MARITIME TRANSPORTATION AND PORTS I

1st Project – Voyage Calculation

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ANNEX

Introduction

The main objective of this first project is to analyse and perform calculations related to a voyage of a selected ship with specific technical characteristics and purpose in relation to its physical nature.

In our case, the work concerns the study of a container ship classified as ULCS (Ultra Large Container Ship), which uses a well-known schedule called "Pendolum" (Fig.2) : this is the typical route of container ships and consists of a collection of goods in a geographical area on several ports, usually it is an ocean crossing with a distribution on a second series of ports, for example goods produced in Asia and distributed in America and Europe. It involves fixed itineraries, with ships making a scheduled service to predetermined ports and the most profitable one. The name is due to the fact that the ship, like a pendulum, moves between geographical areas that are far apart.

Specifically, the ship under observation and study is the Munich Maersk, part of the EEE ships class of the well-known company.
The relevant starting points for this specific ship are the amount of cargo it can carry (20,000 TEU) and the important route between the Asian and European markets (Shanghai-Shenzhen-Sines-Rotterdam).
In relation to these macro characteristics, our study will consist in subjecting the ship to a complete analysis including travel costs, operating costs, capital costs, time and profit.

All of this will be related to the concrete and real existence of problems that owners and companies face daily in the shipping sector, always considering compliance with the regulations and laws that exist in this sector.

Fig.1 Munich Maersk

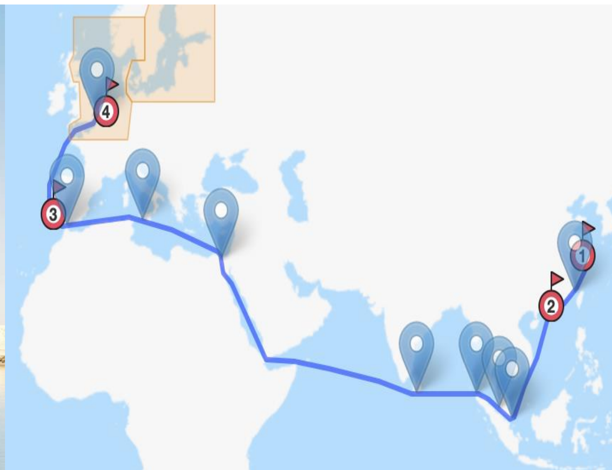

Fig.2 “Pendulum” route

1. Freight rates

A freight rate is the cost of transporting a certain cargo from one location to another. The price is determined by the kind of cargo, mode of transport, weight of the cargo, and distance to the delivery location. Many shipping companies utilize dimensional weight to calculate their prices, which takes into consideration both the cargo's weight and volume. Intermodal container shipping charges are primarily influenced by the route chosen rather than the weight of the cargo, as long as the container weight does not exceed the maximum loading capacity. Prices per Twenty Foot Equivalent Unit (TEU) can range from $300 to $10,000 based on availability and demand for a certain route.
In our case, the calculation of the Freight Rate, for a ship departing from the port of Shanghai and with destination the port of Rotterdam, not completely loaded with its dimensions and considering the time of the year, is estimated by the well-known website searates.com around the value of 9000 $/TEU.
The approximation appears to be consistent with the price trend of today's intermodal market, what can be put under criticism is the aspect related to the Maersk company which operates with ships having their own container and hub, with the relative consideration of a lowering of the real price related to the cost of the container.

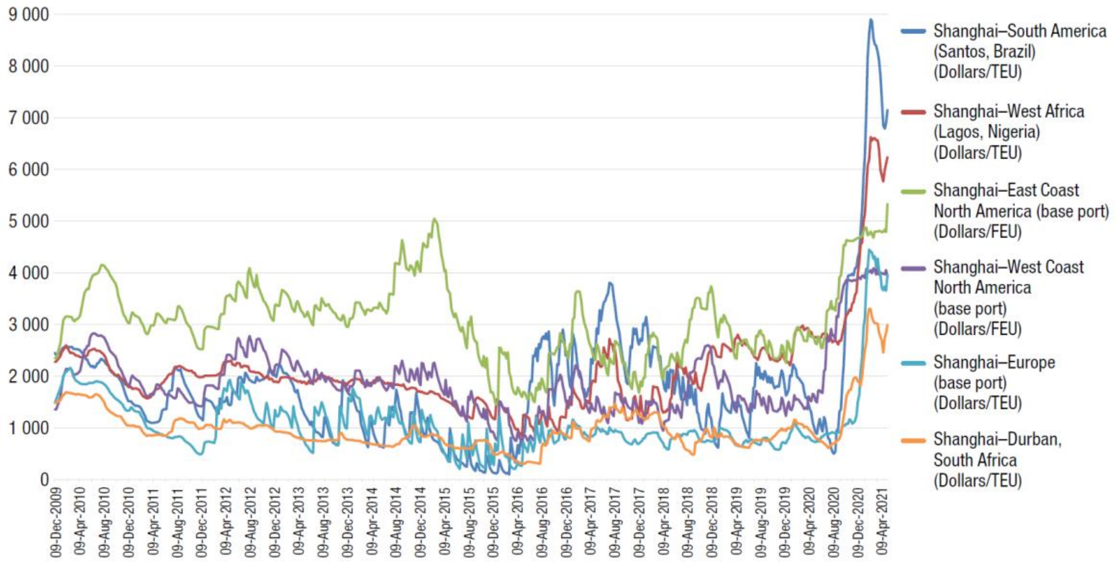

Figure 1: Shanghai containerized freight index, weekly spot rates, 18 December 2009–9 April 2021

2. Ballast condition

Invasive aquatic species pose a significant hazard to marine ecosystems, and shipping has been recognized as a main avenue for species introduction into new settings. The problem grew as commerce and traffic volume rose over the previous few decades, particularly with the development of steel hulls, which allowed vessels to use water as ballast instead of solid items. The repercussions of introducing new species have been severe in many parts of the world. Quantitative statistics suggest that the rate of bio-invasions is increasing at an alarming rate. As the volume of seaborne trade grows overall, the problem may not have reached its apex.

The Ballast Water Management Convention, however, approved in 2004, attempts to restrict the spread of dangerous aquatic species from one place to the next by setting rules and procedures for the management and control of ships' ballast water and sediments.
All ships in international trade are required by the Convention to manage their ballast water and sediments to a specified standard, in accordance with a ship-specific ballast water management plan. All ships will also be required to have a ballast water record book and an international ballast water management certificate on board. The ballast water management regulations will be implemented gradually over time. Ships should swap ballast water in the middle of the ocean as a temporary solution. However, most ships will ultimately need to incorporate an on-board ballast water treatment system.
To aid in the execution of the Convention, a number of guidelines have been produced.
All ships will be required to establish a Ballast Water and Sediment Management Plan under the Convention. All ships will be required to carry a Ballast Water Record Book and to follow certain ballast water management protocols. Existing ships will be obliged to do the same, but only after a period of transition.
In the particular case of our ship, as it is constantly 75% loaded, the ballast water is present in limited quantities and subject to the regulations according to the pre-established itinerary: the Shanghai-Rotterdam route crosses oceans and seas with completely different ecosystems, which is why port after port the water must be treated and discharged controlled by the authorities, in order to prevent and respect the rules of the regulations.

3. Voyage Plan

In recent years, a new route was opened between China and the Netherlands, enabling shipping cargo through the Arctic. This route significantly cut down the shipping time and made sea freight even more beneficial. Although we won’t be studying this new route, it’s important to remind how in the last years the shipping industry has evolved and upgraded.
Shipping goods by sea is the most affordable out of the available options for importing and exporting goods, but it also takes the longest. Still, many importers choose sea freight. There is a wide range of ports and companies that operate various routes.
There are plenty of seaports in China, and a lot belong to the largest in the world. Some of the most essential are located in Shanghai, Shenzhen, Ningbo, and Qingdao.

The Netherlands, on the other hand, is home to the largest port in Europe: the port of Rotterdam. A good deal of products shipped to the old continent would likely go through this port anyway. It is convenient to ship by sea as there are major seaports on both sides and between them as well.

The Munich Maersk, as we described before, is a very voluminous container ship of approximately 20000 TEUs. Just like her “sisters” which include vessels such as the Madrid, Moscow, Milan, Manchester etc. type of ships, the routes are studied beforehand. Therefore, each one of these ships will have a specific route that is defined by Maersk itself.
In our case, the ship we studied will do a well-known, and consistent through the years, voyage. From the first port of China in Shanghai it will leave for it’s second stop in Shenzhen. After that, a long trip will lead it to the port of Sines in Portugal and finally in Rotterdam. The resume of this trip can be identified here below:

Navigation Route
Yangshan Guadong Terminal (Shanghai) - Yantian International Container Terminals (Shenzhen) - Container Terminal XXI (Sines) - APM Terminal Maasvlakte II (Rotterdam)

This route is very peculiar and will find through its route several locations where the vessel will have to transit that will have to be analysed thoroughly studied to ensure the voyage plan and the time of navigation will be correctly studied. The most important ones are two crucial areas: the Malacca Strait and the Suez Canal.

The Malacca Strait

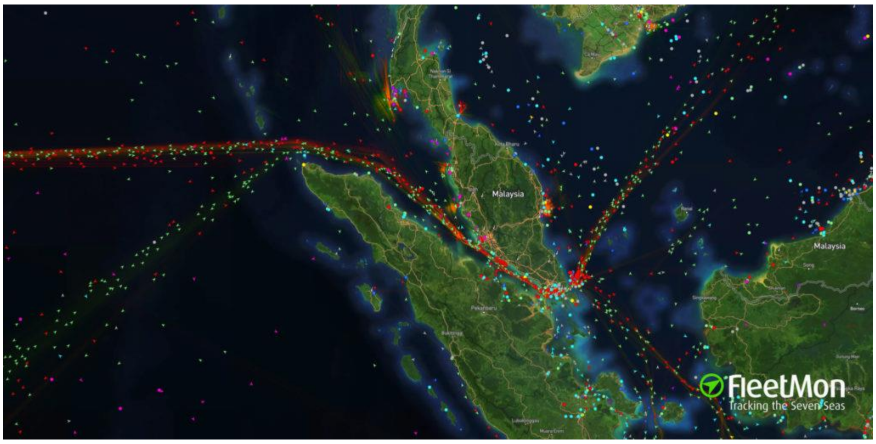

Figure 2: Malacca Strait from a satellite view, FleetMon.

Sandwiched between Malaysia and the Indonesian island of Sumatra, the Malacca Strait serves as the main shipping route connecting the Indian Ocean and the Pacific Ocean, making it one of the most important shipping lanes in the world.

It is the busiest strait in the world, with some 100,000 vessels plying annually through it. An estimated 25% of the world's trade passes through this narrow strait, making it important economically, as well as politically.

If the Strait of Malacca were blocked, nearly half of the world's shipping fleet would be required to reroute around the Indonesian archipelago, such as through the Lombok Strait between the Indonesian islands of Bali and Lombok or through the Sunda Strait between the Indonesian islands of Java and Sumatra. Rerouting would tie up global shipping capacity, add to shipping costs, and potentially affect energy prices.

The depths in the Strait of Malacca are generally irregular and a considerable portion of the bottom is of sand wave formation. Depths in the main shipping channels vary from 14.9 to over 100m. Deep-draft vessels should, therefore, take particular note of the latest depths over shoals lying in or near the fairway

The Suez Canal

Figure 3: Suez Canal as seen from its entrance showing container ships crossing.

Suez Canal, Arabic Qanāt al-Suways, sea-level waterway running north-south across the Isthmus of Suez in Egypt to connect the Mediterranean and the Red Seas. The canal separates the African continent from Asia, and it provides the shortest maritime route between Europe and the lands lying around the Indian and western Pacific oceans. It is one of the world's most heavily used shipping lanes. The canal extends 193 km (120 miles) between Port Said (Būr Saʿīd) in the north and Suez in the south, with dredged approach channels north of Port Said, into the Mediterranean, and south of Suez. The canal does not take the shortest route across the isthmus, which is only 121 km (75 miles). The Suez Canal is an open cut, without locks, and, though extensive straight lengths occur, there are eight major bends.

In 2018 there were 18,174 transits of the Suez Canal, according to the Suez Canal Authority. That number rose to 18,880 in 2019, or about 51.5 per day. Container ships and tankers made the largest percentage of transits during those years.

Today, an average of 50 ships navigate the canal daily, carrying more than 300 million tons of goods per year. In 2014, the Egyptian government oversaw at $8 billion expansion project that widened the Suez from 61 meters to 312 meters for a 21-mile distance. The project took one year to complete and, as a result, the canal can accommodate ships to pass both directions simultaneously. Despite the widened route, in March 2021, an enormous container ship heading from China became stuck in the canal and blocked more than 100 ships at each end of the vital shipping artery. The incident disrupted global trade for nearly a week.

SECA / ECA: (Sulphur) Emissions Control Area

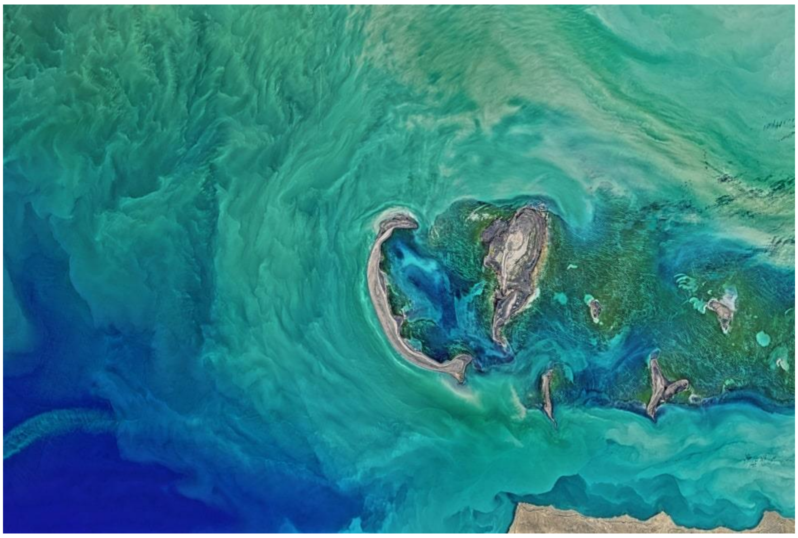

Figure 4: pollution displayed in an archipelago of the Indian Ocean

Emission Control Areas (ECAs), or Sulphur Emission Control Areas (SECAs), are sea areas in which stricter controls were established to minimize airborne emissions from ships as defined by Annex VI[1] of the 1997 MARPOL Protocol.

The emissions specifically include SOx, NOx, ODSs and VOCs[2] and the regulations came into effect in May 2005.[3][4] Annex VI contains provisions for two sets of emission and fuel quality requirements regarding SOx and PM, or NOx, a global requirement and more stringent controls in special Emission Control Areas (ECA).[5] The regulations stems from concerns about "local and global air pollution and environmental problems" in regard to the shipping industry's contribution. In July 2010, a revised more stringent Annex VI was enforced in the Emission Control Areas with significantly lowered emission limits.[2]

As of 2011 there were four existing ECAs: the Baltic Sea, the North Sea,[4] the North American ECA, including most of US[6] and Canadian coast[5] and the US Caribbean ECA.[5]

In our study case, the ECAs that we want to consider for the voyage of the vessel is the Baltic and North Sea ECAs. Further information regarding the propulsion in this area will be provided in our voyage calculations. Reducing any kind of harmful emission for the environment is one of the main objectives of nowadays in engineers and must be pursued by all means.

Therefore, for our voyage consideration in order to achieve an objective and clear calculation of voyage time and costs we will have to make several assumptions and considerations to get the closest possible to a condition that somewhat represent a case of reality. We want to start by identifying the ports that we must consider for our voyage, to understand the total distance of your voyage and consequently the total time and costs.

To calculate the average distance between these ports we will use the Haversine formula which determines the great-circle distance between two points on a sphere given their longitudes and latitudes. Important in navigation, it is a special case of a more general formula in spherical trigonometry, the law of haversines, that relates the sides and angles of spherical triangles. The formula can be explicitly described as:

where:

$$\begin{aligned} d &= 2r \arcsin\left(\sqrt{\operatorname{hav}(\varphi_2 - \varphi_1) + \cos(\varphi_1)\cos(\varphi_2)\operatorname{hav}(\lambda_2 - \lambda_1)}\right) \\ &= 2r \arcsin\left(\sqrt{\sin^2\left(\frac{\varphi_2 - \varphi_1}{2}\right) + \cos(\varphi_1)\cos(\varphi_2)\sin^2\left(\frac{\lambda_2 - \lambda_1}{2}\right)}\right) \end{aligned}$$

- φ_1, φ_2 are the latitude of point 1 and latitude of point 2 (in radians),
- λ_1, λ_2 are the longitude of point 1 and longitude of point 2 (in radians).

Figure 5: Haversine formula.

Using this formula above we will obtain the distance between each port. For this the latitude and longitude (in radians) for each port has been found:

- Yangshan Guadong Terminal (Shanghai): 0.168π, 0.671π
- Yantian International Container Terminals (Shenzhen): 0.125π, 0.635π
- Container Terminal XXI (Sines): 0.211π, -0.049π
- APM Terminal Maasvlakte II (Rotterdam): 0.289π, 0.022π

After using the formula, we obtained the distances in nautical miles between each port:

Shanghai – Shenzhen	Shenzhen – Sines	Sines – Rotterdam	[port-to-port]
1124	**13813**	**2113**	**[nautical miles]**

Table 1: Distances port to port.

The total nautical miles of the voyage (one way) are 17046 nautical miles. It's important to make a consideration regarding our result: the Haversine formula is very precise when it comes to considering several locations scattered around the globe because it considers the effective curvature of the Earth. However, it doesn't consider the distance between each of these locations don't go through water ways and therefore lacks precision when it calculates the distance between two locations on the planet that are far away, such as Shenzhen and Sines. To obtain a better approximation of this distance we could consider some auxiliary locations between each port to better calculate the actual distance of the voyage through water of the Munich Maersk. Therefore, we decided to round up the total voyage distance up to 18000 nautical miles.

We can now consider each phase of our voyage for the container vessel.
Starting from the Yangshan Guadong Terminal in Shanghai, our vessel will be loaded up to 75% of her entire capacity. After checking that everything's in its right place, our voyage starts.

Before leaving for open waters, the Munich will go through a short distance in which it's speed will be decreased in order to leave the port (not more than 12 knots), maintain all eventual necessary safety requirements and reduce the number of harmful SOx and NOx releases near the land waterways by introducing either the exhaust gas scrubbers available or the marine diesel in this area. This consideration will be done for each time we will have to approach one of the ports and when we will enter the ECA in the North Sea. This said as our voyage starts we will have roughly 5/6 nautical miles of restricted condition before leaving for open waters. After thoroughly checking the ships technical characteristics, it was possible to assume that the average speed in open waters is roughly 18,4 knots: this type of consideration was made by analysing the technical sheets available on internet of the Madrid Maersk, another EEE Mark container ship which uses pretty much the same propulsion and auxiliary machines as the Munich Maersk. This speed will be the one we will mostly travel with throughout this voyage.

Next considerations will be done regarding the passage through the Malacca Strait and the Suez Canal.

Malacca Strait: vessels navigating in the Straits of Malacca and Singapore are required to comply with the 'Rules For Vessels Navigating Through the Straits of Malacca and Singapore' adopted by the IMO Maritime Safety Committee 69 in 1998, in accordance with the provision of Resolution A.858(20). We won't include every type of regulation, but the most important ones are, as far as it is safe and practicable, to proceed at speed of not more than 12 knots for the entire length of the strait (580 nautical miles).
Suez Canal: as it was expectable, the Suez Canal Authority issued an entire rule of navigation for the crossing of the canal. After the March of 2021 obstruction by the grounding of the Ever Given container ship, several regulations have been modified and enforced to ensure a safe and stable traffic through the waterway. We won't be considering all the rules of navigation but in a real study case we will have to perform very strict considerations and calculations in order to ensure a safe passage of our ship, which is as large as the one that got grounded less than a year ago. For this project, we will consider an average of 15 hours for the waiting time and the transit of our ship.

Locations	Distance [miles]	Speed [kn]	Time [days]	Waiting time [days]	Queuing time [days]	Total navigation time [days]
Shanghai (Port approach)	6	12	0.02	0.042	0.25	
Shanghai - Shenzen	1124	18	2.60			
Shenzhen (Port arrival and departure)	12	12	0.04	0.042	0.25	
Malacca Strait	580	12	2.01	0.042	0.25	
Suez Canal	120	12	0.63	0.042	0.25	
Shenzhen - Sines	13813	18	31.97			44
Sines (Port arrival and departure)	12	12	0.04	0.042	0.25	
Sines - Rotterdam	2113	18	4.89			
Rotterdam (Port arrival and departure)	12	12	0.04	0.042	0.25	
Total			42.25	0.250	1.5	

Table 2: Calculation of the total navigation time.

Using the formula from the slides to calculate the voyage time:

$$Tn = \frac{D}{24 \times V}$$

where Tn is the voyage time in days, D the distance in nautical miles and V the travelling speed, we will obtain this table.

Next, we want to make a few considerations regarding service times. The main objective of our container ships is to travel with goods, unload them, load another amount of cargo and then sail again for the next port up to the last one. It's obvious how this process needs to be optimized. For this project we will consider that our ship, due to its size and importance in the market, will always arrive at its scheduled time without waiting time. However, we must consider the service time in order to process the loading and unloading of material. This time can be calculated using the formula available from the slides:

$$Ts = 2 \times \frac{CDW}{Cll} \times c$$

where CDW is the cargo deadweight, C_{LL} is the loading/unloading rate, c the fraction of deadweight that is loaded/unloaded.
In a condition close to reality a container ship such as the Munich Maersk is loaded not only with TEU containers but also with FEUs; we will consider the vessel loaded with 50% TEUs and 50% TEUs. If we consider that our ship will always travel with 75% of its capacity (cargo deadweight which means roughly 15000 containers), we consider that roughly 30% will be unloaded and loaded in Shenzhen, 30% in Sines and the total amount in Rotterdam. The loading and unloading ratio will depend on the level of automation of each port. For example, since the Shanghai Container Terminal is extremely efficient, we considered that the operators will use up to 6 gantry cranes per ship at the same time to perform this operation.

Locations	Unload/load rate [container/h]	Fraction of CDW	Time [hours]	Time [days]
Shanghai	240	0.75	48.7	2.0
Shenzhen	240	0.3	38.9	1.6
Sines	120	0.3	77.9	3.2
Rotterdam	210	0.75	55.6	2.3
Total				9.2

Table 3: Calculation of service time.

At this point it's possible to obtain the total amount of days, including navigation and loading/unloading conditions, for our vessel throughout its voyage. Rounding up the amount we will obtain roughly 53 days of voyage.

4. Voyage costs

This chapter has the important and necessary objective of studying and understanding the costs that are included in the voyage of the Munich Maersk to Rotterdam. First of all, we want to calculate the ship's fuel consumption considering its intermediary trips and analysing the conditions in which it approaches the port and goes through the Malacca Strait and Suez Canal. The formula we will use is:

$$Qf = q \times P \times Tv$$

where Qf is the amount of fuel used for a specific voyage, q is the SFOC, P is the propulsion power (MCO) and Tv the duration of the voyage. As we discussed before, through the straits and approaching the coastline (and the port) the ship will change its fuel to a Marine Diesel (MGO) in order to reduce the emissions of SOx and NOx. In the table below each voyage has been considered and therefore each consumption.

Locations	Distance	Speed	Time	Qfuel (Heavy Fuel Oil)	Qfuel (Marine Diesel)
Shanghai (Port approach)	6	12	0.5	/	3
Shanghai - Shenzen	1124	18	62.44	313	/
Shenzhen (Port arrival and departure)	12	12	1	/	5
Malacca Strait	580	12	48.33	/	2905
Suez Canal	120	12	10	/	50
Shenzhen - Sines	13813	18	767.4	3844	/
Sines (Port arrival and departure)	12	12	1	/	5
Sines - Rotterdam	2113	18	117.4	588	/
Rotterdam (Port arrival and departure)	12	12	1	/	5
Total			1009	4745	2973

Table 4: Calculation for fuel consumption for Heavy Fuel Oil and Marine Diesel.

After finding out the number of consumptions (in tons) for each type of fuel, the next step is to calculate the costs necessary to cover the fuel expenses. In this case, we used values of prices of fuel correlated to each port in which the ship refuels. Information regarding the US$/t has been retrieved through sites that gave the price per ton updated to the last changes in the market.

Bunkers					
Type	Location	Quantity [t]	Price [US$/t]	Cost [US$]	Total [US$]
Heavy Fuel Oil	Shanghai - Shenzen	313	433	135440	9789568
	Shenzhen - Sines	3844	433	1664441	
	Sines - Rotterdam	588	433	254613	
	Rotterdam (refuel)	18162	525	9534956	
Marine Diesel	Shanghai (Port)	3	801	2006	253453
	Shenzhen (Port)	5	801	4012	
	Malacca Strait	242	682	165119	
	Suez Canal	50	771	38621	
	Sines (Port)	5	719	3602	
	Rotterdam (Port)	60	667	40093	
					10043021

Table 5: Calculations for total price of fuels, compared to day to day market prices.

As for the other expenses that need to be calculated we have to consider of course the costs for the cargo handling. For this calculations, the tables and PDFs available on the sites of the port authorities gave us the information to obtain the table below, representing the cargo handling costs for each operation and each port:

Cargo Handling Costs					
Type	Port	Quantity [TEUs]	Price [USD/container]	Cost [US$]	**Total [US$]**
Loading	Shanghai	15000	350	5250000	**7815000**
	Shenzhen	4500	350	1575000	**5940000**
	Sines	4500	220	990000	**13755000.0**
	Rotterdam	0	225	0	
Unloading	Shanghai	0	350	0	
	Shenzhen	4500	350	1575000	
	Sines	4500	220	990000	
	Rotterdam	15000	225	3375000	

Table 6: Calculations for cargo handling costs

The other expenses, such as canal fees, disbursements for loading and unloading, tug and pilot fees have been obtained and portrayed in a table:

Other Expenses		
Loading Port Disbursements	Shanghai	27359 [US$]
	Shenzhen	
	Sines	
	Rotterdam	
Dischargin Port Disbursements [US$]	Shanghai	39164 [US$]
	Shenzhen	
	Sines	
	Rotterdam	
Bunkering Port Disbursements	Shanghai	18112 [US$]
	Shenzhen	
	Sines	
	Rotterdam	
Canal dues (all fees included)	Suez	835224 [US$]
Insurance Premium	All voyage	150000 [US$]
Tug and Pilotage costs	Average for all ports	240000 [US$]
Other expenses (port agency, taxes, mooring/unmooring)	Average for all ports	639200 [US$]
Total Voyage Expenses ($)		**24911857 [US$]**

Table 7: Other expenses available in our voyage study.

5. Operating costs

Operating costs are the expenses aimed at maintaining the activity of the ship's operations. In this case the following factors are considered as operational costs:

- Manning
- Stores and consumables
- Maintenance
- Insurance
- Administration

As already mentioned, several of these factors will be paid by the owner in the 44 days of cruise provided by the service of the ship.

Manning

For the cost of manning, we start by calculating the number of crew members present.
The following formula provides for the assignment of K1, K2 and K3 values in relation to the nationality and origin of the crew and the type of ship on which they embark. The formula is completed by the cubic number CB and the power of the engine with which the ship sails.

$$N = K1 + K2 \cdot CN/1000 + K3 \cdot HP^{1/2}$$

The
manning cost can then be calculated using the following formula, which relates the amount of crew, with USD exchange rate, and the K value attributed to the nationality and type of ship on which they board.

$$\$Ct = K \cdot N^{0.95}$$

Type	Constant	Value	Cost [US$]
Manning Cost	N [people]	28	900707,4
	Type	European B	
	K	38000	

Table 8: Manning costs.

Stores and consumables

Lubricating oil as well as crew provisions are costs given by the following equation:

$$\$Cal = K1 \cdot N + K2 \cdot CN^{0.25} + K3 \cdot HP^{0.7}$$

With K1=3500, N being the number of crew, K2= 4000 (dry cargo ship), K3=200 (2Stroke diesel engine), CN (cubic number) = LOA×B×D and HP (propulsion power) = MCO, it is possible to obtain the cost over the voyage. These values remain fixed over the voyage and in case years.

Stores and consumables	K1	3500	464845,8
	K2	4000	
	K3	200	
	N [crew]	28	
	CN	343791,55	
	HP [KW]	29640	

Table 9: Store and consumable costs.

Insurance

The cost of insurance is annual and given by:

$$\$Cs = K1 \, . \, \$V + K2 \, . \, GT$$

Being the container ship a dry cargo ship, of Dwt > 80 000, K1 takes a value of 0.006 and K2 of 2.50. In table of characteristics it is possible to obtain the other values: V (market value of the ship) and GT.
With this, and always taking into account the number of days occupied by the owner and the client, we have an annual insurance cost of:

Insurance and P&I	K1	0,006	649715,0
	K2	2,5	
	V [US$]	19000000	
	GT [m3]	214286	

Table 10: Malacca Strait from a satellite view, FleetMon.

Maintenance

The ship will have mandatory periodic maintenance and maintenance as well as occasional. For the calculation of the occasional maintenance the respective equation is applied, where K1is fixed and K2 depends on the type of engine and stroke, at the end P is the initial cost of the ship:

$$\$Cmr = K1 \cdot \$P + K2 \cdot HP^{0.66}$$

Insurance and P&I	K1	0,006	649715,0
	K2	2,5	
	V [US$]	19000000	
	GT [m3]	214286	

Table 11: Insurance costs.

To spot the maintenance, the following equation is given:
Since K1= 0.006 and the ship is powered by 4-stroke diesel, the value of K2 takes the value of 2.5.
The maintenance costs are summed. Since the maintenance costs increase by 5% per year.

PM - Periodic maintenance costs can be calculated as a fraction of the ship's initial cost like:

$$\$Cd = K1 \cdot \$P$$

Periodic maintenance	K1	0,006	114000,0
	P [US$]	19000000	

Table 12: Maintenance costs.

Where K1 depends by the nature of the ship and P is the price of the new ship.

Administration:

Where depends by the type of cargo:

	US$/Ano
Navios Tanques	150.000
Navios de Carga Seca	120.000
Navios Costeiros	70.000

Administration Costs	-	-	120000,0

Table 13: Administration costs.

As the work concerns the financial study of the shipowner, it is important to understand the total costs that the shipowner will pay at the end of the voyage. Summing up all the instalments, the ship will have a Total Operating Cost of:

Total Operating Costs/year	**2409660,2**
TOTAL OPERATING COSTS/DAY	**6693,5**
TOTAL OPERATING COSTS/VOYAGE	**282815,9**

Table 14: Summary and calculation of the total operating costs.

Divided also in relationship with the cost per day and at the and the cost of the total voyage.

6. Capital Costs

The capital costs include the expenses incurred in obtaining the ship, such as purchase costs paid to a shipbuilder or former owner, mortgage repayments, leasing charges, other loan charges, initial registration fees, taxes, and any bareboat charter hiring. Are also defined like fixed debt payment (interest and capital), equity dividends.

Capital costs arise from the initial purchase price (newbuilding price), in our case the initial price of the ship is 190mln $, also the periodic cash re-payments to banks or equity investors, plus interest, that permit to analyze the revenues. Revenue is an important value of cash received from the sale of the vessel, related to the initial investment that identify the newbuilding price plus a margin of 5%-15% (Ka) for shipowner expenses during construction.

Newbuilding price is defined by: steel, equipment, machinery, special equipment and materials, labour, plus a shipyard margin (Kb).

The equation used for the total calculation of capital costs is:

$$\$V = \$P \,.\, (1 + Ka)$$

$$\$P = (\$A + \$E + \$M + \$X) \,.\, (1 + Kb)$$

where it’s possible to obtain the following tables related to the Capital Costs obtained in relation of the annuity of the voyage.

Capital Costs	
Newbuilding price [US$]	19000000
Interest Margin [%]	9
Life Time [years]	4
Capital Costs [US$/day]	16290,8
Total Capital Costs	**700506,4**

Table 15: Summary and sum of total capital costs.

Annuity of The voyage		
Ship Cost	19000000	USD
Rate	0,09	
Service Time	4	years
CR	0,309	
A year 2021	5864704,6	USD
A day	16290,8	USD
A voyage	688326,0	USD

8. Required freight rate for break-even

Required Freight Rate

The required freight rate is the value to be charged in order to obtain a Net Present Value (NPV) at the end of the project. For this particular case, it corresponds to the price to be charged for each trip. To calculate these values, we iterated through a 7% increase in each iteration until a positive NPV was obtained:

Voyage Comparisons					
Cargo [TEU]	Rate [US$/TEU]	Gross Freigth [US$]	Comission [%]	Freight [US$]	
15000,0	9 000,0	135000000,0	7	125550000,0	
			Voyage Surplus	9450000,0	
Gross voy surplus	Gross Daily	Running Costs [US$]	Freight [US$]	Net Flux [US$]	Net Flux Daily [US$]
		2409660,2	125550000,0	123140339,8	2763,5

Table 16: Comparisons with freight rate, commission and net flux.

Then, through an interpolation between the revenue and NPV values of the last two iterations, it was concluded that to obtain a zero NPV (break-even), the prices of the trips will have to be increased by 98,216 %. The prices of each type of corresponding to the required freight rate can be seen in following table:

Voyage Comparisons					
Cargo [TEU]	Rate [US$/TEU]	Gross Freigth [US$]	Comission [%]	Freight [US$]	
15000,0	9 000,0	135000000,0	98,216	2408400,0	
			Voyage Surplus	132591600,0	
Gross voy surplus	Gross Daily	Running Costs [US$]	Freight [US$]	Net Flux [US$]	Net Flux Daily [US$]
		2409660,2	2408400,0	-1260,2	0,0

Table 17: calculations to reach break-even.

The freight rate for break-even is calculated and verified.

9. Summary and conclusions

		[US$]	[%]	[US$]
Capital costs	Capital costs	16453755	38	16453755
Operating costs	Crewing/manning	900707	2	2409660
	Stores and consumables	464846	1	
	Regular maintenance and repairs	160392	0	
	Insurance	649715	1	
	Administration	120000	0	
	Periodic maintenance and repairs	114000	0	
Voyage costs	Fuel costs main propulsion	9789568	22	24677221
	Fuel costs auxiliary propulsion	253453	1	
	Port charges	639200	1	
	Tuggage fees	240000	1	
	Pilotage fees		0	
	Canal dues	835,224.84	2	
	Cargo handling	13755000	32	
Total costs		43540635	100	43540635

From our work we can deduce the reality and impact of the cost of operating a VLCS under the full scope of the ship owner's responsibility.
In addition to planning the route and the costs related to it, we have analyzed the costs related to the operations that constantly coexist in the Asian-European route for a vessel with these characteristics, and the related capital costs existing in the physicality of it.
Finally, we analysed the time charter rate assumed by the requests and its related costs, concluding with a financial-economic aspect related to break even and its optimizations.

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