 10:58	14.04.2016 15:59	15.04.2016 10:21	15.04.2016 16:22	16.04.2016 10:44
Low (BP)	09.04.2016 23:00	10.04.2016 18:57	11.04.2016 05:47	12.04.2016 17:37	13.04.2016 04:27	13.04.2016 09:00	13.04.2016 19:50	14.04.2016 00:31	14.04.2016 11:21
High (AV)	09.04.2016 23:00	11.04.2016 22:55	13.04.2016 08:53	15.04.2016 04:16	16.04.2016 06:10	16.04.2016 11:52	17.04.2016 15:00	17.04.2016 23:16	19.04.2016 00:32
Average (AV)	09.04.2016 23:00	11.04.2016 10:28	12.04.2016 16:53	14.04.2016 09:16	15.04.2016 03:38	15.04.2016 08:52	16.04.2016 04:12	16.04.2016 11:07	17.04.2016 01:22
Low (AV)	09.04.2016 23:00	10.04.2016 22:01	12.04.2016 00:54	13.04.2016 14:16	14.04.2016 01:06	14.04.2016 05:52	14.04.2016 17:23	14.04.2016 22:58	15.04.2016 02:13
High (IS)	09.04.2016 23:00	11.04.2016 16:54	12.04.2016 18:47	14.04.2016 11:53	15.04.2016 13:47	15.04.2016 18:49	16.04.2016 20:43	17.04.2016 03:31	18.04.2016 05:25
Average (IS)	09.04.2016 23:00	11.04.2016 04:27	11.04.2016 22:49	13.04.2016 12:54	14.04.2016 07:16	14.04.2016 11:49	15.04.2016 06:11	15.04.2016 11:40	16.04.2016 06:01
Low (IS)	09.04.2016 23:00	10.04.2016 16:00	11.04.2016 02:50	12.04.2016 13:55	13.04.2016 00:45	13.04.2016 04:50	13.04.2016 15:40	13.04.2016 19:48	14.04.2016 06:38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Departure
Antwerp
Oslo
Larvik
Kristiansand
High (BP)
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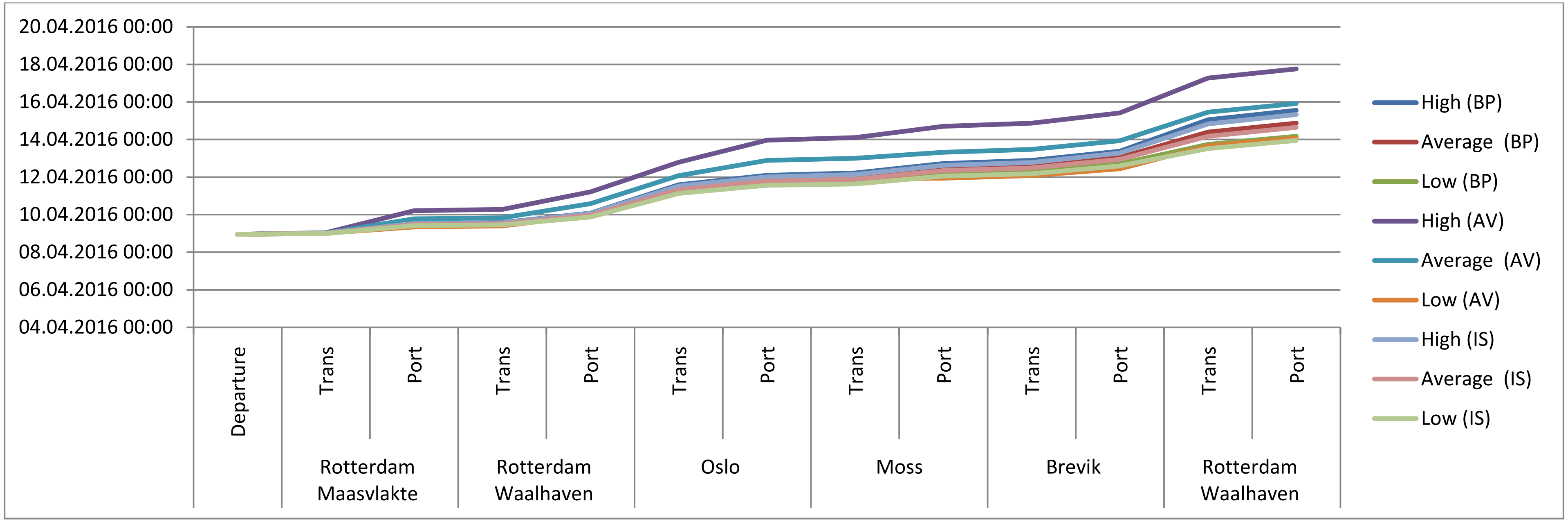
High (IS)
Average (IS)
Low (IS)

Ship 11

	Rotterdam Maasvlakte		Rotterdam Waalhaven		Oslo		Moss		Brevik		Rotterdam Waalhaven	
Best trip	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High	1,58	12,03	1,39	12,03	36,17	12,03	2,91	12,03	4,01	12,03	40,16	12,03
Average	1,25	11,12	1,18	11,12	33,93	11,12	2,37	11,12	3,67	11,12	32,62	11,12
Spread	0,20	0,55	0,13	0,55	1,36	0,55	0,33	0,55	0,21	0,55	4,59	0,55
Low	0,92	10,22	0,97	10,22	31,69	10,22	1,83	10,22	3,32	10,22	25,07	10,22
Average trip												
High	1,76	28,30	1,63	22,35	38,07	27,99	3,26	14,40	4,30	13,02	44,29	12,03
Average	1,43	18,22	1,42	18,03	35,83	19,25	2,72	7,70	3,95	10,73	36,74	11,12
Spread	0,20	6,13	0,13	2,62	1,36	5,31	0,33	4,08	0,21	1,39	4,59	0,55
Low	1,10	8,15	1,21	13,71	33,59	10,51	2,18	0,99	3,61	8,44	29,20	10,22
Increased speed												
High	1,46	12,03	1,29	12,03	34,56	12,03	2,69	12,03	3,68	12,03	37,20	12,03
Average	1,14	11,12	1,08	11,12	32,32	11,12	2,15	11,12	3,33	11,12	29,65	11,12
Spread	0,20	0,55	0,13	0,55	1,36	0,55	0,33	0,55	0,21	0,55	4,59	0,55
Low	0,81	10,22	0,87	10,22	30,08	10,22	1,61	10,22	2,99	10,22	22,11	10,22

EX trip		Rotterdam Maasvlakte		Rotterdam Waalhaven		Oslo		Moss		Brevik		Rotterdam Waalhaven	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High (BP)	08.04.2016 23:00	09.04.2016 00:34	09.04.2016 12:36	09.04.2016 13:59	10.04.2016 02:01	11.04.2016 14:12	12.04.2016 02:13	12.04.2016 05:08	12.04.2016 17:09	12.04.2016 21:10	13.04.2016 09:12	15.04.2016 01:22	15.04.2016 13:23
Average (BP)	08.04.2016 23:00	09.04.2016 00:15	09.04.2016 11:22	09.04.2016 12:33	09.04.2016 23:41	11.04.2016 09:37	11.04.2016 20:44	11.04.2016 23:06	12.04.2016 10:14	12.04.2016 13:54	13.04.2016 01:01	14.04.2016 09:38	14.04.2016 20:46
Low (BP)	08.04.2016 23:00	08.04.2016 23:55	09.04.2016 10:08	09.04.2016 11:07	09.04.2016 21:20	11.04.2016 05:01	11.04.2016 15:15	11.04.2016 17:04	12.04.2016 03:18	12.04.2016 06:37	12.04.2016 16:50	13.04.2016 17:54	14.04.2016 04:08
High (AV)	08.04.2016 23:00	09.04.2016 00:45	10.04.2016 05:03	10.04.2016 06:41	11.04.2016 05:02	12.04.2016 19:06	13.04.2016 23:06	14.04.2016 02:21	14.04.2016 16:46	14.04.2016 21:04	15.04.2016 10:05	17.04.2016 06:22	17.04.2016 18:24
Average (AV)	08.04.2016 23:00	09.04.2016 00:25	09.04.2016 18:39	09.04.2016 20:04	10.04.2016 14:06	12.04.2016 01:56	12.04.2016 21:11	12.04.2016 23:54	13.04.2016 07:36	13.04.2016 11:33	13.04.2016 22:17	15.04.2016 11:02	15.04.2016 22:09
Low (AV)	08.04.2016 23:00	09.04.2016 00:06	09.04.2016 08:15	09.04.2016 09:27	09.04.2016 23:10	11.04.2016 08:46	11.04.2016 19:16	11.04.2016 21:27	11.04.2016 22:26	12.04.2016 02:03	12.04.2016 10:29	13.04.2016 15:41	14.04.2016 01:54
High (IS)	08.04.2016 23:00	09.04.2016 00:27	09.04.2016 12:29	09.04.2016 13:46	10.04.2016 01:48	11.04.2016 12:21	12.04.2016 00:23	12.04.2016 03:05	12.04.2016 15:06	12.04.2016 18:47	13.04.2016 06:49	14.04.2016 20:01	15.04.2016 08:02
Average (IS)	08.04.2016 23:00	09.04.2016 00:08	09.04.2016 11:15	09.04.2016 12:20	09.04.2016 23:27	11.04.2016 07:46	11.04.2016 18:54	11.04.2016 21:03	12.04.2016 08:10	12.04.2016 11:30	12.04.2016 22:38	14.04.2016 04:17	14.04.2016 15:24
Low (IS)	08.04.2016 23:00	08.04.2016 23:48	09.04.2016 10:01	09.04.2016 10:53	09.04.2016 21:07	11.04.2016 03:11	11.04.2016 13:24	11.04.2016 15:01	12.04.2016 01:14	12.04.2016 04:14	12.04.2016 14:27	13.04.2016 12:33	13.04.2016 22:47



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Departure
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Rotterdam Maasvlakte
Rotterdam Waalhaven
Oslo
Moss
Brevik
Rotterdam Waalhaven
High (BP)
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High (AV)
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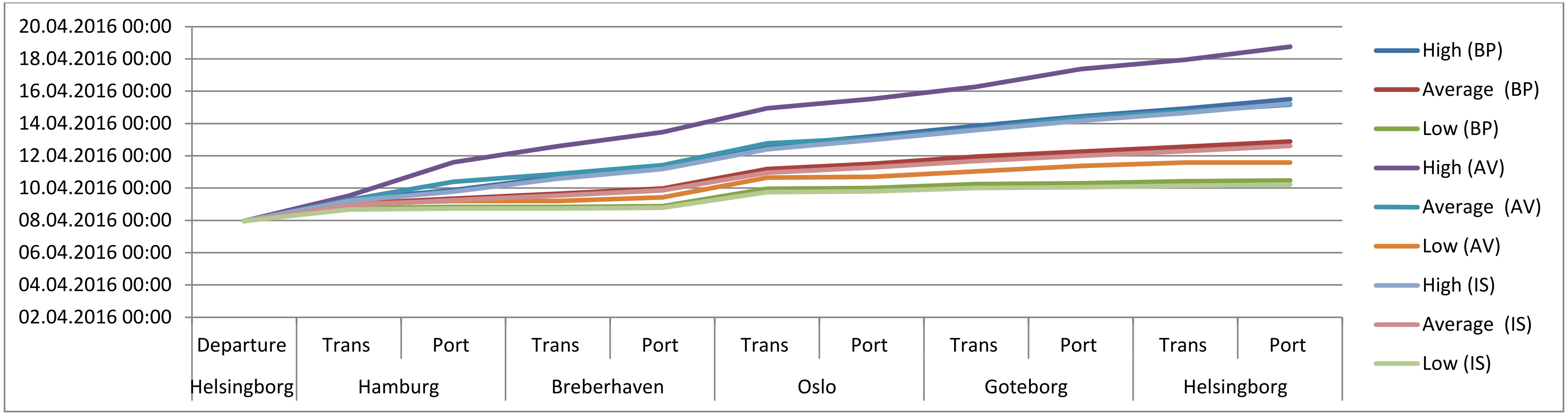
Low (AV)
High (IS)
Average (IS)
Low (IS)

Ship 13 / 14

	Hamburg		Breberhaven		Oslo		Goteborg		Helsingborg	
Best trip	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High	31,95	13,99	19,83	13,99	32,09	13,99	15,68	13,99	11,69	13,99
Average	25,70	7,65	7,32	7,65	28,92	7,65	10,73	7,65	7,25	7,65
Spread	3,80	3,85	7,61	3,85	1,93	3,85	3,01	3,85	2,70	3,85
Low	19,45	1,31	-5,20	1,31	25,75	1,31	5,79	1,31	2,81	1,31
Average trip										
High	37,70	49,44	24,27	20,61	35,60	13,99	18,00	26,40	13,84	19,36
Average	31,45	26,93	11,75	13,05	32,43	7,65	13,06	17,22	9,40	10,01
Spread	3,80	13,69	7,61	4,60	1,93	3,85	3,01	5,58	2,70	5,69
Low	25,19	4,41	-0,76	5,49	29,27	1,31	8,11	8,03	4,96	0,65
Increased speed										
High	29,62	13,99	19,48	13,99	29,46	13,99	14,70	13,99	11,35	13,99
Average	23,36	7,65	6,97	7,65	26,29	7,65	9,76	7,65	6,90	7,65
Spread	3,80	3,85	7,61	3,85	1,93	3,85	3,01	3,85	2,70	3,85
Low	17,11	1,31	-5,55	1,31	23,12	1,31	4,81	1,31	2,46	1,31

EX trip	Helsingborg	Hamburg		Breberhaven		Oslo		Goteborg		Helsingborg	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High (BP)	07.04.2016 23:00	09.04.2016 06:57	09.04.2016 20:56	10.04.2016 16:46	11.04.2016 06:46	12.04.2016 14:51	13.04.2016 04:50	13.04.2016 20:31	14.04.2016 10:31	14.04.2016 22:12	15.04.2016 12:12
Average (BP)	07.04.2016 23:00	09.04.2016 00:42	09.04.2016 08:21	09.04.2016 15:40	09.04.2016 23:19	11.04.2016 04:14	11.04.2016 11:53	11.04.2016 22:37	12.04.2016 06:16	12.04.2016 13:31	12.04.2016 21:10
Low (BP)	07.04.2016 23:00	08.04.2016 18:26	08.04.2016 19:45	08.04.2016 19:45	08.04.2016 21:04	09.04.2016 22:49	10.04.2016 00:07	10.04.2016 05:55	10.04.2016 07:13	10.04.2016 10:02	10.04.2016 11:21
High (AV)	07.04.2016 23:00	09.04.2016 12:42	11.04.2016 14:08	12.04.2016 14:24	13.04.2016 11:01	14.04.2016 22:37	15.04.2016 12:37	16.04.2016 06:37	17.04.2016 09:01	17.04.2016 22:52	18.04.2016 18:13
Average (AV)	07.04.2016 23:00	09.04.2016 06:26	10.04.2016 09:22	10.04.2016 21:07	11.04.2016 10:10	12.04.2016 18:36	13.04.2016 02:16	13.04.2016 15:19	14.04.2016 08:32	14.04.2016 17:56	15.04.2016 03:57
Low (AV)	07.04.2016 23:00	09.04.2016 00:11	09.04.2016 04:36	09.04.2016 04:36	09.04.2016 10:05	10.04.2016 15:21	10.04.2016 16:40	11.04.2016 00:47	11.04.2016 08:49	11.04.2016 13:46	11.04.2016 13:46
High (IS)	07.04.2016 23:00	09.04.2016 04:37	09.04.2016 18:36	10.04.2016 14:05	11.04.2016 04:05	12.04.2016 09:32	12.04.2016 23:32	13.04.2016 14:14	14.04.2016 04:13	14.04.2016 15:34	15.04.2016 05:34
Average (IS)	07.04.2016 23:00	08.04.2016 22:21	09.04.2016 06:00	09.04.2016 12:59	09.04.2016 20:38	10.04.2016 22:55	11.04.2016 06:34	11.04.2016 16:20	11.04.2016 23:59	12.04.2016 06:53	12.04.2016 14:32
Low (IS)	07.04.2016 23:00	08.04.2016 16:06	08.04.2016 17:25	08.04.2016 17:25	08.04.2016 18:44	09.04.2016 17:51	09.04.2016 19:09	09.04.2016 23:58	10.04.2016 01:17	10.04.2016 03:45	10.04.2016 05:03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Departure
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Helsingborg
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High (BP)
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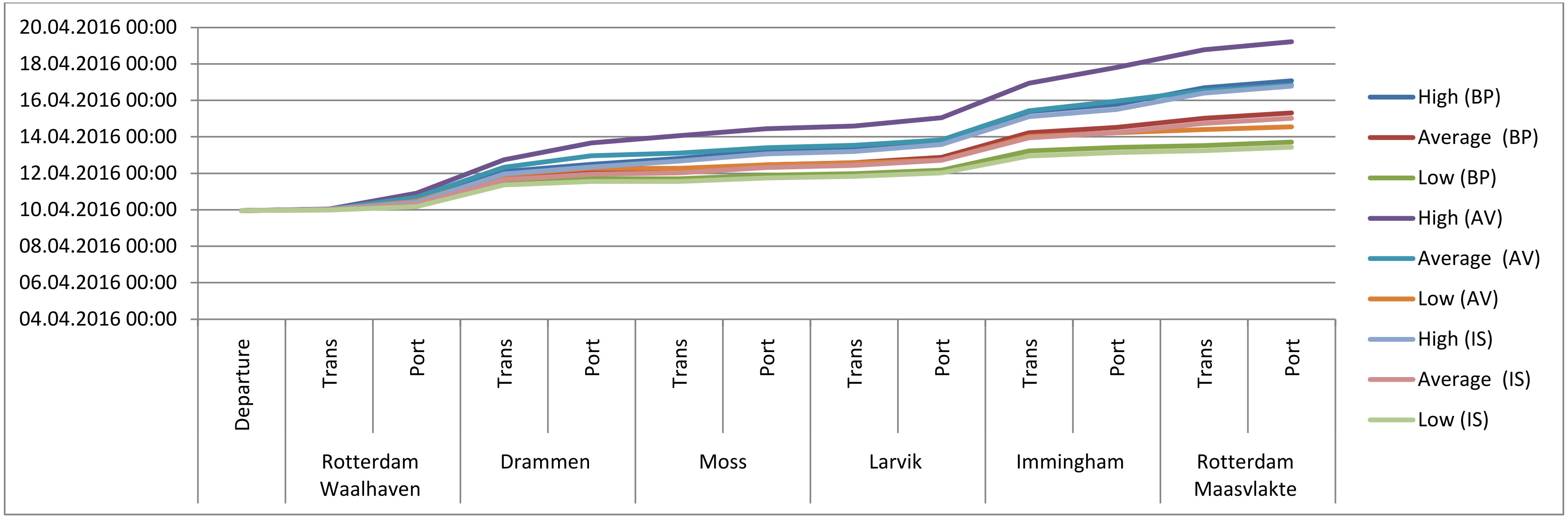
High (IS)
Average (IS)
Low (IS)

Ship 15

	Rotterdam Waalhaven		Drammen		Moss		Larvik		Immingham		Rotterdam Maasvlakte	
Best trip	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High	1,60	9,27	40,60	9,27	8,00	9,27	3,33	9,27	39,70	9,27	21,90	9,27
Average	1,23	6,91	36,15	6,91	2,07	6,91	2,88	6,91	32,40	6,91	12,25	6,91
Spread	0,22	1,43	2,70	1,43	3,61	1,43	0,27	1,43	4,44	1,43	5,87	1,43
Low	0,87	4,55	31,70	4,55	-3,87	4,55	2,44	4,55	25,10	4,55	2,60	4,55
Average trip												
High	1,87	20,94	44,06	22,14	9,38	9,27	3,56	10,74	45,76	20,52	23,31	10,69
Average	1,50	15,95	39,61	15,20	3,45	6,91	3,11	7,20	38,46	12,74	13,66	7,22
Spread	0,22	3,04	2,70	4,22	3,61	1,43	0,27	2,15	4,44	4,73	5,87	2,11
Low	1,14	10,95	35,16	8,26	-2,49	4,55	2,67	3,66	31,17	4,97	4,00	3,74
Increased speed												
High	1,48	9,27	37,31	9,27	7,81	9,27	3,19	9,27	36,75	9,27	21,66	9,27
Average	1,12	6,91	32,86	6,91	1,88	6,91	2,75	6,91	29,45	6,91	12,01	6,91
Spread	0,22	1,43	2,70	1,43	3,61	1,43	0,27	1,43	4,44	1,43	5,87	1,43
Low	0,76	4,55	28,42	4,55	-4,06	4,55	2,30	4,55	22,15	4,55	2,35	4,55

EX trip		Rotterdam Waalhaven		Drammen		Moss		Larvik		Immingham		Rotterdam Maasvlakte	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port	Trans	Port
High (BP)	09.04.2016 23:00	10.04.2016 00:35	10.04.2016 09:51	12.04.2016 02:27	12.04.2016 11:43	12.04.2016 19:43	13.04.2016 05:00	13.04.2016 08:19	13.04.2016 17:35	15.04.2016 09:17	15.04.2016 18:34	16.04.2016 16:28	17.04.2016 01:44
Average (BP)	09.04.2016 23:00	10.04.2016 00:14	10.04.2016 07:08	11.04.2016 19:17	12.04.2016 02:12	12.04.2016 04:16	12.04.2016 11:11	12.04.2016 14:04	12.04.2016 20:58	14.04.2016 05:22	14.04.2016 12:17	15.04.2016 00:32	15.04.2016 07:27
Low (BP)	09.04.2016 23:00	09.04.2016 23:52	10.04.2016 04:25	11.04.2016 12:07	11.04.2016 16:40	11.04.2016 16:40	11.04.2016 21:14	11.04.2016 23:40	12.04.2016 04:13	13.04.2016 05:19	13.04.2016 09:52	13.04.2016 12:28	13.04.2016 17:01
High (AV)	09.04.2016 23:00	10.04.2016 00:51	10.04.2016 21:48	12.04.2016 17:51	13.04.2016 16:00	14.04.2016 01:23	14.04.2016 10:39	14.04.2016 14:13	15.04.2016 00:57	16.04.2016 22:43	17.04.2016 19:14	18.04.2016 18:32	19.04.2016 05:14
Average (AV)	09.04.2016 23:00	10.04.2016 00:30	10.04.2016 16:26	12.04.2016 08:03	12.04.2016 23:15	13.04.2016 02:42	13.04.2016 09:36	13.04.2016 12:43	13.04.2016 19:55	15.04.2016 10:23	15.04.2016 23:07	16.04.2016 12:47	16.04.2016 20:00
Low (AV)	09.04.2016 23:00	10.04.2016 00:08	10.04.2016 11:05	11.04.2016 22:15	12.04.2016 06:30	12.04.2016 06:30	12.04.2016 11:03	12.04.2016 13:43	12.04.2016 17:23	14.04.2016 00:32	14.04.2016 05:31	14.04.2016 09:31	14.04.2016 13:15
High (IS)	09.04.2016 23:00	10.04.2016 00:29	10.04.2016 09:45	11.04.2016 23:03	12.04.2016 08:19	12.04.2016 16:08	13.04.2016 01:24	13.04.2016 04:36	13.04.2016 13:52	15.04.2016 02:37	15.04.2016 11:53	16.04.2016 09:33	16.04.2016 18:49
Average (IS)	09.04.2016 23:00	10.04.2016 00:07	10.04.2016 07:01	11.04.2016 15:53	11.04.2016 22:48	12.04.2016 00:41	12.04.2016 07:35	12.04.2016 10:20	12.04.2016 17:15	13.04.2016 22:42	14.04.2016 05:37	14.04.2016 17:37	15.04.2016 00:32
Low (IS)	09.04.2016 23:00	09.04.2016 23:45	10.04.2016 04:18	11.04.2016 08:43	11.04.2016 13:16	11.04.2016 13:16	11.04.2016 17:50	11.04.2016 20:08	12.04.2016 00:41	12.04.2016 22:50	13.04.2016 03:23	13.04.2016 05:45	13.04.2016 10:18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Moss
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Immingham
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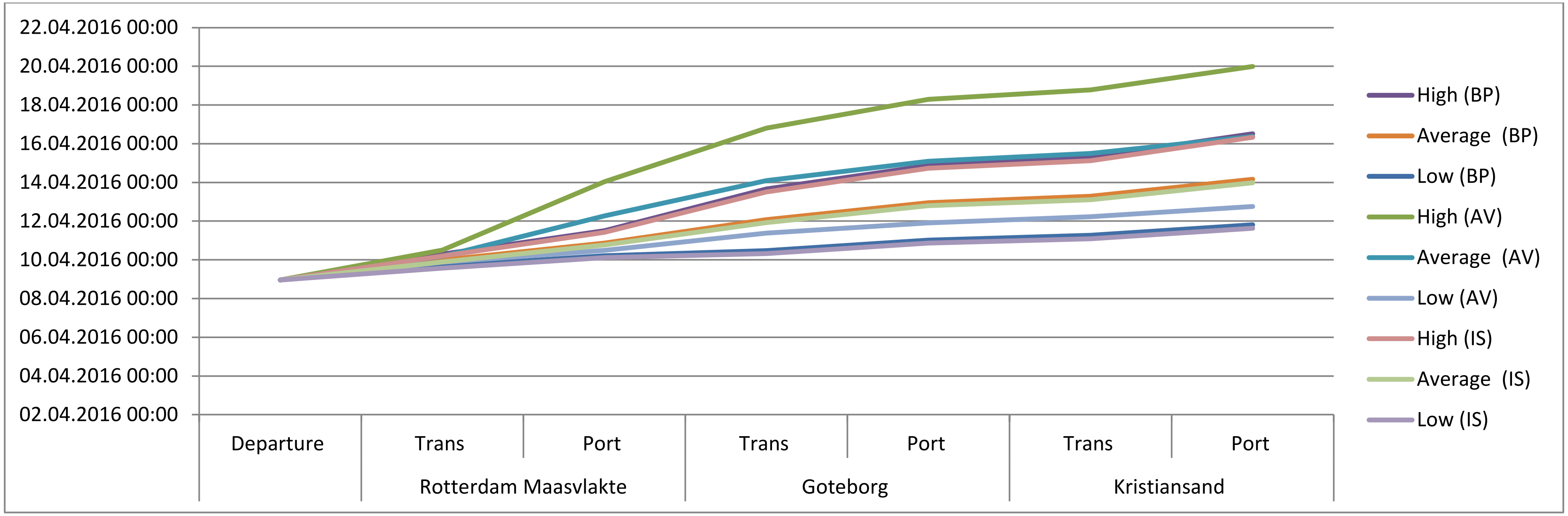
Average (IS)
Low (IS)

Ship 16 / 17

	Rotterdam Maasvlakte		Goteborg		Kristiansand	
Best trip	Trans	Port	Trans	Port	Trans	Port
High	32,15	29,12	51,70	29,12	10,17	29,12
Average	24,63	20,99	29,10	20,99	8,20	20,99
Spread	4,57	4,94	13,74	4,94	1,20	4,94
Low	17,11	12,86	6,50	12,86	6,23	12,86
Average trip						
High	37,01	84,87	66,59	35,47	11,63	29,12
Average	29,49	49,86	43,99	24,03	9,66	20,99
Spread	4,57	21,28	13,74	6,96	1,20	4,94
Low	21,97	14,85	21,39	12,58	7,69	12,86
Increased speed						
High	29,91	29,12	50,31	29,12	9,43	29,12
Average	22,39	20,99	27,71	20,99	7,45	20,99
Spread	4,57	4,94	13,74	4,94	1,20	4,94
Low	14,87	12,86	5,12	12,86	5,48	12,86

		Rotterdam Maasvlakte		Goteborg		Kristiansand	
Best trip	Departure	Trans	Port	Trans	Port	Trans	Port
High (BP)	08.04.2016 23:00	10.04.2016 07:09	11.04.2016 12:16	13.04.2016 15:57	14.04.2016 21:04	15.04.2016 07:15	16.04.2016 12:22
Average (BP)	08.04.2016 23:00	09.04.2016 23:38	10.04.2016 20:37	12.04.2016 01:43	12.04.2016 22:42	13.04.2016 06:54	14.04.2016 03:53
Low (BP)	08.04.2016 23:00	09.04.2016 16:06	10.04.2016 04:58	10.04.2016 11:28	11.04.2016 00:19	11.04.2016 06:33	11.04.2016 19:24
High (AV)	08.04.2016 23:00	10.04.2016 12:00	14.04.2016 00:52	16.04.2016 19:27	18.04.2016 06:56	18.04.2016 18:34	19.04.2016 23:41
Average (AV)	08.04.2016 23:00	10.04.2016 04:29	12.04.2016 06:20	14.04.2016 02:20	15.04.2016 02:21	15.04.2016 12:01	16.04.2016 09:00
Low (AV)	08.04.2016 23:00	09.04.2016 20:58	10.04.2016 11:49	11.04.2016 09:12	11.04.2016 21:47	12.04.2016 05:28	12.04.2016 18:20
High (IS)	08.04.2016 23:00	10.04.2016 04:54	11.04.2016 10:01	13.04.2016 12:20	14.04.2016 17:27	15.04.2016 02:52	16.04.2016 07:59
Average (IS)	08.04.2016 23:00	09.04.2016 21:23	10.04.2016 18:22	11.04.2016 22:05	12.04.2016 19:04	13.04.2016 02:32	13.04.2016 23:31
Low (IS)	08.04.2016 23:00	09.04.2016 13:52	10.04.2016 02:43	10.04.2016 07:50	10.04.2016 20:42	11.04.2016 02:11	11.04.2016 15:02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