University of Twente

Master Thesis

Financial Engineering and Management

Market Analysis for Unique Featured Heavy Cargo Transportation Vessels

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Abstract

Global Seatrade is a company that owns heavy cargo transportation vessels. These vessels show similarities and differences among themselves as well as to vessels of competing companies. In general the vessels can be conceived as being unique. For this reason, market analysis is difficult to do. In our research we try to take up this challenge and focus on two different aspects and try to compare them in a model. First, the characteristics of the vessels are of interest. Secondly, we assess the cargo markets in which the vessels are operating. We improved the current method of keeping up voyage information and calculating voyage profitability. The different voyage aspects can be compared in this new model. Financial data of 2016 form the basis of our analysis. The model mainly functions as a comparison method. Deriving forecasting statements out of it is more difficult.

Contents

1 Introduction

In this section we give a short overview of the company Global Seatrade for which we conducted the research. We denote the company's name as GS from now on. In order to comprehend the research objective, we give some general information. First, we describe the structure and the current fleet of GS. Secondly, we give the company's mission. After the general overview, we explain the principle of Roll-on Roll-off. This subject is of high interest for GS and consequently forms the basis of the research. Then we clarify the new planned projects. We conclude the introduction of our research with the main research question and its corresponding sub-questions.

1.1 The company: Global Seatrade

The website of GS (GlobalSeatrade, 2017) introduces the company as follows:

'*Global Seatrade is a shipping company specialized in the overseas transportation of windmills, offshore equipment and small heavy lifts up to 240 tonnes. The management of Global Seatrade counts former masters of Heavy Lift vessels with extensive experience in the industry. They are closely involved in cargo operations and assist in ports where and when required. The crew and employees of Global Seatrade are key for the no nonsense mentality that reflects from Global Seatrade.*' (GlobalSeatrade, 2017)

1.1.1 Company Structure

Hartman Marine Group of which GS is a daughter company, has some other subsidiaries. Hartman Marine Shipbuilding BV and Hartman Marine Yachts BV are the main ones. The vessels which GS owns are registered in separate corporations themselves as well. Figure 1 is a graphical representation of the structure described.

Hartman Marine Group and mainly Hartman Marine Shipbuilding function like a shipyard. They have the ability to design and manage the process of building vessels. Usually the construction of the hull takes place in Poland. The completion of a vessel is normally done in Urk, the Netherlands. The company does not own a wharf and does not employ shipbuilders. Therefore, most work is outsourced to specialized companies.

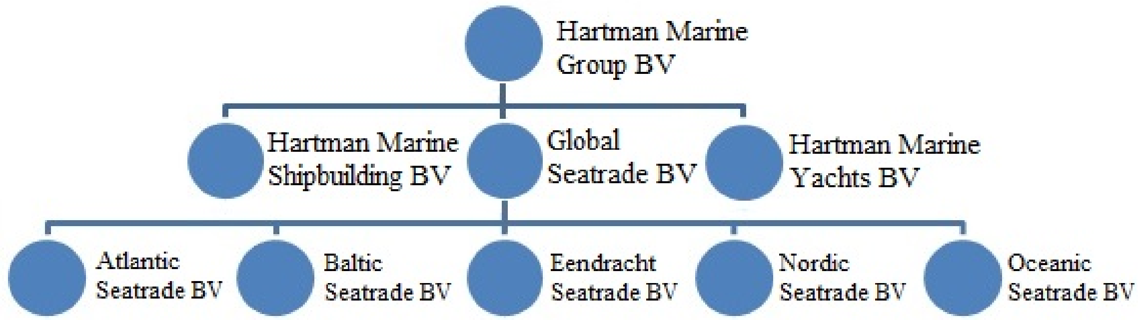

Figure 1: Company structure.

Hartman Marine Yachts has been launched in 2014. The founding was driven by the the wish to build classical luxury yachts. At this moment one yacht has been built. Furthermore, the design of a second yacht has been made.

We describe the vessels that GS owns in Section 1.1.2. GS exploits and runs its vessels. This includes making the planning of the crew, keeping up the stocks and making calculations for transport issues, like request and bunkering. However, contact with principals occurs through a broker.

1.1.2 Fleet

GS owns different types of vessels. The first type that was designed, was *Trader 18*. See Figure 2. Two vessels were built of this type, named *Eendracht* (2008) and *Atlantic* (2011). Hartman Marine Shipbuilding later designed type *M*^{2} *Runner*, see Figure 3, of which they also built two vessels, named *Oceanic* (2012) and *Nordic* (2013).

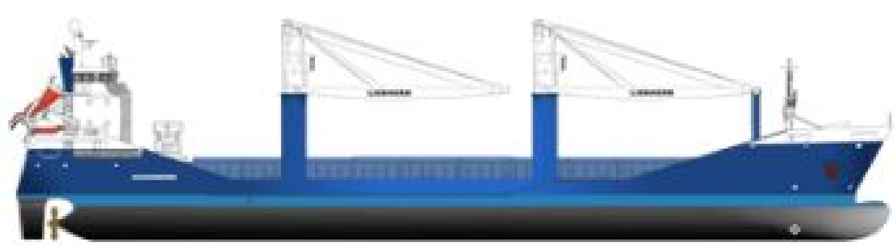

Figure 2: Type *Trader 18*.

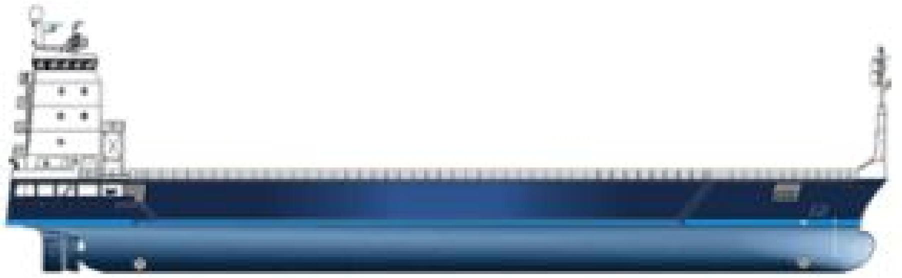

Figure 3: Type M^2 *Runner*.

In 2015 a new vessel type was designed. This type is called R^2 *Carrier*. After the designing phase, the construction of a vessel of this type immediately started. The construction of the hull took place in Poland. On 3 April 2017, the hull was towed to Urk. The building of the vessel was completed there in about fifteen weeks. The new vessel is called *Baltic*. See Figure 4.

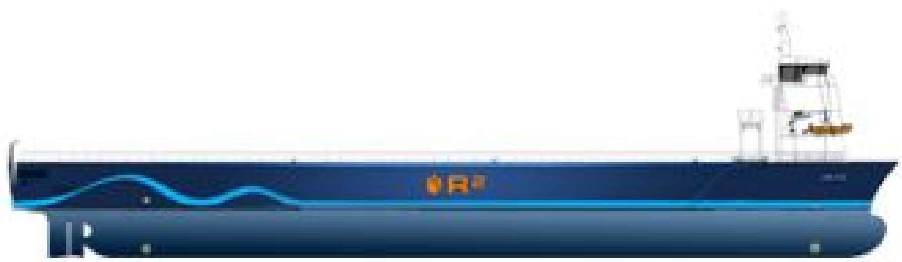

Figure 4: Type R^2 *Carrier*.

1.1.3 Mission of the company

GS always strives for low costs and tries to offer specialized services at the same time. Therefore we identify GS as being in a ‘cost and differentiation focused’ position compared to Porter’s generic strategies (Porter, 1980). However, GS does not try to serve a specific niche-market, but aims to maximize the number of overseas transportation possibilities. Some principles help GS to get enough demand for its services, such that the vessels are fully in operation through a year. In the vessel developing phase, GS tries to minimize vessel sizes, while maximizing loading possibilities. This combination automatically leads to relatively low transportation costs. Furthermore, low costs are reached through an environment in which every employee always looks for the cheapest options. GS operates the vessels as optimal as possible.

Loading and discharging occurs very rapidly and the number of empty sailing days without cargo are reduced as much as possible. In the model of Treacy and Wiersema (1993), GS would get high marks on the aspect of 'operational excellence'.

The specialized services of GS are achieved with an innovative way of thinking. GS tries to provide the vessels with features that add value for its clients. The combination of relatively short measurements and special features forms unique and competing vessels. One of the features is a Roll-on Roll-off ramp. A description of this is given next. Please note that this feature will be abbreviated to RoRo from now on.

1.2 Roll-on Roll-off

Vessel type R^2 *Carrier* is provided with a RoRo-ramp. *Baltic*, an R^2 *Carrier* vessel type, is the first vessel of GS with this feature. A ramp is used to roll the cargo on deck. For heavy cargo this is a convenient solution. Lift-on lift-off (LoLo), which is the counterpart of RoRo, has some disadvantages. Cranes have a lifting capacity, which constrains the maximum cargo weights. For rolling opportunities the maximum weight of cargo plays a role to a lesser extent. Furthermore, objects to be transported become increasingly valuable too. This increases the cost of insurance for lifting likewise.

Different aspects of RoRo have been investigated in the last decades, since the feature is not innovative in itself. Ferries for example make use of ramps to load and unload vehicles. Research for these vessels has been done regarding the slamming of the ramps against the quay during loading (Samuelides and Servis, 2002). Furthermore, loading optimizations for stowage plans have been carried out (Øvstebø et al., 2011). Other vessels that have been provided with RoRo are specialized car carriers (Tupper, 2013). Pontoons also form an alternative, but these vessels are not self-propelling. Finally, there are semi-submersible RoRo vessels, but for these vessels the term Float-on float-off (FloFlo) would cover the functioning better than RoRo.

The way GS uses RoRo is not completely comparable with the above mentioned vessel types. Of course heavy cargo can be transported with those vessels, but the characteristics differ completely. Research about RoRo in combination with overseas heavy cargo transportation vessels like the R^2 *Carrier* is lacking.

Not being able to compare the vessels of GS to general vessel types does not mean that GS has a unique concept. Two competing vessels that were built in 2016/2017 show comparable characteristics. These vessels have comparable dimensions and features and are owned by a Dutch firm. However, there is one big difference. This difference is the position of the RoRo-ramp and the accommodations/bridge. GS places the RoRo-ramp at the back and the accommodations/bridge in the front of the vessel, see Figure 4. The competing vessels have these placed in the opposite positions. The disadvantage of these vessels is that the front then needs to be lifted open for loading, which constrains possible cargo heights. Additionally, the construction of a front which can be opened, is more expensive than the construction of a ramp at the backside of a vessel.

1.3 Research objective

In the development phase of new vessel types, GS wishes to be able to make systematic considerations. The uniqueness of the vessel types makes it difficult to make the right assumptions and to make correct predictions about financial matters. The aim of our research is to link vessel characteristics and cargo combinations to current vessel types and to forecast the financial performances.

1.4 Research questions

We conduct our research to give GS some guidelines during its considerations. Three issues play an important role. Firstly, vessel characteristics are related to cargo combinations. Vessel dimensions and features are key factors in possible combinations of loading. GS wants to know what the effects on possible cargo categories are when characteristics of vessels change. Size of the vessels for example plays an important role. Secondly, we want to forecast future demand for services of GS. The markets of its current cargo is still developing. GS wants to be prepared for these developments. Furthermore, the unique features of vessels make it possible to handle specific demands. We do some research to find the relation between changing vessel characteristics and future demand. Thirdly, we make a financial forecast based on changing vessel characteristics, cargo combinations and expected demand. We conclude our research with a model from which expected revenues can be deduced from certain vessel and cargo variables.

In order to find some relations between the aspects mentioned, we define the main research question next. Note that the three elements of this research question correspond to the three issues described above.

How can vessel characteristics be related to possible cargo combinations, what are the expected effects in demand when vessel characteristics become more specific and which model helps to indicate and decide upon possible financial revenues?

In order to find an answer to the main research question, subquestions are stated to guide the process. After each part, the subsequent subquestions are given:

1. How can vessel characteristics be related to the cargo combinations?
    (a) *What are typical vessel characteristics in the cargo vessel industry?*
    (b) *What vessel characteristics influence possible cargo combinations?*
    (c) *In which categories can heavy cargo be divided?*
    (d) *What influence does an enlargement of a vessel have on possible cargo combinations?*
2. What are the expected effects in demand when vessel characteristics become more specific?
    (a) *Are there examples in other industries which show that specialization leads to specific demand?*
    (b) *Is the vessel under construction likely to be asked for transports as those performed currently?*
    (c) *How are the markets of the major cargo categories developing?*
3. Which model helps to indicate and decide upon possible financial revenues?
    (a) *Are the current vessels of GS outperforming market competitors?*
    (b) *How can an increase of vessel size be related to expected performance?*
    (c) *How is the expected financial performance influenced by the world economy?*
    (d) *Which model links vessel characteristics to financial revenues?*
    (e) *What performance can be expected of the vessel currently under construction?*

1.5 Research method

We carry out the research in three phases.

Phase one: Secondary research
This phase is required to become familiar with maritime jargon. GS made data available regarding its vessels. From these data, vessel characteristics and features can be deduced. With a literature research we complement the list of important vessel specifications for heavy cargo transportation vessels. Additionally, we give an overview of all past transports performed by the current fleet of GS. From this we make a classification of cargo categories.

Phase two: Primary research
In this phase we link changes of vessel characteristics and cargo combinations. Combinatorial considerations form the basis for a model that forecasts performance of vessels. Furthermore, we assess the environments of major cargo categories. Together, we examine the need for an expansion of the fleet and base this on market developments primarily.

Phase three: New model and financial analyses
During this phase we introduce our new model for comparing financial relations between vessel characteristics and cargo markets. We test the model with voyage information from 2016. Furthermore, we consider in this phase the two concept vessels of GS. We analyze both projects, and compare financial relations between vessel characteristics and revenues.

The order of the research questions will be followed during this research. The three phases can be distinguished as follows. *Phase one*, starts in Section 2 and ends before Section 2.5. *Phase two*, then continues in Section 4. From Section 5 *Phase three* starts and concludes our research. However, it is not precluded that some sections have overlapping items from different phases.

2 Vessel characteristics and cargo combinations

The overseas transportation market is enormous. There are many different types of cargo, contracting opportunities, earning models and vessel categories. Before assessing the heavy cargo transportation market for GS, a description of the used terms is required. Subsequently, we provide answers to the first research question. This question was divided as follows:

1. How can vessel characteristics be related to the cargo combinations?
   (a) *What are typical vessel characteristics in the cargo vessel industry?*
   (b) *What vessel characteristics influence possible cargo combinations?*
   (c) *In which categories can heavy cargo be divided?*
   (d) *What influence does an enlargement of a vessel have on possible cargo combinations?*

2.1 Description of terms

Tramp shipping company: 'An ocean carrier company operating vessels not on regular runs or schedules. They call at any port where cargo may be available' (MarAd, 2008).

GS is in particular a tramp shipping company. Transportation requests enter the office such that calculations of costs and optimizations of planning can be made. Sometimes vessels are chartered for a longer time to perform consecutive identical transports. However, this does not make GS a line shipping company. The requests for services by GS are provided by a broker, this broker acts specifically as a chartering broker.

Chartering broker: 'Company with current market knowledge, dealing with cargo, acting as intermediary between buyers and sellers in return for a percentage commission on the transaction' (Stopford, 2009).

A distinction between combinations and categories of cargo has to be made. GS is specialized in transportation of heavy cargo. Hence, cargo has to be regarded as unique objects with significant dimensions. In general the cargo cannot be classified as 'bulk'.

Cargo categories: Classification of cargo objects.

Cargo combinations: Different or similar cargo objects, being transported in one journey between loading and discharging.

Additionally, a distinction between characteristics and features of vessels has to be made. GS competes with overseas heavy cargo transporting companies. Some elements of vessels are comparable. The distinction is made between elements that are expressed in quantities and elements which the vessels possibly posses.

Vessel characteristics: Dimension of a vessel and its facilities expressed in quantities.

Vessel features: Classification of equipments and qualifications of vessels expressed in 'yes' or 'no'.

2.2 Vessel characteristics

During the process of vessel design, several considerations need to be made. Consequently the future performance of a vessel depends on the decisions made during the design process. Since this multitude of decisions influence each other, optimizations are only possible using constraints. Relevant research has already been done to the benchmarking of ship designs. Fathi et al. (2013) define a method which combines information about the physical characteristics of a vessel, its intended use and weather conditions. They point out that some vessel characteristics influence the service to certain markets, while others do not. They also point out that the choices are a trade-off with the operating costs of the vessel. Lun et al. (2010) describe that the optimal vessel size depends on cargo availability, transit time and service frequency. Large carrier vessels are relatively low-cost and are suitable for line shipping operations. However, the filling of large carriers is a difficult job. The search for cargoes and port restrictions make the planning process very inflexible. Large vessels operating in specific markets face potential burdens when these markets shrink.

During the design process of its first vessel, GS tried to make the vessel as commercial as possible. One of its goals was high speed, obtained by means of an optimal hull shape. The vessel has a block coefficient[1] Cb of 0.59 which is relatively low. Furthermore, GS aims to improve its flexibility by minimizing the vessel sizes.

[1]Block coefficient is defined as $Cb = \frac{\nabla}{L*B*T}$ where ∇ is the displacement volume, L is length, B is beam and T is draught (Lindstad et al., 2014).

Taking everything to account, we limit our research to characteristics that influence loading possibilities. We assume that GS maintains its commercial and flexible view in the design process. We do not include weather conditions, which was one of the three investigated items by Fathi et al. (2013). In general, we do not take up the elements in our research that do not directly influence loading possibilities.

Vessel characteristics influencing cargo possibilities can be divided into three categories. First, we describe the weight of a vessel excluding and including cargo weight. Secondly, we explain the dimensions of the cargo spaces. Finally, we explain the frequently used comparison to container sizes.

2.2.1 Vessel weight

The weight of a vessel can be utilized in different ways. For example, the authorities use the weight for port charges. We however, focus on possible cargo weights, which is closely related to vessel weights. First we give definitions of gross and net tonnage. Both are unitless quantities, indicated by GT and NT respectively.

Gross Tonnage: 'Applies to vessels, not to cargo, $GT = 0.2V + 0.02V log_{10}(V)$ where V is the volume in cubic meters of all enclosed spaces on the vessel' (Eyres and Bruce, 2012).

Net Tonnage: 'Applies to vessels, not to cargo, $NT = 0.2V_c + 0.02V_c log_{10}(V_c)$ where V_c is the total volume of cargo spaces in cubic meters' (Eyres and Bruce, 2012).

Note that the two definitions given above are mostly used for classification purposes. Next a more indirect way of measuring is defined using the principle of Archimedes.

Displacement Tonnage: The weight of the water that a vessel displaces, equals the weight of the vessel without cargo, expressed in tonnes.

Deadweight Tonnage: 'The total weight of cargo that the vessel can carry when loaded down to its marks, including the weight of fuel, stores, water ballast, fresh water, crew, passenger and baggage' (Stopford, 2009).

Deadweight tonnage is expressed in dwt. Table 1 gives the four different tonnages for every type of GS its vessels. Observe that no definition explicitly gives the maximal cargo weight for vessels. However, as a rule it is generally accepted that non-cargo items account for about 5% of the total deadweight in medium-sized vessels (Stopford, 2009).

Table 1: Vessel type tonnages.

	Trader 18	*M2 Runner*	*R2 Carrier*
Gross Tonnage	2981 GT	2989 GT	2975 GT
Net Tonnage	1198 NT	893 NT	887 NT
Displacement Tonnage	5486 tonnes	4755 tonnes	4748 tonnes
Deadweight Tonnage	3500 dwt	3285 dwt	3263 dwt

2.2.2 Cargo space dimensions

For modeling purposes it would be more convenient when cargo spaces were rectangular-shaped to test different combinations of cargo. We also see this when we look at the descriptions of vessel classifications. Cargo spaces are generally described by length, width and height. A more accurate description of the cargo spaces of the current vessels of GS is needed.

The vessels of GS have a hold which can be covered by pontoon hatches such that a deck arises. Halfway the height of the hold also pontoon hatches can be placed such that a tweendeck arises. Hence, the vessels of GS have four possible, on-board adjustable, cargo space combinations. See Figure 5. Notice that this only holds when total lengths are covered. The number of combinations increases, when taking into account that decks also can be removed partly. In Table 2 the exact dimensions of cargo spaces for all three vessel types are given.

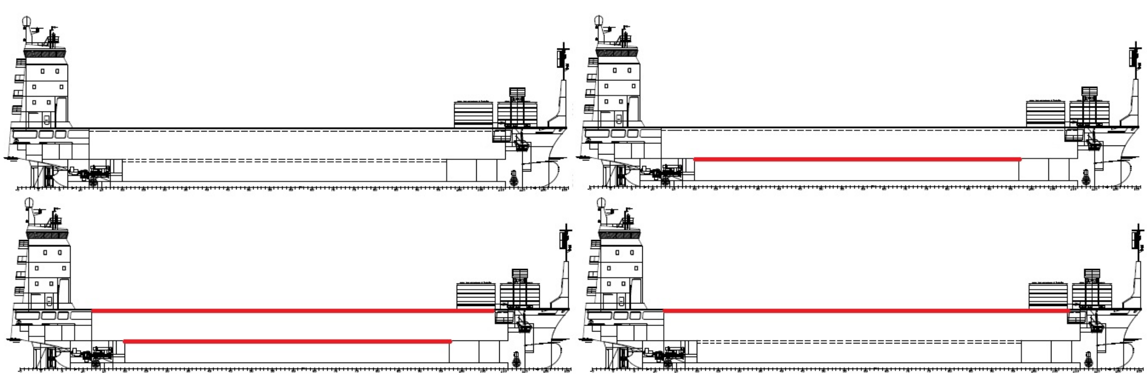

Figure 5: Removable decks: four combinations.

Table 2: Cargo space dimensions.

	Vessel type			
	Trader 18	*M^2 Runner*	*R^2 Carrier*	Unit
Hold capacity	4396	6209	5871	m^3
Upper hold length	63,6	69,3	63,80	m
Lower hold length	31,5	53,9	49,00	m
Upper hold width	11,5	12,5	12,5	m
Lower hold width	11,0	12,0	12,0	m
Hold height	8,15	8,30	8,30	m
Upper hold height	4,63	4,60/3,90	4,60/3,90	m
Lower hold height	3,50	3,20/3,90	3,70/3,90	m
Hold floor surface	1039	1450	1380	m^2
Deck length	66,7	90	80	m
Deck width	11,8	15	15	m
Deck floor surface	788	1300	1200	m^2

2.2.3 Container capacity

The third way of describing vessel characteristics that influence cargo possibilities, is the expression of cargo spaces in container capacity. A TEU, or twenty-foot equivalent unit, is normally used. Exact measurements of these containers are not prescribed. However, the length, width and height are about 5,9; 2,35 and 2,39 meters respectively. The payload capacity usually is around 25000 kg. However, denoting the container capacity of a vessel only takes into account the dimensions of the container. Loading a vessel to its container capacity does not mean that the vessel can carry them when they are maximally loaded. Table 3 gives the container capacities for the vessels of GS.

Table 3: Vessel type container capacity.

	Trader 18	*M2 Runner*	*R2 Carrier*
Deck	163 TEU	199 TEU	189 TEU
Hold	73 TEU	105 TEU	98 TEU
Total	236 TEU	304 TEU	287 TEU

2.3 Vessel Features

The unique features, which formed the inducement to our research, can be divided in two categories. The equipment of vessels is tangible and can be used to handle cargo for example. The so-called notations of vessels are not necessarily tangible, nor can be used to handle cargo directly. IMO is the standard-setting authority of the United Nations. Controlling shipowners is necessary to prevent that they do not limit on safety or environmental sustainability. This organization issues the vessel classifications, notations and registration numbers. Next we give descriptions of the features, in particular those interesting for cargo combinations of GS.

2.3.1 Equipment

Cranes 2 ∗120T: Loading and discharging of cargo using two on-board cranes lifting 240 tonnes together.

Dynamic positioning: Automatic positioning mode with the use of thrusters. Four classes can be distinguished. Class 0, manual position control; Class 1, one system supporting manual position control; Class 2, two independently operating systems such that one failure does not influence stability; Class 3, withstanding fire and flood without failures (Kongsberg, 2017).

Removable upperdeck: Open or closed upper hold, possibility to load and unload objects lifting and protect cargo against weather conditions. See Figure 5.

Removable tweendeck: Open or closed lower hold, possibility to load and unload objects lifting and increasing deck surface. See Figure 5.

Roll-on roll-off: Loading and discharging of cargo using a ramp, rolling it from quay to board and vice versa.

Grain fitted: Partitions that prevent grain to move and roll over the deck through wavy conditions.

2.3.2 Notations

Dangerous goods notation: Nine classes identify the possibility to transport dangerous goods. Class 1, explosives; Class 2, gases; Class 3, flammable liquids; and so on (Searates, 2017).

Open top notation: Sailing, loading and discharging with hatches open. In particular high objects can be transported and lifted off at sea.

Special purpose notation: This indicates that a vessel is allowed to transport unusual objects.

In conclusion we now have answered Subquestions 1a and 1b. Cargo space dimensions and maximum transportable weights, vessel equipment and vessel notations are the three general themes in this context. Table 4 is an overview of the characteristics for the current vessels of GS.

Table 4: Vessel features.

Characteristics	*Atlantic*	*Eendracht*	*Nordic*	*Oceanic*	*Baltic*
Cranes 2 * 120T	Yes	Yes	No	No	No
Dynamic positioning	No	No	No	No	No
Removable upperdeck	Yes	Yes	Yes	Yes	Yes
Removable tweendeck	Yes	Yes	Yes	Yes	Yes
Roll-on roll-off	No	No	No	No	Yes
Grain fitted	Yes	Yes	Yes	Yes	Yes

Notations	*Atlantic*	*Eendracht*	*Nordic*	*Oceanic*	*Baltic*
Dangerous goods	Yes	Yes	Yes	Yes	Yes
Open top	No	Yes	Yes	Yes	No
Special purpose	Yes	Yes	Yes	Yes	Yes

2.4 Cargo Categories

In this section we describe the different categories of cargo which are transported by GS, and consequently answer Subquestion 1c. GS kept record of all past transports. However, the quality of these documents increased significantly last years. The overview of 2016 is most complete and therefore most suitable to use.

An overview of cargo categories, made by GS for the transports between 2012-2014, defined the categories of Table 5.

Table 5: Cargo categories of all vessels 2012-2014.

Cargo	**Frequential**	**Cargo**	**Proportional**
General	10%	General	13%
Project	30%	Project	31%
Bulk	5%	Bulk	5%
Windmills	36%	Windmills	35%
Offshore Reels	15%	Offshore Reels	12%
Yachts/Boats	4%	Yachts/Boats	4%

In the document of 2015, a distinction between the different vessels of GS can be found. This classification was made by the company some years ago. Furthermore, every transport number and its corresponding cargo have been described by GS. However, in contrast to the document of 2016, the net number of days are missing in those documents. Hence, the duration of specific transports of 2015 cannot be given, which becomes mainly relevant in Section 4.

In Appendix A, we show the tables regarding travel numbers, cargo categories and net number of days of all vessels from GS being in operation during 2016. From these tables we distill the current general categories. Before doing this, we need to make some assumptions, since the documents are incomplete and ambiguous.

Some travel numbers include different cargo objects. One reason for this is that it is possible to transport a combination of cargo objects in one trip. For this reason the net number of days holds for all categories. However, cargo sometimes needs to be transported to different harbors. This means that the discharging of different cargo objects does not happen on the same day. Precise moments of discharging cannot be found anymore. Therefore, we estimate the duration of cargo objects with the following procedure. Let three objects be on a vessel in one trip which lasts twelve days. We assume each object covers one third of the deck and stayed on it the full trip. Such that the duration is measured as four days.

Furthermore, some data are missing. When no cargo object is given, no categorization of the cargo can be made. In Appendix A this is indicated with a question mark. Vessel *Eendracht*, however, was chartered during the first part of 2016, and this does not belong to any of the classifications either.

Table 6 gives an overview of the categorization in Appendix A. Comparing it to Table 5, some categorical changes can be seen. We added *Container* because we include vessel container capacity in our research. We added the more general category *Industry* which partly covers the former category *Project*. We changed *Offshore Reels* to *Offshore* since pipes and other objects fit in this category as well. In the category *Yacht*, we included boats, but not specific mention them anymore. *Windmills* is changed to *Wind* since supplies belong to this category too. *Bulk* and *General* did not change. Note that goods not packaged in boxes and transported in large volumes can be referred to as bulk. The category *General* contains all sorts of large amounts of small sized products that are likely packaged in boxes.

Table 6: Cargo categories 2016.

	Net number of days (%)				
Category	*Atlantic*	*Eendracht*	*Nordic*	*Oceanic*	All vessels
Bulk	(10)	(0)	(0)	(10)	(5)
Container	(1)	(0)	(3)	(3)	(2)
General	(0)	(29)	(0)	(0)	(5)
Industry	(23)	(10)	(2)	(3)	(14)
Offshore	(37)	(21)	(7)	(25)	(22)
Yacht	(21)	(17)	(0)	(0)	(8)
Wind	(9)	(23)	(69)	(60)	(44)

2.5 Cargo Combinations

Vessel characteristics that are of interest for cargo combinations in our research, we have defined already. In Subquestion 1d, we intend the relation between dimensions of cargo space and dimensions of cargo objects to be important. We will describe several cargo combinations and mainly the positioning of that cargo on current vessels of GS in this Section. In the next Section we give the translation to the enlarged vessels and correspondingly answer Subquestion 1d.

General cargo categories are not suitable to define exactly several combinations of cargo. Stowage plans in heavy cargo industry often involve exact descriptions, drawings and calculations of the way of loading. From the overviews of 2016 in Appendix A, we see that some specific cargo objects were transported several times. Hence, these objects form the basis for combinatorial issues.

Two different types of combinatorial issues can be distinguished. These are related to the two-sided definition of *Cargo combinations* in Section 2.1. Transporting multiple similar cargo objects in one transport is the first type. Transporting multiple different cargo objects, even from different categories, in one transport is the second. The emphasis in this section is on the first type. Note that attention to the second type does not add value, since the number of opportunities is too big. *Oceanic* for example transported windmill components and containers in travel number 201608. Combinations like these can hardly be compared.

2.5.1 Frequently transported cargo objects

Wind industry related objects like turbines, blades and tower sections can be found often in the overview of 2016 in Appendix A. For the offshore industry, GS often transported pipes and reels. Yachts were transported several times as well. Also the category *General* is identified often. However, cargo in this category cannot be identified. Furthermore, due to its massive character, it neither can be and needs to be compared to vessel characteristics. Hence, cargo from category *General* is not regarded in combinatorial contexts. Next we describe two transports of the *Oceanic* that make clear the importance of some vessel characteristics.

Transport 1: Regarding travel numbers 201609, 201610 and 201611 from *Oceanic*. These transports were loaded in Izmir (Turkey) and discharged in Bar (Monte Negro). Through a more thorough investigation of the documents from GS belonging to these transports, we obtained specifications of the cargo. The dimensions of the blades were $50.20 * 2.94 * 2.90$m and 12.2 tonnes per blade. In the lower hold three blades can be placed. In the upper hold four blades can be placed. On the upperdeck seven stacks of three tiers can be placed. In Appendix B, a graphical representation of this way of loading is given. These transports therefore used the tweendeck and the upperdeck. Furthermore, these transports are part of a contract in which GS agrees with its client to transport several objects for an established price. The vessel therefore sails back empty. However, observe that this ‘empty vessel’ should not be confused with empty vessels without cargo not being under contract.

Transport 2: Regard travel number 201619 from *Oceanic*, this transport was loaded in Klaipėda (Lithuania) and discharged in Le Trait (France). The cargo consisted of four reels:

1. One reel on cradles, dimensions $5.50 * 5.85 * 5.60$m and 20 tonnes.
2. One reel on cradles, dimensions $8.60 * 5.95 * 8.72$m and 40 tonnes.
3. Two reels on cradles, dimensions $12.00 * 5.95 * 12.15$m and 80 tonnes.

In the stowage plan in Appendix C it can be seen that this transport made use of the Open top notation of the vessel. Furthermore, observe that the description ‘four reels’ is right but the transport included three different sizes of the reels. In combinatorial context this transport should be indicated as type two.

Comparing *Transport 1* and *Transport 2* shows that the cargo spaces not always completely need to be used. The cargo space dimensions therefore are not the only limiting variable for accepting a transport. In Section 2.6 we elaborate on cargo combinations related to cargo space dimensions.

2.6 Vessel dimensions in relation to cargo combinations

In general, larger vessels do have larger cargo space dimensions. These vessels have more possibilities to transport different sizes of cargo. In combinatorial contexts, the allocation of cargo objects has an increased number of possibilities as well. Companies having their transports between two fixed locations therefore reasonably question themselves to enlarge their tangible assets and consequently relatively reducing their fixed costs. Since they want to transport as much and efficient as possible.

For GS, however, it is not directly logic to purchase larger vessels. First of all, GS does not mainly have similar consecutive transports. In 2016 *Oceanic* had two sets of similar transports for travel numbers: 201609, 201610 and 201611 (See *Transport 1* from Section 2.5.1) and 201624, 201626. *Nordic* only had two similar transports: 201627 and 201628. No two other transports of GS in 2016 had similar cargo. Additionally, no other sequence of two transports had the same harbor as destination.

Secondly, remember from the introduction that GS strives to minimize its current vessels, while maximizing the loading possibilities. This aim resulted in a position where no real competitors could be discovered. Maximizing vessel sizes and consequently maximizing cargo space dimensions such that more cargo can be transported therefore, is not in line with the mission of the company. They possibly will face more competition with larger vessels than usual.

Thirdly, larger vessels will not preferably be deployed for the transportation of single objects which do already fit on the current vessels. Clients after all prefer the cheapest alternatives. Current vessels, however, will still be in service to do these transports.

Fourthly, operationally seen it is more difficult to fully use cargo holds. Some travel numbers do have multiple cargo objects for different destinations. More space implies that more objects are needed to cover the holds. This results in additional destinations when the extra objects need to be transported to other harbors. This issue is comparable to potential burden that large vessels, operating in specific markets, have when their markets shrink, as described in Section 2.2.

Transport 1 from Section 2.5.1 and transports 201627 and 201628 of the *Nordic* are the only transports of GS in 2016, which would have profited from doubled cargo space surfaces. The number of transports could have be decreased in that event after all.

Reasons for the development of larger vessels, should not be found in alternatives for the current transports of GS. The need should come from other aspects. First, some developments in current markets of GS could force GS to develop larger vessels. When objects to transport become larger, the vessels should adapt to it too. Section 3 pays attention to this issue. Secondly, a contract with a client to perform consecutive transports for a long period can cause the need for a large vessel too. A third reason would be, that some cargo objects require some vessel characteristics in which size or frequency plays a role as well. Finally, it is noteworthy that a larger vessel only can be deployed when its expected financial performance is well enough. Larger vessels will be more expensive operationally compared to smaller ones. Expected revenues from services increase with that accordingly.

3 Future demand for specialized transportation services

In the previous Section we identified vessel characteristics and cargo categories. In a broader analysis of Table 6 we demonstrated the differences between several ratios of categories for the vessel types of GS. Vessels *Oceanic* and *Nordic*, both of type *M^2 Runner*, mainly transported wind industry related cargo in 2016. *Atlantic* mainly transported offshore related cargo. The categories *Industry* and *Yacht* rated high at this vessel too. *Eendracht* has mainly been deployed for general transports and also rated high on the categories *Wind* and *Offshore*.

The vessels of GS together mainly transported wind industry related cargo. Also the categories *Offshore* and *Industry* frequently provided the vessels of cargo. Therefore we identify the categories *Wind*, *Offshore* and *Industry* as being most important to GS. The categories *Bulk*, *Container*, *General* and *Yacht* are of main interest for additional purposes such as filling up cargo space or providing cargo for backhauls.

In this Section we do an analysis on the relation between the developments in the wind industry and the offshore market to the characteristics of the vessels of GS. Research Question 2 identifies the order in which we analyze this relation. Please remind that the question was defined as follows:

2. What are the expected effects in demand when vessel characteristics become more specific?
   (a) *Are there examples in other industries which show that specialization leads to specific demand?*
   (b) *Is the vessel under construction likely to be asked for transports as those performed currently?*
   (c) *How are the markets of the major cargo categories developing?*

3.1 Specialization of companies

A very illustrative principle in strategy thinking is the concept about Blue Oceans and Red Oceans of Kim and Mauborgne (2004). Companies can seek for opportunities in the same market as their competitors, and therefore face competition from incumbent firms. This is called the Red Ocean strategy. Alternatively, companies can try to discover new markets and consequently not face any competition for at least a certain period. This is called the Blue Ocean strategy.

One of the most famous examples of a Blue Ocean strategy and mentioned in the article of Kim and Mauborgne (2004), is the development of the Ford Model T. The market for automobile developing companies in America around 1900 was completely covered by luxury car manufacturers. When Ford started producing the low-budget Model T, which was a car not known for its appearances but for its solidity, he created a new market. Ordinary and hardworking people could afford the car. Through an increase of sold cars and some other smart decisions, the fixed costs of production decreased. This caused the price for a Ford Model T to decline. What again resulted in an increase of the number of sold cars.

Another example is the popularity of Cirque du Soleil. In years where regular circuses lost their popularity by children, due to the increase of alternative leisure time activities, Cirque du Soleil managed to change its customer segment. Instead of focusing on children, adults would become its new customers. A big improvement of quality and attracting the best performers to the show, made adults to visit the circus instead of theaters or operas. These well-paying clients now were provided with an exceptional high level of entertainment. The developments made Cirque du Soleil to survive the declining former market (Kim and Mauborgne, 2004).

The theoretical concept of creating markets can be linked to the goal of GS. With unique vessels GS tries to offer special transporting possibilities for the heavy cargo market. The combination of fast and efficient working, the optimal ratio of vessel size to cargo possibilities and the presence of a skilled crew, make the services of GS an interesting option for potential clients. GS wants to know how its current cargo market is developing, so that it can maintain its unique and preferred position. However, creating new markets as meant in the Blue Ocean perspective, is not completely similar to the mission of GS. Remember that GS wants to offer the best alternative in developing markets. Hence, GS is not necessarily 'creating' these markets. But the general perception of thinking differently than competitors, makes the view of GS to match with the Blue Ocean concept.

The two given examples, are not completely corresponding to the intention of Subquestion 2a. It is hard to predict in general, whether the deployment of specialized assets will provide a firm with new clients having specific demands. Companies that invent completely new devices, invite customers to a non-existing market. The demand then follows from the invention. Companies that improve their services do this, first and foremost to better serve their current clients. Hypothetically, the new services can result in a situation where other markets use these improvements as well. GS wants to prepare its new vessels for future developments in the cargo market. Those vessels could prove to be appropriate for other transportation issues too. However, the business plan for the new vessels, should already be closed, based on the current cargo market and its developments.

3.2 Market developments

The three most important cargo categories for GS are *Wind*, *Offshore* and *Industry*. We distinguish two different types of developments in markets. *Type 1*, markets expand or decline. This means that the demand for the same objects increases or decreases. *Type 2*, cargo objects themselves change. The products are improved, the costs change or the measurements alter.

For GS, developments of *Type 1* and *Type 2* in the wind industry are interesting. Both types in the offshore market are also of its interest. However, it is hard to describe how the objects change over time, since the number of different objects in the sub-markets is too big. Therefore only *Type 1* can be investigated. Furthermore, some frequently transported offshore objects are not exposed to developments themselves, pipes and reels for example do not have changing outer characteristics. For industry related cargo, *Type 1* and *Type 2* can hardly be investigated for similar reasons. *Industry* includes too many different types of cargo and can hardly be divided into sub-markets. For instance, in the overviews of Appendix A, cargo descriptions are extremely diverse for the category *Industry*. We will not examine this final category and will not compare it to vessel characteristics either.

3.2.1 Category *Wind*

The wind industry can be divided into onshore and offshore markets. The last submarket should not be confused with the cargo category *Offshore*. Also the term industry should not be confused with the cargo category *Industry*. First, we will describe under *Type 1*, the developments of the wind industry. Secondly, we will explore under *Type 2*, the possible increments in size of wind turbine parts.

Type 1: European countries have decided to set targets for the years 2020 and 2030. In 2020 20% of the energy consumption should come from renewable sources, and in 2030 this should be 27%. (EuropeanUnion, 2017). This indicates that the renewable energy market will increase in Europe. Thus the wind industry will likely increase with it too. The Global Wind Energy Council expects that the total wind generation worldwide will increase from 486.8 GW in 2016 to 817.0 GW in 2021 (GlobalWindEnergyCouncil, 2017b). In 2016, offshore installations generated 'only' 14.4 GW from the total wind energy production (GlobalWindEnergyCouncil, 2017a). In Appendix D a graphical representation of the European offshore wind industry of the years between 2000 and 2016 can be found (WindEurope, 2017). While the offshore market is relatively small, its growth is promising. At the end of 2016 it was a growth of 2.2 GW, representing an increase of 18,2% from 2015 (GlobalWindEnergyCouncil, 2017a). Another promising fact for GS is, that 88% of the worldwide offshore wind industry market is in Europe.

Wüstemeyer et al. (2015), give a possible explanation for the fact that the offshore market represents a small part of the wind industry. A comparison of the project values of the onshore and offshore markets shows that the turbine parts count up to 71% and 40% of the total project value respectively. Assuming that the turbine unit prices are equal, offshore projects are significantly more expensive than the onshore projects. This relative difference, however, is changing fast. Targets for 2020 to have levelized cost of energy prices of offshore sites becoming €100 per 1 MWh, have been reached already in several projects in Europe (GlobalWindEnergyCouncil, 2017a). The drop in additional prices in the offshore market brings it in competition with the onshore counterpart.

Kaldellis and Kapsali (2013), also describe that the offshore wind industry is expanding. European energy policies have contributed to this. Also the strength of the offshore turbines is higher than the onshore turbines, resulting in a higher productivity. Furthermore, they mention that the technological progress narrows the gap between the offshore and onshore markets.

Type 2: In the last decades, wind turbine sizes increased. This caused the relative total costs to decline (Ashuri et al., 2016). The reduction of costs is likely to continue in the coming years. Williams et al. (2017) point out that the cost of wind power in 2030 will expectedly lay between 4.1 and 4.5 dollar cents per kWh. These numbers indicate a decline of 18 to 25% compared to average costs in 2015. However, Ashuri et al. (2016) argue that it is questionable whether the decline in average total costs will still be obtained from upscaling the size of the turbines in the near future. Technological feasibility and economical attractiveness makes the five to seven megawatt turbines cost-efficient nowadays. Furthermore, they appoint that extrapolating data from current models to larger turbines, is difficult because of scaling complexity. We cannot give a fundamental statement about the future sizes of wind turbines.

3.2.2 Category *Offshore*

The offshore industry is generally divided in two sectors: wind industry, and oil and gas industry. Rui et al. (2017) divide the latter sector in four sections, namely: well, subsea system, fixed or floating platform and pipeline. In our research, we will not refer to other maritime activity as offshore industry.

Type 1: In Section 2.5.1, we identified pipes and reels as mainly transported objects for category *Offshore* in 2016. Reels are used, among other things, to transport telecommunication cables that connect overseas areas. The market for this type of connection is still growing. Increasingly more data and new cables with optimized technologies causes this growth. At the beginning of 2017, around 428 cables with a total length of 1.1 million kilometers covered the ocean floors (TeleGeography, 2017). Power cables are also transported with reels. Schell et al. (2017) point out that Europe needs to add 250000 kilometers of transmission capacity before 2050, to meet with the expected rise of the renewable energy market (offshore wind industry).

The oil and gas industry is at a low level currently. Khalifa et al. (2017) analyzed the relationship between changing oil prices and the changing number of oil rigs. They showed that this relationship was predominantly high. The low oil prices of this moment, do not give any reason to expect enormous activity in the oil and gas-sector for the coming years. New construction projects are canceled and current projects are closed down.

3.3 Future transportation possibilities to the fleet of GS

The main cargo category *Wind*, that accounted for about 44% of all transports during 2016, shows good prospects. The market of onshore and offshore wind installations is growing and expectedly keeps on growing in the next few decades. GS has the opportunities with its current vessels and its vessel under construction to become a prominent player for the transports in this market. The main part of the wind industry is located in Northern Europe, which is also ideal for GS.

In category *Offshore* GS will face a comparable market environment as recent years. The share of oil and gas related cargo will be low. Transports of pipes and reels are likely to continue the coming years. Category *Industry* that accounted for 14% of the transports during 2016, is too general to make any specific predictions. However, large industrial objects will expectedly need to be transported as economies around the world grow, see Section 4.3 for more details. The four minor categories, *Bulk*, *Container*, *General* and *Yacht* were not analyzed on developments in markets or changing outer characteristics either. Recall that these categories are used for additional purposes, such as filling up cargo spaces. We assume that the markets of these categories will not decline concurrently.

In Section 2, we did not find indications that GS needs larger vessels to transport more cargo in one trip. In Section 2.6, we gave four reasons that underline this conclusion. Additionally, in this Section we described that the current and expected markets do not give reasons to expect a redundancy of current vessels, and expected market developments give no need for specific characteristics of the vessels. In conclusion, we expect the current vessels and the new vessel under construction, to have enough transportation opportunities through the coming years.

4 Financial expectations

Stopford (2009), describes three variables where owners of vessels are dealing with:

1. Revenues received from the operations with the vessels.
2. Costs of running the vessels.
3. Method of financing the vessels.

For GS these three variables are very interesting. The first and second variable are related to some extent. This property is particularly evident in fuel costs and vessel speed. Increasing the speed increases the fuel consumption, but enables the vessel to transport more cargo in a specific time period. The age and the condition of the vessel also have a significant influence on fuel consumption (Stopford, 2009).

At this moment vessel type *M^2 Runner* runs optimally at a speed of 11-12 knots, vessel type *Trader 18* runs optimally at 17 knots. *Baltic*, a vessel of type *R^2 Carrier*, will expectedly run optimally at 11-12 knots, since its hull is identical to type *M^2 Runner*. The facts that GS benefits from the fast and efficient transports, that GS has minimal times off hire and that the company is functioning well in operational planning, reduce the need of running the vessels on exact optimal speeds. In the planning process optimal speeds are already included and speed alterations are only implemented in order to reach destinations in time.

The second variable, costs of operating a fleet, is divided into three sections by Stopford (2009): operating costs, voyage costs and cargo handling costs. At this moment GS is in particular looking for minimizing the voyages costs. In these minimizations the speed of the vessels are not set as variables. The operating costs and cargo handling costs of GS are already minimized as much as possible. Based on the costs and revenues of voyages, semi net profits of the voyages are calculated and compared. In Section 4.1 more details on these calculations are given.

The main cargo categories of GS were defined in Section 2.4. Since the objects that GS transports are too diverse, we could not do a very thorough investigation on the level of stowage plans. Only a general investigation provided insight about which categories are important in terms of duration of the voyages. For these categories we described the expectations of future developments in Section 3. We described the vessel characteristics of the fleet of GS in Sections 2.2 and 2.3 and also related them to the current cargo objects. Furthermore, we showed that the suitability of the current and the vessel under construction for the future transportation market are good.

In this section, we investigate financial effects of developments in vessel size and cargo environment. First, we analyze the influence of vessel sizes on their profitability between different segments of maritime transportation. Then, we give some general views about the relation between world economy and maritime growth. We relate the cargo environment, depending on the world economy, to expected financial performances. Furthermore, we give the importances of a right fleet mix for the changing cargo environment. Finally, we will point out that the main cargo categories of GS are not necessarily the most profitable ones. Before we start, we describe the method of how GS compares the profitability of its voyages. This method mainly functions as a format for the model of Section 5. We have chosen to split Research Question 3 up into two sections. This Section covers the first part and includes Subquestions a, b, and c. The following Section covers the second part and includes Subquestions d, e and f. Please recall that the first part of Research Question 3 was defined as follows:

3. Which model helps to indicate and decide upon possible financial revenues?
   (a) *Are the current vessels of GS outperforming market competitors?*
   (b) *How can an increase of vessel size be related to expected performance?*
   (c) *How is the expected financial performance influenced by the world economy?*

4.1 Performance of the current vessels of GS

Voyage costs (VC) were considered by Stopford (2009), as one of three variables of costs for fleet operation. In the calculations of voyage profitability of GS, this variable is also used. Stopford describes four underlying items that, taken together, by definition account for the total voyage costs. These items are:

1. Fuel costs for main engines and auxiliaries (FC).
2. Port and light dues (PD).
3. Tugs and pilotage (TP).
4. Canal dues (CD).

Therefore we get the following equation: $VC = FC + PD + TP + CD$. Note that only items are included that are direct variables of costs of voyages. Other costs, such as crew payment, maintenance and other operational costs, cannot directly be distinguished between different voyages, or have a constant influence on voyage costs. Generally, GS uses the same elements. However, they divide it into the following categories:

1. Commission fee, payments to intermediaries (CF).
2. Others, payments to create some willingness (WC).
3. Bunkering costs, same as FC (BC).
4. Dealing costs, administrative handling (DC).
5. Additional, harbor and pilotage costs (PC).

The second element in the calculations for comparing voyages is the voyage revenue. This revenue consists of two parts. The first part is the agreed revenue (RV) that the client pays for carrying out the transport. The second part consists of demurrage payments (DP), which is a compensating revenue for delaying factors for which the client can be held responsible. The semi net profit of a voyage is calculated as: $RV + DP - CF - WC - BC - DC - PC$. This semi net profit should not be confused with the actual profit, because voyage costs are only a part of the total operational costs. Stopford (2009) estimates this part to be 40%.

To compare voyages, one additional operation is needed. Transports have different durations: some transports take more time than others. For that reason GS uses the 'day rate' to measure the semi net profit per day. The 'day rate' is being calculated by dividing the semi net profit by the duration in days. The outcomes of these calculations for different transports show the differences in profitability. GS describes the duration as net days (ND). The following equation is used by GS to calculate the day rates (DR), where i and j represent the vessel and travel number respectively.

$$DR_{ij} = \frac{RV_{ij} + DP_{ij} - CF_{ij} - WC_{ij} - BC_{ij} - DC_{ij} - PC_{ij}}{ND_{ij}} \tag{1}$$

$$i \in \{A, E, N, O, B\}$$

$$j \in \mathbb{N}$$

This model functions well for comparing voyages, on different aspects, inside a company. However, with comparing to voyages of competing firms some problems come across. First of all, detailed voyage information of competing firms is not generally accessible. Besides, if information is available, data items do not necessarily cover corresponding parts of the costs and revenues, so that skewed comparisons between the vessel of GS and the vessels of competing firms cannot be prevented. Although, rates like these are frequently mentioned in financial statements, but there is no obligation to use them. That results in a multitude of terms used for the same notion. One of these terms is time charter equivalent (TCE). For a TCE-ratio no precise definition is given either. For example, some include continuous data of vessel speed or fuel consumption while others only use fixed numbers of these. Notice that the semi net profit is comparable with the daily hire of a manned vessel fully in operation. Since the TCE-ratio has no precise definition, comparisons with semi net profits are unbalanced. For the reason that the ratios are not generally and equally used, the model will mainly function as a basis for the internal model of Section 5.

4.1.1 Competition

In Section 1.1.2 we describe the current fleet of GS. Four vessels are currently in operation. We pointed out that the vessels are relatively unique. The fifth vessel, which starts to be in operation from 18 July 2017 is also a unique vessel. We described that combinations of size, cargo space dimensions, equipments, speed and tonnages together form the uniqueness of the vessels. In particular the vessels are relatively small for the types of transports they perform. Furthermore, the facts that vessel type *Trader 18* is equipped with two cranes and that vessel type R^2 *Carrier* is equipped with a RoRo facility, underline their uniqueness.

GS does not face direct competition from some specific companies, since other companies do not posses matching vessels. We emphasize that competition should be regarded in a more general context for GS. First of all, other ways of transporting cargo objects form an alternative, be it a very unlikely one. Some details to this alternative will be given in Section 4.3. Secondly, transports can also be performed by larger vessels. In maritime markets more vessels of 6000 dwt and higher exist. The disadvantages for these vessels have been described in Sections 2.2 and 2.6. Recall that larger vessels in chartering markets have more difficulties in an operational context. Therefore, larger vessels are less frequently used for single transports and thus do not form a very close competition to GS either. We give more details on the influence of vessel size for different maritime transportation segments in Section 4.2.

The biggest challenge for GS comes from competition in the cargo environment. In Section 3 we already discovered the cargo categories and in Section 4.3 we will explain the importance of a focus on the influence of world economy. One of the aims of GS is to maximize the number of well-paid sailing days of its vessels. Purchasing new vessels involves multiple issues for GS. One additional vessel increases the number of transports needed by one. Periods of a decreased demand for transports may damage the profitability of the whole fleet of GS. However, unexpected short-term positive or negative circumstances are moderated by the fleet. Furthermore, constant operating costs increase, but become lower in average when divided by a higher number of vessels. Therefore, adding one vessel to the fleet has a positive effect on the average profitability of the fleet. Only long-term periods of economic downturn in the cargo environment may harm the profitability of the fleet. In that case having a large fleet causes a problem, since the vessels in some sense compete with each other. In this context it is a well-considered decision of GS to try to diversify its vessels, so that the number of transportation possibilities is maximized.

4.1.2 Fleet renewal and fleet deployment

The age of a vessel influences the performance of the vessel in two ways:

1. Maintenance costs for older vessels are higher than for younger ones.
2. Also the hull is affected by the salt water during years of sailing, which slowly influences the ideal streamline of the vessel.

The age of a vessel is one of the factors that contribute to the **fleet renewal problem**. This problem is interesting in several segments of transport companies. Øyvind S. Patricksson et al. (2015) point out that the renewal problem for maritime sector is very important. Age of the vessels, large investments, an uncertain market and operational costs are other factors of this problem. Øyvind S. Patricksson et al. (2015) add changes in environment, new regulations, and the emergence of new technologies to this list, and mention that some of these are obligated by governments to all vessels of the fleet. The intention of the fleet renewal problem is to minimize life-cycle costs.

Besides the renewal problem of a fleet, there is the **fleet deployment problem**. In the fleet deployment problem, a company links its vessels to the available transportation requests. The intention of this problem is to reduce total traveling distance, and thus maximizing profit or minimizing cost (Chandra et al., 2015). Andersson et al. (2015) also relate speed optimization to this fleet deployment problem.

Another problem that is mentioned in the literature, and which is closely related to the fleet deployment problem is the **maritime inventory routing problem** (MIRP). This one also indicates the problem for an optimal deployment of a fleet. Linear programming is used to find optimal solutions given a set of constraints. Song and Furman (2013) for example, made a practical approach to the problem containing the following constraints: set of ports, set of vessels, load and discharge quantities, time horizon planning and travel times between ports.

In contrast with the industry, GS expanded its fleet in the past few years. While other shipping companies postponed the construction of new vessels, GS kept the focus on new innovative projects. The fleet of GS is relatively young, which is particularly advantageous with regard to the average maintenance costs. GS has always been spared a necessary decommissioning of older vessels. The continuing development has proven to be promising for GS. The fleet deployment problem that some firms are dealing with does not really have an impact on GS's financial performance either. GS does not plan its voyages too far ahead and the relatively few vessels, the diversity of vessel types and the broad scope of cargo objects have shown to fit easily into fine transporting schedules. As mentioned above, GS does not incorporate vessel speed for optimization. Service speed only forms the starting position. Therefore, the case study of RoRo shipping from Andersson et al. (2015) is not relevant for GS either.

4.2 Vessel size and financial performance

Vessel sizes are increasing through the years. The capacity of container vessels for example has increased from 96 TEU in 1959 to 19000 TEU in 2015. In 2018 container vessels with a capacity of 22000 TEU will expectedly be in operation (WorldShippingCouncil, 2015). ABB, a Swiss technological firm, calculated that the costs of transporting one TEU for one day at sea decreases as vessel capacity grows. For a vessel with a capacity for 12500 TEU the costs of transporting one TEU are \$12,43 per day. For a vessel with a capacity for 18000 TEU, these costs are \$10,99. When the capacity of a vessel will grow to 24000 TEU, the average costs will expectedly decrease further to \$9,57 (ABB, 2017).

We have seen that an increase of vessel size for container vessels is really a challenge. Increasing capacity seems to be negatively correlated with the average costs, since fixed costs, for example, are spread over more cargo. However, the calculations assume full shipments. This restriction matters less for vessels for which full shipments are easier to obtain, like container vessels, dry bulk vessel and oil vessels. Such vessels are more interested in optimal conditions, for this reason. For GS full shipments are harder to obtain. The transports of GS are always measured accurately. Situations of performing transports for which extra cargo is available are very uncommon. Increasing vessel sizes in general reduce average costs. However, the fact that GS has no cargo that always guarantees full shipments makes the profitability of larger vessels less certain for GS.

Adland et al. (2016) also describe the fact that vessels have different cargo space filling objectives. **Vessel's capacity utilization** is a general concept which measures the cargo quantity that is actually used against the maximally possible cargo quantity. Adland et al. (2016) notice that several segments of cargo vessels have different ways of expressing the cargo carrying capacity. Bulk carriers are interested in cargo in tonnes, gas carriers measure their capacity in cubic meters, container vessels have to do with a capacity in TEU. Furthermore, Adland et al. (2016) mention that RoRo vessels express their capacity in lane meters. In general the distinction is made between a capacity utilization expressed in volume and in weight.

Adland et al. (2016) present a model that describes the utilization of the cargo-carrying capacity. Adland et al. (2016) found several drivers of this utilization. Fuel price, distances sailed and value of the cargo are some of these. Unfortunately, one contextual factor of this model does not correspond to the situation of GS. The model takes into account freight rates, and focuses on a trade-off between additional costs to additional revenues from extra tonnages. Furthermore, Adland et al. (2016) mention the importance of the differences between time charter vessels and voyage charter vessels, which are two extremes of each other. The former of these does not necessarily needs a maximal usage of cargo space, since the vessel is hired on a daily basis. In other words: the less cargo they transport, the less costs and the more profit they have left. The latter of these two, the variant which gets paid a fixed price per tonnage, wants to maximize cargo-carrying capacity.

The capacity utilization of the vessels of GS is likely needed to be expressed in terms of weight, since GS is less interested in maximizing cargo space volumes. Therefore, increasing vessel sizes will not necessarily improve the expected financial performance extraordinarily. Furthermore, GS generally cannot be assigned to one of the two extremes described (time chartering and voyage chartering). The vessels are not chartered frequently, nor getting paid corresponding to the transported tonnes of cargo. Therefore, a maximization of possible loading weight should not be a strict goal of GS either. However, since GS operates in the heavy cargo market, maximal loading weights cannot completely be ignored. In the new model of Section 5.2 we will incorporate cargo weights. The weights will not be assessed in terms of utility (as in the case of the voyage charters), but in terms of vessel limitations.

4.3 Influence of the world economy

Corbett and Winebrake (2008), describe that globalization and the maritime shipping environment have a symbiotic relationship. While the globalization results in an increasing demand for transports, the maritime sector facilitates the movement of large goods. Furthermore, they point out that some maritime transports, like heavy and large cargo transports, cannot be substituted by other forms of transport. Aircrafts are the only real challengers. In terms of time aircrafts are much faster. However, expressed in energy and price per unit, aircrafts are less efficient. (Jugović et al., 2015) also indicate 'world economy' as one of the factors influencing the demand for maritime shipping. They emphasize that excellent knowledge about the world economy is necessary, since the economic environments change rapidly and substantially. Three underlying factors have to be kept in mind:

1. The business cycle indicates a continuous sequence of increasing and decreasing demand.
2. The trade elasticity forms a point to focus on. This elasticity means that the industrial growth rate is hardly in line with maritime growth rates.
3. Developments in different industries cause increasing or decreasing demand for some goods, also called the trade development cycle. Pantuso et al. (2014) discovered similar relationships between world wide trade and maritime demand. We will describe these relationships next.

Since the financial crisis of 2009, the worldwide trade dropped with 22,9% (Pantuso et al., 2014). Pantuso et al. (2014) compared rate movements of world wide trade with the supply of transports. While demand for transports has a quick response to the world trade, the supply has a slow respond to the world wide trade and to the demand for transports. While the demand decreased after 2009, the world fleet kept on growing by 7%. The main reason for this growth is the large number of orders for new vessel, which were made far in advance. Pantuso et al. (2014) emphasize that this also explains why old vessels were demolished three times more often as normal since 2009. Three maritime market cycles were identified after that. The first cycle consists of large changes in cargo industries. The second cycle is caused by developments in the world economy that are not related to cargo industry. The third cycle is formed by seasonal changes. Mainly agricultural goods show these characteristics. Hence, for GS this latter cycle is not interesting.

In Section 3 we found what effect the changing of markets of main cargo categories has on transport prospects for GS. We concluded that the diversity of types of cargo objects and different industries have a positive effect in this context. The operational flexibility of GS also influences the prospectives positively. Global factors may influence the financial prospective as well. Long-term and short-term cycles in world wide trade should be distinguished. It is important to understand that time is needed between observing market changes and for all market players to adapt to these changes. The approach of GS, to focus primarily on its own business management, is beneficial in this context. Therefore, the opportunities of vessel features in relation to cargo market are of main interest for GS. For this reason, GS wants to have an improved method of comparing its own vessels in relation to the cargo they transport and the features that are used. In Section 5 we develop a model that provides GS in its need for such a method.

5 Financial valuation model

Russo et al. (2016) compared RoRo and LoLo services in the short sea shipping market. Remind that LoLo was introduced for the indication of lift-on lift-off equipment. In their paper the focus is on a closed sea basin, the Mediterranean Sea and two specific routes, South-Italy (S-I) and Italy-South (I-S). They base their comparisons on containerized cargo and include a hub-and-spokes network. The results of the comparison showed that terminal costs for LoLo services are higher than for RoRo services. GS endorses this comparison. For example the insurance costs for lifting activities, are larger and increase as cargo becomes more valuable. Russo et al. (2016) point out that transporting costs of RoRo services are higher than the transporting costs of LoLo services. In this situation, Russo et al. (2016) found that for S-I transports longer than 900/1000 miles, LoLo is the most cost efficient service. For shorter transports RoRo is more cost efficient. For I-S transports, the threshold was at 700 miles. Note that the difference follows from the insertion of a hub-and-spokes network in the research of Russo et al. (2016).

The comparison of Russo et al. (2016), is to some extent interesting for GS. GS does not necessarily want to know when to use which type of vessel, but GS is highly interested in how valuable some vessel characteristic are for them. Contrary to the comparison, GS does not only operate on a short shipping market and its vessels do not only transport containerized cargo. Therefore, a more general overview is needed. Furthermore, the expected transporting costs of the vessel type R^2 *Carrier* is expected to be equal to the other vessel types and particularly to vessel type M^2 *Runner*. Therefore, comparisons between costs of the vessels, as in the article, are superfluous to be made. The vessels of GS are not really 'competing' against each other in this context.

Phase two of the methodology, which was the primary research, is followed by *Phase three* from now. *Phase three* treats the financial considerations of GS. The main goal of this phase is to develop a model for GS, that can be used to look closely at different voyage and vessel aspects and its financial effects. In the previous sections we have already identified most of the aspects and pointed out which are and which are not important. First, we summarize these. After that we describe the current method of comparing voyages. Then, we explain our new model, and describe how the model needs to be interpreted. The model is primarily intended for GS to use in the future. However, we test the model with the data that is currently available and we analyze the results. For elements that cannot be derived from the available documents, we have to make some assumptions.

In Section 4 we treated the first part of Research Question 3. In this Section we will cover the second part of the same research question. Please remind that the second part of Research Question 3 was defined as follows:

3. Which model helps to indicate and decide upon possible financial revenues?
   (d) *Which model links vessel characteristics to financial revenues?*
   (e) *What performance can be expected of the vessel currently under construction?*

5.1 Current method

The starting point for this Section is the method described on page 31. The outcome of the method consists of the net day rates of the voyages performed by the vessels of GS. The outcomes are kept up in overviews. The knowledge that is obtained from these overviews is primarily used by GS in the context of analyzing the profitability of certain voyages. Close examination of performances of voyages and comparisons between voyages are not yet done by GS. An improvement to the method and the way of storing data, enables GS to get better financial insights about voyages, vessel features and cargo markets. In the first part we will describe which information is already kept up by GS. Then, we explain how information should be gathered alternatively. Some additional information will be needed and we need to make some assumptions. Since Microsoft Excel is used by GS already, we have chosen to develop the model in Excel as well. The usability of an Excel model is fine for our purposes. In the overviews of Appendix A, we see voyages being denoted by travel numbers. The first four numbers stand for the year in which the voyages were done. The final two numbers are a consecutive numbering to indicate the order of the voyages. For example, the first voyage of a vessel in 2017 has voyage number: 201701.

Equation 1 contains the following variables: RV, DP, CF, WC, BC, DC, PC and ND. Please recall that for each voyage, the variables need to be determined. This is not problematic for the revenue and the demurrage payments. The payments to intermediaries are known too. Costs to create some willingness are kept up by GS precisely, even though they are very low. These expenses are done in cash or in goods. Furthermore, bunkering costs need to be estimated. The days of bunkering do not always correspond with the loading and discharging days of a voyage. Also the prices of bunkering are constantly moving. The best way of measuring the bunkering costs would be, by measuring the contents of the tank at the first and the last days of the voyage, and calculate the costs based on the amount of fuel used. The dealing costs for administrative handling, and the additional harbor and pilotage costs can easily be determined by checking the invoices. The final variable, which is the number of days of the voyages is recorded precisely. The way in which GS records its data is suitable for the new model of Section 5.2. However, the more precisely data can be recorded, the more accurately the final conclusions can be made. With the implementation of the new model we have to take this in mind.

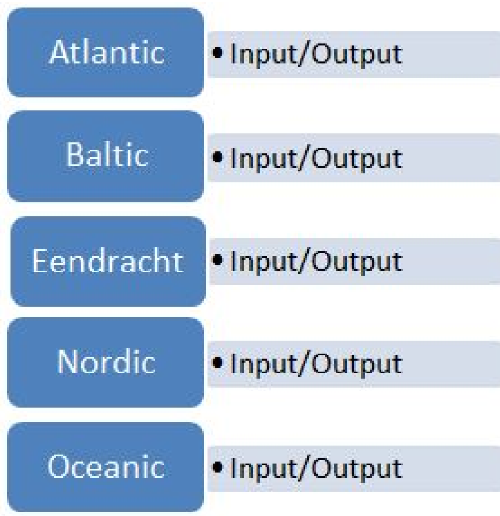

Figure 6: Structure of data for the current method.

The current overviews of GS are in Microsoft Excel documents. In Figure 6 the structure of these documents is given. Observe that the information of the different vessels is not linked yet. For each travel number the corresponding values for the variables are reported. From this, the day rates are automatically calculated. In Appendix A, we also see that a description is given about what kind of cargo objects were transported. However, other information than the voyage day rates is not being deduced yet by GS from the current overviews. A few adaptations to the overviews, a little extra information and some assumptions make better opportunities for having a more thorough look at voyage associated specifications and comparing activities.

5.2 New model

In our research we discovered several relationships between vessel features and combinations of cargo objects. Furthermore, we investigated which cargo industries show good prospectives. The model we introduce in this Section, makes it able to link those elements to expected financial performances.

The following sections are specifically relevant for the new model. In Section 2.3, we described the features of the vessels. There we divided the features in equipment and notations. This distinction indicates tangible and intangible specifications of the vessels. In Table 4, for each vessel the corresponding features can be found. In addition, the categorization of cargo object is of interest. In Section 2.4, the categorization as suggested, was given. Table 6 is a categorized overview of all transports of 2016.

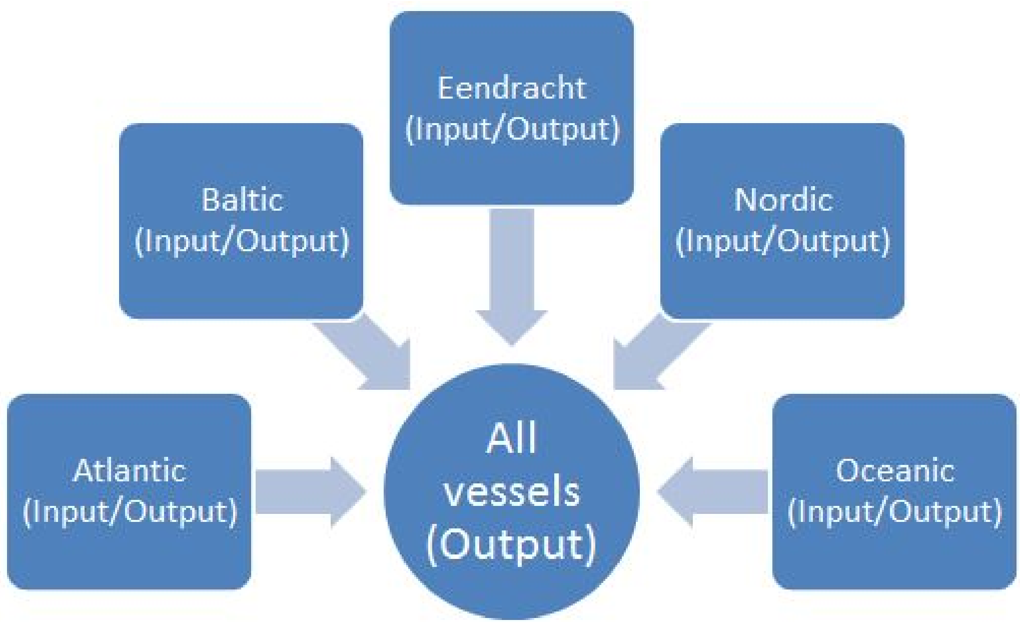

Figure 7: Structure of data for the new model.

Figure 7 represents the structure of the data in the new model. Corresponding to the current method we still have the overviews of different vessels in which voyage information needs to be imported. Voyage day rates remain accessible. In general those overviews are meant to distinguish voyages. For the new model we have chosen to add one output sheet. In that overview vessel features and different cargo markets can be distinguished and compared. In Appendix E, the Excel format of the input/output overviews of the vessels and the output document of all vessels are shown. Next, we describe which extra voyage information is needed for our model. Then, we explain how the new model functions and how the results should be interpreted.

Extra information about the cargo is the first element we want to add in our model. In order to compare the different cargo industries, the market to which the cargo belongs should be given. However, describing the cargo object itself is too specific. For this reason we suggested seven different cargo categories. In Section 2.5 we mentioned that multiple cargo objects from different cargo categories can be transported in one voyage. Therefore, we add an opportunity in our model to indicate all these different cargo categories. However, the weights still need to add to one. The choice can be made between manually spreading '1' over several categories, or to indicate several categories as '1'. The file then automatically treats these with a certain factor, so that the sum still adds to one. Additionally, from loading and discharging documents, the weight of the cargo can be found. Also dimensions of the cargo are given, which makes it possible to derive the surface in square meters and size in cubic meters.

The second element we add to the model, is information about the used vessel features during a voyage. This element, is the only thing we need to know that, cannot yet be derived from invoices or other documents. For every voyage it needs to be reported which features were used. The best way of collecting this information, is by contacting the vessel during each voyage. It is possible that multiple categories need to be assigned during one voyage. For example, on-board cranes can be used to lift the cargo on the tweendeck. Both the cranes and the tweendeck then need to be indicated as 'used'. This reveals a problem, because not all vessels have the same characteristics and notations. In order to avoid confusion, it is possible to make a selection out of different categories in the overviews.

5.2.1 Matrix representation

Representing the documents as matrices, results in the following forms. The overviews of voyage information for the different vessels have a column with voyage numbers. We use columns with a length of 100 in our model, since the number of voyages in one year will not exceed this number. Therefore, we define a column vector $V_{vessel} = (v_i) \in \mathbb{R}^{100}$. We use the next six columns to describe harbor and account information, and they have no other function besides that. We use the following seven columns to distinguish the market to which the cargo belongs. $A_{vessel} = (a_{i,j}) \in \mathbb{R}^{100,7}$. The factor that we need, to make sure that the rows of A_{vessel} add to one, is $F_{vessel} = (f_i) \in \mathbb{R}^{100}$. The used vessel features are indicated next. Observe that the number of columns of this matrix is not equal for all vessels. Therefore, we define for *Atlantic*, *Baltic*, *Nordic* and *Oceanic* $B = (b_{i,j}) \in \mathbb{R}^{100,6}$ and for *Eendracht* $B = (b_{i,j}) \in \mathbb{R}^{100,7}$. Then five columns for information about cargo dimensions follow, $C = (c_{i,j}) \in \mathbb{R}^{100,5}$. The final twelve columns represent the financial information. For this we use $D = (d_{i,j}) \in \mathbb{R}^{100,12}$.

The rows of the document in which vessel features and market can be compared, use the columns of the previous matrices. $O_{vessel} = (o_{i,j}) \in \mathbb{R}^{(13,14),19}$ is the output matrix. Observe that the documents have a different layout: a row is added to separate cargo markets from vessel features. See furthermore, that after each column an extra column is added in which percentages are displayed. These columns form a matrix together, $P_{vessel} = (p_{i,j}) \in \mathbb{R}^{(13,14),19}$. Figure 8, represents the structure of the matrices of the new model and corresponds to Figure 7. Observe that the number of rows partly depends on the corresponding number of vessel features. O_{vessel} and P_{vessel}-matrices for vessel *Eendracht* have 14 rows. For the other current vessels, this number is 13.

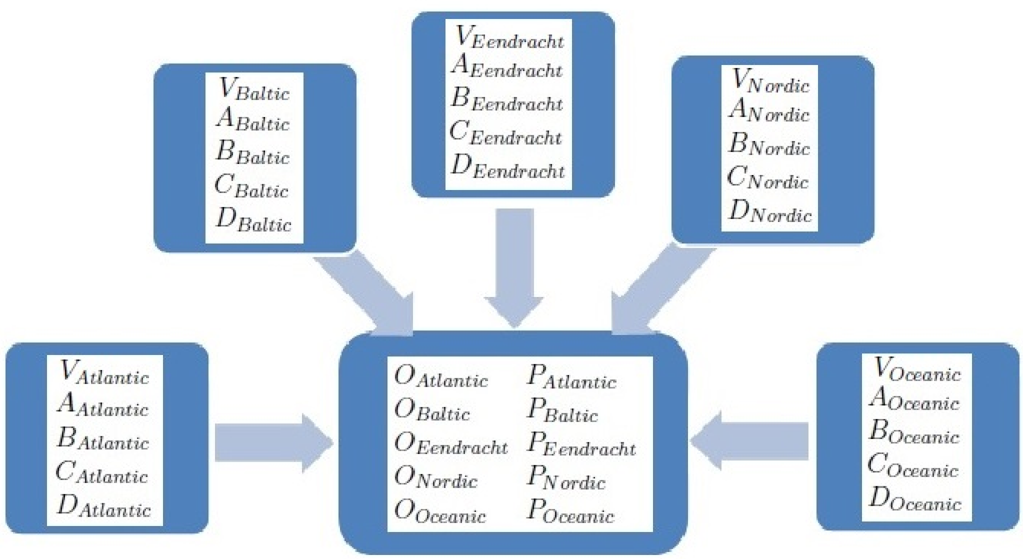

Figure 8: Matrix-structure of the new model.

The columns of matrices O_{vessel} and P_{vessel} alternate in the documents. Two examples follow, one for a cargo market and one for a vessel feature. Furthermore, we give the calculation of the P_{vessel}-matrix.

Our model calculates financial information about the cargo market *Industry* for vessel *Atlantic* as follows:

$$o_{4,j} = \sum_{i=1}^{100}(a_{i,4} * f_i * c_{i,j}) \quad \forall\, j = 1, ..., 5$$

$$o_{4,j} = \sum_{i=1}^{100}(a_{i,4} * f_i * d_{i,j-5}) \quad \forall\, j = 6, ..., 17$$

Financial information about vessel feature *Removable Tweendeck* for *Nordic* is calculated with the following formulas:

$$o_{9,j} = \sum_{i=1}^{100}(b_{i,2} * c_{i,j}) \quad \forall j = 1, ..., 5$$

$$o_{9,j} = \sum_{i=1}^{100}(b_{i,2} * d_{i,j-5}) \quad \forall j = 6, ..., 17$$

The percentages of revenues belonging to the vessel *Eendracht* are calculated with the following formula:

$$p_{i,j} = \frac{o_{i,j}}{\sum_{i=1}^{14} o_{i,j}} \quad \forall i = 1, ..., 14 \quad \forall j = 1, ..., 16$$

Notice that a column with percentages with respect to day rates is not useful. In our model this column is replaced for every row, by a division of costs by revenues.

$$o_{i,17} = \frac{o_{i,14}}{o_{i,8}} \quad \forall\, i = 1, ..., 14$$

5.2.2 Interpretation of output

The overviews of the vessels should be interpreted in the same way as the overviews of the vessels from the current method of GS. The main goal of these overviews is to display the net day rate of all voyages as explained in Section 4.1. The overview introduced with the new model should be interpreted in the following way. This overview shows the cargo market and the vessel features for each feature. The rows of the cargo markets start with the number of voyages. For each market it can be seen how much voyages were carried out during the corresponding year. The column next to it gives percentages for these numbers. If one out of ten voyages was performed for a specific market category, 10% is showed there. The percentages of all market categories together add to 100%. The following columns should be interpreted equally. For example net number of days of voyages for specific market categories, or average day rates to market categories can be derived from it too. The rows for the vessel features are displayed next. The interpretation is slightly different compared to the previous rows, since multiple vessel features can be assigned as 'used'. Looking again at the number of voyages, the number of times a specific vessel feature was used can be seen. Each element in the column that shows percentages can have a value of 100% itself. Therefore, the column does not add maximally to 100%. Since multiple vessel features in theory can be used during all transports. Though, it is interesting to know how often a feature was used. Looking at revenues for example, indicates to which part of the generated revenue a specific feature contributed.

5.2.3 Example

In this Section we give an example of our model. Recall that five overviews are meant for the input of data for the five different vessels. The Microsoft Excel output file, is automatically generated from these five overviews. Since these calculations are the same, we have chosen to show an example for only one vessel. We give ten examples of travel numbers of the *Atlantic* in 2018, see Figures 9, 10 and 11. Recall that the cargo categories in Figure 9 are; A: *Bulk*; B: *Container*; C: *General*; D: *Industry*; E: *Offshore*; F: *Yacht* and G: *Wind*.

Travelnumber	Loading	Dischar	Distanc	Accoun	Broker	Laycan	Cargo	A	B	C	D	E	F	G	Factor
201801	Examp	Examp	Examp	Examp	Examp	Examp	Example							1	1
201802	Examp	Examp	Examp	Examp	Examp	Examp	Example		1						1
201803	Examp	Examp	Examp	Examp	Examp	Examp	Example			1					1
201804	Examp	Examp	Examp	Examp	Examp	Examp	Example				1	1			0,5
201805	Examp	Examp	Examp	Examp	Examp	Examp	Example				1	1	1		0,33333
201806	Examp	Examp	Examp	Examp	Examp	Examp	Example					1			1
201807	Examp	Examp	Examp	Examp	Examp	Examp	Example					1		1	0,5
201808	Examp	Examp	Examp	Examp	Examp	Examp	Example					1		1	0,5
201809	Examp	Examp	Examp	Examp	Examp	Examp	Example							1	1
201810	Examp	Examp	Examp	Examp	Examp	Examp	Example					1			1

Figure 9: Ten example travel numbers (1).

Recall that the vessel characteristics in Figure 10 are; A: *Deck Cranes*; B: *Removable Deck*; C: *Removable Tweendeck*; D: *Special Purpose*; E: *Grain Fitted* and F: *Dangerous Goods*.

						Som	Som	Som	Som	Som
						11	45	39500	19500	31250
						Gem	Gem	Gem	Gem	Gem
Vessel Characteristics						1,1	4,5	3950	1950	3125
A	B	C	D	E	F	Nr. Voyages	Nr. Units	CBM	M2	MT
1						2	1	3500	1500	2900
1	1					1	2	3600	1600	2950
1	1					1	3	3700	1700	3000
1	1	1				1	4	3800	1800	3050
1	1	1				1	5	3900	1900	3100
1	1	1				1	2	4000	2000	3150
	1	1				1	4	4100	2100	3200
1						1	6	4200	2200	3250
1						1	8	4300	2300	3300
1		1	1			1	10	4400	2400	3350

Figure 10: Ten example travel numbers (2).

Som	Som	Som	Som	Som	Som	Som	Som	Som	Som	Som		
44700	100	44800	1600	350	19100	320	90	21460	23340	45		
Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	
4470	10	4480	160	35	1910	32	9	2146	2334	4,5	540,122	
omzet	demurrag	totaal opb	commissi	others	bunkers	hand. kst	overig	totaal kst	resultaat	net days	day rate	Kst/Opb
3000	0	3000	200	50	1500	0	20	1770	1230	3	410	59%
3200	0	3200	200	20	2000	0	20	2240	960	4	240	70%
2500	0	2500	150	30	1600	0	50	1830	670	5	134	73%
2000	0	2000	100	50	1700	0	0	1850	150	6	25	93%
15000	0	15000	150	20	1800	50	0	2020	12980	9	1442	13%
6000	0	6000	200	30	1900	50	0	2180	3820	2	1910	36%
5000	0	5000	150	50	2000	30	0	2230	2770	3	923	45%
2500	0	2500	100	20	2100	80	0	2300	200	5	40	92%
2700	0	2700	150	30	2500	10	0	2690	10	6	2	100%
2800	100	2900	200	50	2000	100	0	2350	550	2	275	81%

Figure 11: Ten example travel numbers (3).

Figures 12, 13 and 14 are the generated tables by our model in Microsoft Excel files, from the data of Figures 9, 10 and 11.

	Nr. Voyages	%	Nr. Units	%	CBM	%	M2	%	MT	%
	Som 11		Som 45		Som 39500		Som 19500		Som 31250	
	Gem 1,1		Gem 4,5		Gem 3950		Gem 1950		Gem 3125	
Atlantic										
Bulk	0	0%	0	0%	0	0%	0	0%	0	0%
Container	1	9%	2	4%	3600	9%	1600	8%	2950	9%
General	1	9%	3	7%	3700	9%	1700	9%	3000	10%
Industry	0,8333333	8%	3,66667	8%	3200	8%	1533,33	8%	2558,33	8%
Offshore	3,8333333	35%	20,6667	46%	15750	40%	8083,33	41%	12283,3	39%
Yacht	0,3333333	3%	1,66667	4%	1300	3%	633,333	3%	1033,33	3%
Wind	4	36%	14	31%	11950	30%	5950	31%	9425	30%
Deck Cranes	10	91%	41	91%	35400	90%	17400	89%	28050	90%
Removable Deck	6	55%	20	44%	23100	58%	11100	57%	18450	59%
Removable Tween	5	45%	25	56%	20200	51%	10200	52%	15850	51%
Special Purpose	1	9%	10	22%	4400	11%	2400	12%	3350	11%
Grain Fitted	0	0%	0	0%	0	0%	0	0%	0	0%
Dangerous Goods	0	0%	0	0%	0	0%	0	0%	0	0%

Figure 12: Output of example, generated by the new model (1).

omzet	%	demurrage	%	totaal opbrengs	%	commissie	%	others	%	bunkers	%
Som 44700		Som 100		Som 44800		Som 1600		Som 350		Som 19100	
Gem 4470		Gem 10		Gem 4480		Gem 160		Gem 35		Gem 1910	
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
3200	7%	0	0%	3200	7%	200	13%	20	6%	2000	10%
2500	6%	0	0%	2500	6%	150	9%	30	9%	1600	8%
6000	13%	0	0%	6000	13%	100	6%	31,667	9%	1450	8%
18550	41%	100	100%	18650	42%	625	39%	146,67	42%	7400	39%
5000	11%	0	0%	5000	11%	50	3%	6,6667	2%	600	3%
9450	21%	0	0%	9450	21%	475	30%	115	33%	6050	32%
39700	89%	100	100%	39800	89%	1450	91%	300	86%	17100	90%
33700	75%	0	0%	33700	75%	950	59%	200	57%	11000	58%
30800	69%	100	100%	30900	69%	800	50%	200	57%	9400	49%
2800	6%	100	100%	2900	6%	200	13%	50	14%	2000	10%
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

Figure 13: Output of example, generated by the new model (2).

Som		Som		Som		Som		Som			
320		90		21460		23340		45			
Gem		Gem		Gem		Gem		Gem		Gem	
32		9		2146		2334		4,5		540,122	
hand. kst	**%**	**overig**	**%**	**totaal kst**	**%**	**resultaat**	**%**	**net days**	**%**	**day rate**	**Kst/Opb**
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
0	0%	20	22%	2240	10%	960	4%	4	9%	240	70%
0	0%	50	56%	1830	9%	670	3%	5	11%	134	73%
16,6667	5%	0	0%	1598,33	7%	4401,67	19%	6	13%	733,611	27%
221,667	69%	0	0%	8393,33	39%	10256,7	44%	14	31%	732,619	45%
16,6667	5%	0	0%	673,333	3%	4326,67	19%	3	7%	1442,22	13%
65	20%	20	22%	6725	31%	2725	12%	13	29%	209,615	71%
290	91%	90	100%	19230	90%	20570	88%	42	93%	489,762	48%
130	41%	70	78%	12350	58%	21350	91%	29	64%	736,207	37%
230	72%	0	0%	10630	50%	20270	87%	22	49%	921,364	34%
100	31%	0	0%	2350	11%	550	2%	2	4%	275	81%
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

Figure 14: Output of example, generated by the new model (3).

The column ‘Nr. Voyages’ in Figure 12 was generated as follows. Since no voyages transported objects within category *Bulk*, the upper element is 0. In one voyage, containers were transported. Therefore, the element behind cargo category *Container* is 1. We see that the total number of voyages adds to 11. Because, travel number 201801 represents two consequential voyages belonging to one order. Furthermore, some elements in the same column are decimal numbers. Because, some travel numbers were assigned to multiple cargo categories. The factors, shown in Figure 9 contributed to these elements. The cargo category *Yacht* was only assigned in travel number 201805, two other categories were assigned there as well. Therefore, only one third of a voyage is indicated there. In next column, the percentages are showed. For example, cargo category *Wind* gives: $\frac{4}{11} \approx 36\%$.

The rows representing vessel characteristics should be considered correspondingly. In 10 of the total 11 voyages *Deck Cranes* were used. Which gives $\frac{10}{11} \approx 91\%$. We see that the notations: *Grain Fitted* and *Dangerous Goods* were not used at all. Recall that the interpretation of this final percentage, and of all percentages related to vessel characteristics, is different from the interpretation of the percentages related to cargo categories, as we described in Section 5.2.2

In general all columns and rows are generated in the same way as described above. The column 'Total Revenue' however is the sum of columns 'Revenue' and 'Demurrage'. Again we see that no revue was created with objects from category *Bulk*. Interesting to see in this example, is that the largest part of the total revenue was coming from category *Offshore*. This number was calculated as follows: $\frac{18650}{44800} \approx 42\%$. In line with the alternative interpretation of percentages related to vessel characteristics we explain the 89% too. We see that deck cranes played a role in a revenue of €39800. Which is $\frac{39800}{44800} \approx 89\%$ of the total revenue. Furthermore, the day rates are calculated by dividing the result by net number of days. For cargo category *Wind* this is: $\frac{2725}{13} \approx 209,6$. Column 'Kst/Opb' is calculated by dividing total cost by total revenue. For vessel characteristic *Special Purpose* this is: $\frac{2350}{2900} \approx 81\%$.

5.3 Results

The data of the current method for reporting financial details of voyages can be used to test the new model. For the part about comparing markets we have to make some small assumptions. However, for the part of comparing vessel features we have to make larger assumptions. Information about the voyages of 2016 of the vessels *Atlantic*, *Eendracht*, *Nordic* and *Oceanic* has been made available by GS. Details will not be shown in this paper.

In Appendix A, the categorization of all transports of 2016 is given. For the voyages in which one category is indicated, this category is also used in our analysis. The factor of those voyages with a single category, is 1. For the voyages in which multiple categories are indicated, we closely look at the objects themselves. The distinction is made by estimated sizes, since these are not recorded precisely yet. For example, for voyage number 201608 of vessel *Oceanic* we assume factor $0,3$ for category *Containers* and factor $0,7$ for category *Wind*. For the information for the missing categories, we decided to equally spread the factor 1 over the seven indicated categories. Since vessel *Eendracht* was chartered during the first ten voyages of 2016, we leave these voyages out of the analysis. The used vessel features cannot be determined exactly anymore. However, considering the cargo objects, we select the features of which we assume that were used during the voyages.

5.4 Analysis

In Section 2 we derived from the overviews of the current method which market industries are most important to GS. In Section 3 we investigated for these categories which developments can be expected. However, we argued that the assumption: 'the most important market categories are those in which GS is transporting most time of the year,' does not necessarily need to be true. Other aspects may appoint a different ranking. For example, market categories which are most profitable, can be regarded as most important as well. The new model enables that markets can be compared on different aspects.

From the model, can be derived which part of the total revenue of each vessel was generated by which cargo category. For the vessel *Atlantic* most revenue came from the category *Industry*. For *Eendracht* most revenue was generated by the category *General*. *Nordic* and *Oceanic* generated most of the revenue with category *Wind*. Instead of adding a column 'Total Cost' to the tables, we have chosen for columns with 'Cost/Revenue'. From these ratios we derive that the cargo market *Yacht* has the highest costs with respect to the generated revenue. This is due to the high insurance costs. For category *Wind* we observe the same relation.

Furthermore, categories *Wind* and *Industry*, had the best average net day rates during 2016. Category *Bulk* had by far the worst net day rates. This corresponds to the idea of GS that they rather transport bulk cargo, than finding no cargo at all. It must be said that this category at least shows positive results as well.

Mainly used vessel features can also be derived. This is in contrary to the current method. Therefore, we had to estimate this for each transport of 2016. We derived from this that *Deck Cranes*, at the vessels of type *Trader 18*, are often used with respect to the number of voyages. The feature *Removable Deck* has frequently been used by all vessels. Notation *Open Top* has shown to be valuable for *Eendracht*, since it contributed to a large part of the generated revenue. The notations *Special Purpose*, *Grain Fitted* and *Dangerous Goods* were needed only a few times during 2016.

Please recall that we may not consider this final analysis on vessel features entirely accurate, since many assumptions were to be made. Analysis on the features becomes more valuable after the implementation of the model in the organization and with the right way of reporting. A table that combines the numbers of used features of different vessels does not add any value for analysis purposes. For each vessel only the corresponding features can be compared.

5.4.1 Vessel under construction

In Section 1.2 we described the principle of Roll-on Roll-off. Vessel *Baltic* of type R^2 *Carrier* which started to be in operation on the 18^{th} of July 2017, is in the possession of this feature *RoRo*. The expectation of transport possibilities for this vessel seems to be good. We discovered that this vessel will be suitable to transport in the same markets as the current vessels of GS. The RoRo-ramp has some advantages with respect to these vessels. Instead of lifting the objects with *Deck Cranes* or cranes in the port, objects are rolled on board. The high insurance cost, which became visible especially in the market categories *Yacht* and *Wind*, will minimize significantly. With an increasing value of cargo objects, the demands for transports by this vessel are likely to increase as well. The other characteristics of this vessel are corresponding to the vessels of type M^2 *Runner*. Therefore, we expect *Baltic* to perform at least as well as these vessels.

In the new model we inserted an overview for vessel *Baltic*. However, we cannot derive any information from data from 2016, since no voyages were yet made then. When the model is implemented in the second part of 2017 and after some voyages are done, we are able to identify which markets are most important for this vessel. During the construction of the *Baltic*, GS has been approached by several clients about whether the vessel can transport some large vehicles like trucks and cranes. Therefore, we leave the possibility open to add a new market category *Vehicles*. The same holds for the used vessel features. Since no data are available yet, we cannot precisely determine in advance how valuable the features are. The expectation that the RoRo-ramp is valuable and will be used frequently, needs to be checked after some voyages.

6 Conclusion

Global Seatrade, the company for which we conducted our research owns different types of vessels. The distinctions between the different vessel types were categorized and analyzed on value. Weights of the vessels, and the dimensions of cargo spaces both form a constraint on the possible quantity of cargo to transport. We found that, for different cargo markets the relation between maximizing quantities and sizes are different. Operating vessels in main markets where GS is active, are not necessarily optimal when they are as large as possible. Other characteristics, namely the set of vessel features have a larger impact on the number of possibilities. Deck cranes, the removable decks and the open top notation of some vessels facilitate a lot of opportunities for the cargo transports of GS. These characteristics give the vessels enormous flexibility. Other aspects contribute to the flexibility of the company as well. Short-term planning, interchangeability of the crew between the vessels and its fast-working mentality are some of these. Both, the vessel characteristics as well as the company's flexibility have resulted in a growing company through the past years.

Cargo markets *Wind* and *Offshore* accounted for the biggest part of transports during 2016. Mainly in the wind industry a lot of possibilities can be expected. This energy sector is growing and will be growing in the coming decades. For example, in Europe goals were set to generate 27% of the European energy consumption from renewable resources. The number of offshore wind farms will increase with this, since the project costs keep on decreasing significantly. This growth gives GS a lot of opportunities in the coming years.

The current vessels as well as the vessel under construction, are prepared for the expected developments of the objects in the cargo markets. For the coming years, we do not expect changes to the cargo market and the objects themselves that make the current vessels superfluous. Furthermore, the developments in the cargo markets show cycles of increasing and decreasing demand. The fact that GS operates in different cargo markets, motivates the idea that GS will not face a financial decline when just one market has bad times. One additional remark about the future transportation possibilities needs to be made. The vessels of GS are 'competing' against each other in some sense. Every vessel of GS needs to have cargo at the same moment. One additional vessel in the fleet gives one extra challenge when cargo is not always and everywhere available anymore. However, one poorly operating vessel can be compensated by the other vessels. Therefore, looking at the average profitability is necessary. The larger the fleet, the lower the impact of one vessel on the overall performance.

The final goal of this study was to develop a model that improves the current method of comparing different voyages of the vessels of GS. This method did not take into account yet, the different characteristics of the vessels. Market categories could not be distinguished either. With the model we developed, these aspects can be compared. The most important markets are not necessarily the ones from which the highest daily profits can be generated. Another way of ranking the cargo markets, can be done by checking the number of days the vessels transported object of the different markets. Comparisons like these, can easily be performed with our new model. For example, we found that the largest parts of revenue came from transporting wind- and offshore-related cargo during 2016.

Also the value of the characteristics of the vessels can be compared with the new model. However, forecasting statements could not yet be made. The available data were not sufficient. Therefore data need to be supplemented during future transports. From the model then, can be derived how much the contribution of a characteristic was to the revenue, or in how much voyages a specific characteristic was used. When the new vessel with the Roll-on Roll-off facility has been in operation for a while, statements for the future decisions can be derived from the model.

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Appendices

A Cargo categories 2016

Table 7: Cargo categories 2016 *Atlantic*.

Travel nr.	Category	Net days
201601	?	6,7
201602	Yachts Offshore	15.9
201603	Industry	4,04
201604	Yachts Bulk Yachts Yachts	36.48
201605	Industry	20,84
201606	Industry	8,24
201607	Offshore Industry Industry	20,31
201608	Yachts	23,41
201609	Offshore	29,24
201610	?	14
201611	?	11,44
201612	Offshore	29,92
201613	Offshore	21,35
201614	Wind	11,96
201615	Industry	5,06
201616	Industry	4,88
201617	Industry	7,18
201618	Wind	13,46
201619	Offshore Containers Offshore Offshore Offshore	7,99
201620	Bulk	19.09
201621	Offshore	3.32

Table 8: Cargo categories 2016 *Eendracht*.

Travel nr.	Category	Net days
201533	?	8,83
201601	?	6,15
201602	?	15
201603	?	15
201604	?	15
201605	?	15
201606	?	15
201607	?	15
201608	?	15
201609	?	15
201610	?	2
201611	Yachts Offshore	20,39
201612	General	3,9
201613	General	12,9
201614	Offshore	6,02
201615	General	12,01
201616	Industry General	16,09
201617	?	10
201618	Wind General	5,16
201619	General	20,09
201620	Wind	14,5
201621	Industry	5,97
201622	General	5,93
201623	Wind	6,52
201624	Industry	12,46
201625	Yachts General	4,09
201626	Wind	4,14
201627	General	3,13

201628	General	4,48
201629	Wind Yachts	6,29
201630	Wind Yachts	0,76
201631	Offshore	22,76
201632	Yachts	25.58

Table 9: Cargo categories 2016 *Nordic.*

Travel nr.	Category	Net days
201601	Industry	8,45
201602	Wind	27,05
201603	Offshore	8,04
201604	Wind	12,38
201605	Industry	12,96
201606	Wind	8,71
201607	Wind	11,3
201608	Offshore	6,64
201609	Wind	6,25
201610	Wind	26,27
201611	Industry	19,82
201612	Industry	9,71
201613	Industry	7,22
201614	?	12,58
201615	Offshore	8,98
201616	Wind	10,8
201617	?	5,86
201618	Wind	19,42
201619	Wind	12,18
201620	Wind	9,17

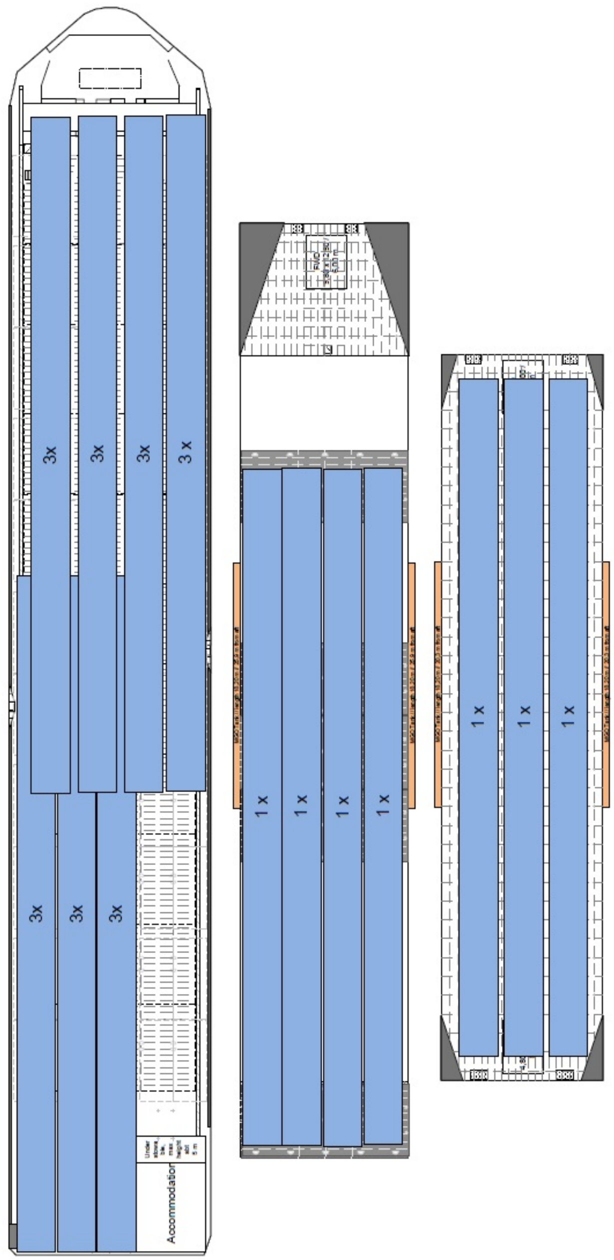
201621	Wind	8,65
201622	Wind	4,26
201623	Wind	7,29
201624	Wind	8,79
201625	Wind	7,08
201626	Wind	11,71
201627	Wind	6,37
201628	Wind	6.88
201629	Offshore	0,21
201630	Wind	9.95
201631	Wind	10.02
201632	Industry	10.75

Table 10: Cargo categories 2016 *Oceanic*.

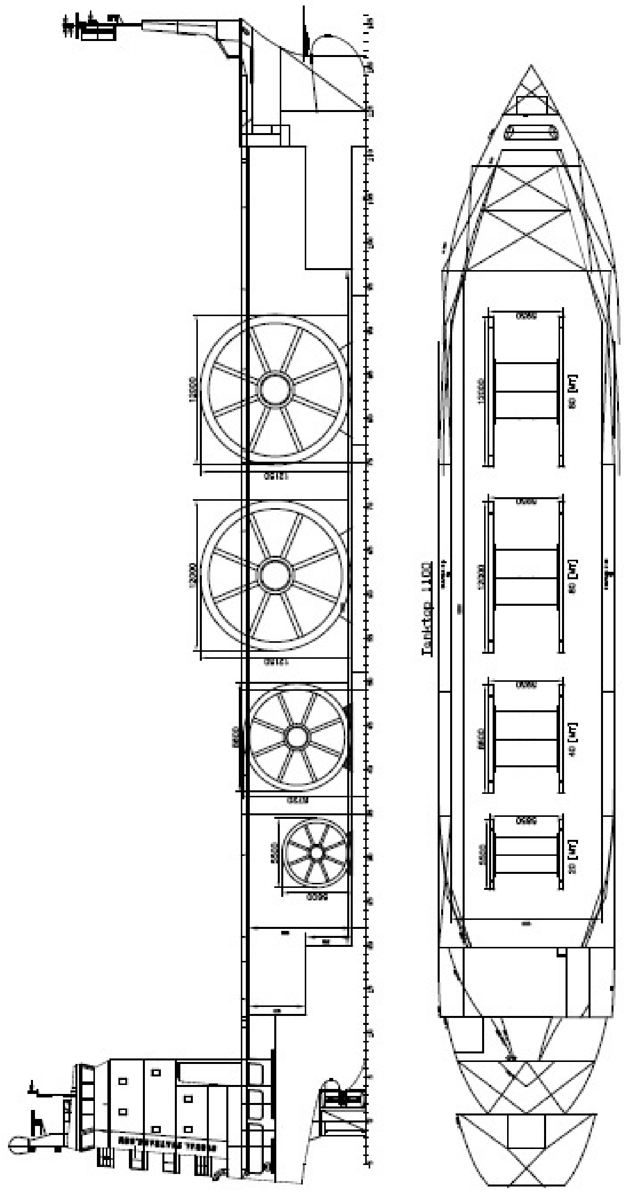
Travel nr.	Categories	Net days
201542	?	5,5
201601	Offshore	23,04
201602	Wind	11,94
201603	Wind	9,36
201604	Wind	9,61
201605	Bulk	8,29
201606	Wind	7,96
201607	Offshore	10,13
201608	Wind Containers	19
201609	Wind	5,06

201610	Wind	5,95
201611	Wind	8,91
201612	?	19
201613	Wind	4,07
201614	Wind	5,49
201615	Wind	13,74
201616	Bulk	9,76
201617	Wind	10,08
201618	Wind	10,25
201619	Offshore	6,73
201620	Wind	7,06
201621	Wind	4,2
201622	Wind	7,68
201623	Offshore	10,03
201624	Wind	5,93
201625	Wind	6,27
201626	Wind	9,9
201627	Bulk	5,46
201628	Wind	6,68
201629	Wind	16,84
201630	Wind	9,19
201631	Wind	12,12
201632	Offshore	8.8
201633	Offshore	9.89
201634	Offshore	8.08
201635	Industry	10.84
201636	Offshore	6.14
201637	Wind	11.86

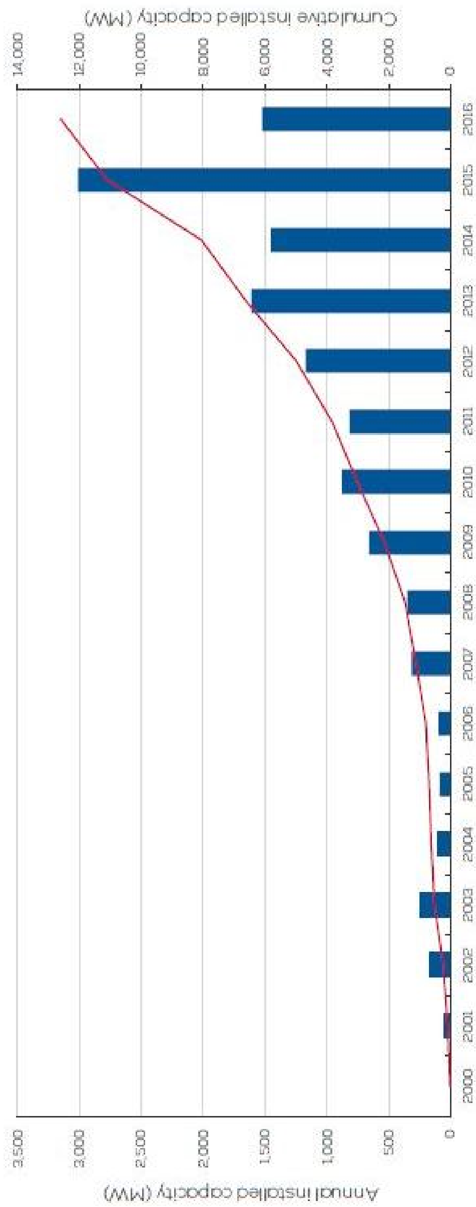
B Stowage plan *Oceanic* 201609-201611



C Stowage plan *Oceanic* 201619



D Cumulative and annual offshore wind installations 2000-2016



E New model Microsoft Excel file

Voyage overview of *Atlantic*.[2]

Atlantic

Kapitein
Kantoor
Output

Choose 1	
Bulk	A
Container	B
General	C
Industry	D
Offshore	E
Yacht	F
Wind	G

Travelnumber	Loading Port	Discharging Port	Account	Broker	Laycan	Cargo	A	B	C	D	E	F	G	Factor

Choose Multiple	
Deck Cranes	A
Removable Deck	B
Removable Tween	C
Special Purpose	D
Grain Fitted	E
Dangerous Goods	F

Vessel Characteristics					
A	B	C	D	E	F

Nr. Voyages	Nr. Units	CBM	M2	MT
Som	Som	Som	Som	Som
0	0	0	0	0
Gem	Gem	Gem	Gem	Gem
0	0	0	0	0

omzet	demurrage	tot opbrengst	commissie	anders	bunkers	hand. kst	overig	tot kst	resultaat	net days	day rate	kst/opb
Som	Som	Som	Som	Som	Som	Som	Som	Som	Som	Som		
0	0	0	0	0	0	0	0	0	0	0		
Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	Gem	
0	0	0	0	0	0	0	0	0	0	0	0	

[2]This overview represents the voyage overview of the *Atlantic*. Observe that the setup of this overview is comparable with the voyage overviews of the other vessels.

Combined overview of all vessels.

The following tables are positioned vertical under each other.

Atlantic	Baltic	Eendracht	Nordic	Oceanic
Bulk	Bulk	Bulk	Bulk	Bulk
Container	Container	Container	Container	Container
General	General	General	General	General
Industry	Industry	Industry	Industry	Industry
Offshore	Offshore	Offshore	Offshore	Offshore
Yacht	Yacht	Yacht	Yacht	Yacht
Wind	Wind	Wind	Wind	Wind
Deck Cranes	Removable Deck	Deck Cranes	Removable Deck	Removable Deck
Removable Deck	Removable Tween	Removable Deck	Removable Tween	Removable Tween
Removable Tween	Special Purpose	Removable Tween	Special Purpose	Special Purpose
Special Purpose	Roll-on Roll-off	Special Purpose	Grain Fitted	Grain Fitted
Grain Fitted	Grain Fitted	Grain Fitted	Dangerous Goods	Dangerous Goods
Dangerous Goods	Dangerous Goods	Dangerous Goods	Open Top	Open Top
		Open Top		

The following tables are positioned next to each other for each vessel.

Som		Som		Som		Som		Som	
	0		0		0		0		0
Gem		Gem		Gem		Gem		Gem	
	0		0		0		0		0
Nr. Voyages	%	**Nr. Units**	%	**CBM**	%	**M2**	%	**MT**	%
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###
0	#######	0	###	0	###	0	###	0	###

Som		Som		Som		Som		Som		Som	
0		0		0		0		0		0	
Gem		Gem		Gem		Gem		Gem		Gem	
0		0		0		0		0		0	
omzet	**%**	**demurrage**	**%**	**totaal opbreng**	**%**	**commissie**	**%**	**others**	**%**	**bunkers**	**%**
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###
0	######	0	#####	0	###	0	###	0	######	0	###

Som		Som		Som		Som		Som			
0		0		0		0		0			
Gem		Gem		Gem		Gem		Gem		Gem	
0		0		0		0		0		0	
hand. kst	**%**	**overig**	**%**	**totaal kst**	**%**	**resultaat**	**%**	**net days**	**%**	**day rate**	**Kst/Opb**
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%
0	##	0	###	0	####	0	###	0	###	0	0%