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Deliverable n. 3.1

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Abstract

The aim of Deliverable 3.1 is to specify design and operational requirements for baseline vessels that will be used during the project. This also includes the determination of operational routes. The selected ship types, tankers and RoPax, are considered to be the most safety critical. Specifically, a VLCC tanker and a large RoPax ship have been selected based on market statistics, demand and design practices. The other two smaller vessels, AFRAMAX and Handy-Size RoPax, have been selected to enhance the range of the baseline vessels.

Technical data which have not been outlined in this report will be made available to the consortium members on their request.
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1. Executive Summary

This report describes the process of selecting the baseline designs to be used over the course of the project. Firstly, we have defined the selection of ship types as described in the DoW, namely RoPax and Tanker ships. According to accident statistics, these ship categories are regarded to be the most safety critical. That is, they clearly stand out when comparing historical data of operational and occupational accidents for different ship types. IMO has also recognized the need of decreasing the associated risk of Tanker and Ropax vessels that contribute greatly to the societal and environmental risks.

Further to defining the types of vessels to work with, the report outlines the various sub-categories of Tanker and RoPax vessels that are nowadays prominent in the market. Identifying the latest market trends, in terms of vessel sizes and in terms of operations is deemed necessary in order to specify correctly the baseline designs.

Specific designs within these two categories have been selected and represented in two databases, with data coming from:
- fleet databases provided by the ship operators, AMC and TLG, and
- the bridge simulation database available with HSW.
- NAP design office archive.

Additionally, market statistics and trends were used to narrow down the options and confirm their validity.

For the tanker market VLCC vessels are considered to have the most potential impact in terms of the overall risk and for the Ropax market, vessels between 180m to 210m. Therefore a VLCC modern design has been selected as the first baseline and a modern large Ropax as the second baseline design. However two additional smaller vessels for each ship type have also been selected in order to capture the effect of varying global design factors between different ship sizes; an AFRAMAX and a Handy-Size RoPax vessel. Following the selection of the baseline designs a technical specification is given in order to define all aspects and assumptions that might be used in the experiments (WP4) and design optimization (WP6). The report is divided into two main parts the Tanker Vessels Analysis and the Ropax Vessel analysis, chapter 3 and chapter 4. These chapters provide respectively information on the potential impact that the selected vessels might have following an accident and also outline their technical specifications. The specifications are limited to what is needed for the purpose of this project, linking global design factors to the human performance onboard. Further to that, general arrangement drawings are provided for each baseline. Many of the technical data and drawings related to these baseline vessels are not included in the report; however they are available upon request for the partners of FAROS that need to carry out further studies (motion, vibration, risk identification etc.).

Indicative available data for the baseline designs:
Lines Plans, Machinery Arrangements, Deck Layouts, Hydrostatics, Loading Conditions, Sea Trials, Vibration Reports and further drawings.
For both ship types specific routes have been defined, taking into consideration real market sea routes, sea state data and level of difficulty in terms of operations (traffic, intermediate ports etc.). The selected routes take also into account the available data of the bridge simulator that will be utilized later on the project.

The report concludes with identification of various uncertainties that shall be taken into account prior to the design optimization process in (WP6). Uncertainties are divided in two categories, design uncertainties and operational uncertainties. Based on the vessel’s dataset, the ranges and the frequencies of general particulars are described. Some operational uncertainties as speed can also be defined by the dataset, however data related sea state distributions need to taken by the indicated literature. Lastly uncertainties related to new regulations, market trends and fuel prices are described.
2. SELECTION OF SHIP TYPES

FAROS project will focus on specific ship types, which are considered as safety critical. Based on the accumulated research, industrial and operational experience of the consortium partners, Tankers and Ro-Ro Passenger Ships are denoted to have strong links with occupational accidents and the overall societal risk. Statistics on personal and ship-level accident frequencies further contribute towards this selection. See Fig. 1 and Fig. 2 below.

Fig. 1: Distribution of the personal risk across different ship types [2]

![Distribution of personal risk](image)

Fig. 2: Distribution of the societal risk across different ship types [SAFEDOR IP, FP6]

![Distribution of societal risk](image)

The two identified ship types encompass subcategories of ships varying in size and design specifications, implied by different operational conditions such as physical restrictions in infrastructure and passages. Below are the various types and their associated sizes. Taking into consideration the needs of project FAROS, we have to identify the most representative ship size for our baseline designs, reflecting important economic, environmental and relevant societal impacts. The identification of the most appropriate types of Tanker and Ropax ships will then lead us to proposing relevant routes, which not only fulfill operational criteria of the selected ships, but are also of interest for their prominent effect on the crew performance.
2.1 Selected Ship Types and their Size Categories

<table>
<thead>
<tr>
<th>Tanker Ships:</th>
<th>Ropax Ships:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panamax Tanker, ~ 45,000 DWT</td>
<td>Ropax, ~ 120-140m length</td>
</tr>
<tr>
<td>Aframax Tanker, ~ 100,000 DWT</td>
<td>Ropax, ~ 140-180m length</td>
</tr>
<tr>
<td>Suezmax Tanker, ~ 150,000 DWT</td>
<td>Ropax, ~ 180-200m length</td>
</tr>
<tr>
<td>VLCC Tanker, ~ 300,000 DWT</td>
<td>Cruise Ropax, Over 210m</td>
</tr>
</tbody>
</table>

To fulfil their missions, both Tanker and Ropax vessels must operate safely and must maintain a high level of environmental performance. Many European operators recognize the need to build and operate this kind of ships to high standards. Both categories are engaged in national and international seaborne trades.

2.2 Transported Commodities: Oil

Crude oil is the largest individual commodity traded by sea. The demand for crude oil grew rapidly during the 1960s. At that time, oil was cheap and the economies of Western Europe and Japan switched from coal to oil as their primary energy source (Stopford, 2009). The major destinations of crude oil shipments are the refineries of eastern Asia, Western and Mediterranean Europe as well as North America. Nowadays the European Union, the United States, China and Japan are the major importers of crude oil, while the primary source of supply to serve this demand is the Middle East, the Caribbean (Venezuela, Gulf of Mexico) and lately growing sources of Russia and West Africa (Nigeria).

Fig. 3: Major Producers of Oil Petroleum [USCG, 2011].

Additional to those primary sources, Asian oilfields and North Sea offshore fields generated significant crude oil supply. Combining the demand and supply of crude oil within the context of geographical proximity, we have main crude oil trade patterns as below:
• Middle East – North America
• Caribbean – North America
• West Africa – North America
• Russia – European Union
• Middle East – Asia

Moreover, we shall not exclude the trade of refined products, shipped in smaller tankers and on shorter voyages such as from Caribbean refineries to the US Gulf coast and from South East Asian refineries to East Asian markets, for instance. The tonnage of ocean borne refined products trade is estimated to be over a quarter of the tonnage of crude oil shipments (Fleming K. Douglas, 2002).

**Fig. 4: World Trade flow of Oil according to BP. [www.bp.com]**

**Table 1: Millions of Oil Tonnes Loaded for Sea Transport.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>1442</td>
</tr>
<tr>
<td>1980</td>
<td>1871</td>
</tr>
<tr>
<td>1990</td>
<td>1755</td>
</tr>
<tr>
<td>2000</td>
<td>2163</td>
</tr>
<tr>
<td>2010</td>
<td>2010</td>
</tr>
</tbody>
</table>

Tankers transport crude oil by all four types of charter agreements: the voyage charter, the time charter, the bareboat charter, and contract of affreightment. In a voyage charter, the charterer rents the vessel from the loading port to the discharge port. In a time charter, the vessel is hired for a set period of time, to perform voyages as the charterer directs. In a bareboat charter, the charterer acts as the ship’s operator and manager, taking on responsibilities such as providing the crew and maintaining the vessel. Finally, in a contract of affreightment, or COA, the charterer specifies a total volume of cargo to be carried in a specific time period and in specific sizes.
2.3 Typical Tanker Operations

The utilization of the Tanker fleet is quite complex and it is directly connected to the market. Nowadays, operators more often consider slow steaming in order to balance market. In the depressed market, minimizing marginal cost by slow-steaming is more profitable than increasing revenue by operating vessels at full speeds. However, the operating condition of the vessel determines also the ranges of the operating speed. The average voyage time distribution, based on a statistical analysis of voyage records is displayed in the chart below, relevant to different tanker ship sizes [8].

![Voyage Time Distribution Chart]

Fig. 5: Typical Voyage Time Distribution and Operating Speeds. [8]

2.4 Transported Commodities: Passengers / Vehicles

The demand of ferry services is quite complex and fragmented. There are not many available sources for global statistics on ferry traffic. The figures on the table below from ShiPax indicate that the ferry industry is a very important on a global economy level, carrying almost 2 billion people and over 250 million cars, buses and trucks per year (Wijnolst, 2009).

<table>
<thead>
<tr>
<th>Region</th>
<th>Pax</th>
<th>Cars</th>
<th>Buses</th>
<th>Trailers</th>
<th>Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE &amp; Baltic</td>
<td>20%</td>
<td>46%</td>
<td>78%</td>
<td>55%</td>
<td>64%</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>26%</td>
<td>15%</td>
<td>12%</td>
<td>23%</td>
<td>12%</td>
</tr>
<tr>
<td>America</td>
<td>19%</td>
<td>36%</td>
<td>7%</td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>South East Asia</td>
<td>32%</td>
<td>1%</td>
<td>1%</td>
<td>13%</td>
<td>10%</td>
</tr>
<tr>
<td>All others</td>
<td>3%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>World (Million Units)</td>
<td>1681.9</td>
<td>225.2</td>
<td>0.7</td>
<td>36</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Table 2: Traffic volumes and regional distribution in the ferry market 2007. [ShiPax, 2008]
The main role of the ferry is the continuous transport of people and their associated baggage, vehicles etc. Ferry payloads range from passengers only to passenger plus their accompanying cars, trucks, trailers and trains. There are ferries that operate only night time with full passenger crew sleeping accommodations and others that operate a 24-hour service with limited sleeping facilities.

### 2.5 Typical Ropax Operations

The traffic demand for Ropax vessels changes seasonally and can affect their operations with regards to speed, standby time and routes. Usually Ropax vessels are engaged in three types of crossings, short distances, medium and long.

**Short Distances:** Depending on the route sailing time for short distances can be from 1 up to about 6 hours, such as Dover Straits and Southern Baltic crossings. Usually vessels in such routes travel in unprotected waters with some exceptions (Southern Baltic) and are subject to severe weather and sea conditions. The significant wave heights encountered on these short crossings have been found to range between 1.5 m to 3.0 m.

**Medium Distances:** Sailing time exceeds 6 hours and usually there is also a night crossings were most of the passenger have cabins. The significant wave height has been found to range from 1.5 m to 7+ m in the Atlantic exposed areas.

**Long Distances:** Vessels involved in longer routes usually surpass 180 m in length. Due to the competition with other means of transportation for longer routes (airlines) this type of vessel focus also in carrying freight vehicles and unaccompanied trailers. Due to their increased length usually such ships if modern sail in higher service speeds that the smaller ones. Sailing is in open sea with rough weather conditions and significant wave height of 1.5 to 8+ depending on the area.

<table>
<thead>
<tr>
<th>Routes</th>
<th>Short Distances (nm)</th>
<th>Medium Distances (nm)</th>
<th>Long Distances (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>English Channel</td>
<td>20-90</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Irish Sea</td>
<td>40-120</td>
<td>130-150</td>
<td>-</td>
</tr>
<tr>
<td>Baltic</td>
<td>50-120</td>
<td>280-480</td>
<td>600-800</td>
</tr>
<tr>
<td>North Sea</td>
<td>-</td>
<td>200-300</td>
<td>550-700</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>30-130</td>
<td>200-350</td>
<td>350-450</td>
</tr>
</tbody>
</table>

Table 3: Example of route distances for Ropax vessels. [Nautical Almanac, 2004]

Nowadays, the range of operational speeds for RoPax vessels is between 22 to 26 knots, depending on their trading requirements. In general, RoPax vessels require a range of operating speeds to be able to cope with their often tight schedule. The reserve speed can be estimated as 1.1 to 1.2 x the service speed. The average speed of these ships has increased over time; in 1983 the average speed was approximately 16 knots, whereas in 2003 the average speed increased to approximately 20 knots. The average speed is a major operational factor because of its relationship with the fuel consumption and the ship’s time schedule. This is also associated to the risk of encountering rough weather during the passage, where speed needs to be maintained and usual port delays where speed needs to be increased thus increasing again the fuel consumption. Typical speeds (knots) and fuel consumptions (t/day) vary with ship’s size and type of route as in table 4.
### 3. TANKER VESSELS ANALYSIS

The previous chapter discussed the initial selection of ship types for the purposes of FAROS project. The significance of the markets represented by the two ship types was outlined together with their typical operational profiles. This chapter focuses on the first ship type, Tankers and firstly reviews the potential impact coming from the operation of the most prominent tanker designs which are the VLCCs. Further it presents an outline specification of a VLCC tanker and a representative dataset for the selection of the main particulars. The chapter concludes with the presentation of an additional outline specification for a smaller type, an AFRAMAX tanker.

#### 3.1 Potential Impact: VLCC Tanker Fleet

Petroleum product and Crude Oil have been carried in ships for more than a century now. After the WWII, the rapid expansion of the world economy resulted in an increased demand from energy products and mainly oil. It was during that time that the trade pattern of long routes developed, mainly from the Persian Gulf to the major Western Consumers and Japan. The second closing of the Suez Canal in June 1967 as a result of the Six-Day War sent the tanker market into a three year boom. The owners were becoming very rich, and building bigger and bigger ships. In 1966, the first ship over 200,000 tons deadweight was delivered. (Devanney, 2006). Following a series of accidents, the tanker market has been gradually regulated in order to minimize accidents with big environmental and societal impact. In 1992 the amendment of Annex I of MARPOL introduced to the tanker market the double hull requirements with a phase-in period, however in 2001 after the Erica disaster and then 2003, the phase-out period of single hull vessels was accelerated with the revisions of Annex I.

**Market Preferred VLCC Sizes:**

200,000-310,000 DWT: Very Large Crude Carriers are designed for the carriage of crude oils on longer voyages. Vessels in the traditional 270,000 to 310,000 DWT range have a payload of about 2 million barrels. While size differ in accordance to the physical restrictions of the assigned routes. Port restrictions often involve limits on draft, beam and airdraft.

The VLCC fleet totalled 594 vessels at the end of 2011, only 12 of them are aged over 20 years old, in terms of deadweight, fully two thirds of the fleet is less than 10 years old. As the earnings across the board in the tanker market have been rather poor since 2009, the average scrapping age has fallen from previous times. During the period
2000-2005 the average age of demolished tankers in the size range from Aframax to VLCC was at 26 years and is now down at 21 years.

![Average Demolition Age, Crude Tanker Segment 2000-2011](image)

**Fig. 6: Average Demolition Age per Tanker Ship Type. [www.bimco.org]**

VLCC vessels have become more attractive the recent years due to a number of reasons, mainly their flexibility in the market, the lower shipbuilding prices and the economies of scale achieved through their size and operational envelope. The representative price of a new-building VLCC in 2005-2006 was around $120million while now it is estimated around $85million.

![Tanker Order Book 2012-2017](image)

**Fig. 7: Tanker Order Book 2012-2017 [BRS, http://www.brs-paris.com]**

At the moment there is considerable pressure on the Tanker Market spot rates that affects all types of tanker ships. This pressure comes mainly from the oversupply of tonnage and relatively weak demand. However it is expected that the old tonnage will be phased-out and the demand will pick up from developing countries as India and Brazil. Particularly for VLCC, owners are not very keen in scrapping and they prefer to utilize low freights for their older tonnage or even use them as floating storage or convert them to FPSO vessels.

Currently the average OPEX for modern VLCC is about $10,000, while the spot average voyage rates form the first semester of 2011 to the second quarter of 2012 fluctuate between $23,000 to $27,000 per day. The selected average rates representative for modern Vacs as our baseline design can be further used in the
progress of the project in order to calculate running costs and revenue for the selected routes.

![VLC Average Earnings Modern $/Day](image)

Fig. 8: VLCC Average Earnings [Clarkson Research].

**Expected Impact**
The total risk of operation for VLCCs is assumed to be the sum of individual risks that will be handled in this project as accident scenarios. Collision, Grounding, Flooding and Fire/Explosion are considered as the prominent accident scenarios. Looking into VLCCs the long term effect upon economics and social wellbeing is envisaged to be significant due to the following areas of impact.

**Crew Impact:** Having in mind that the frequency of an occupational accidents being 6.4/100 per ship-years [2], almost 64,000 seafarers each year are at risk of injury permanent disability and death. For each of the accident scenarios to be selected for the baseline design the expected number of fatalities can be models as the potential loss of life or serious injury per ship operational period. This can be estimated on the basis of the Average Crew number derived for modern VLCC, being 38 persons. VLCCs have the higher average of Crew number related to other tanker ship types.

**Environmental Impact:** The consequences to the environment for each identified scenario can be represented as oil pollution and destruction of natural areas, the CO2 impact of such ships can also be taken into account as environmental impact related to the operation of the vessel and not accident scenarios. VLCCs have the highest average tank size, thus the higher probability of oil outflow as well as the highest average in crude oil carried (except ULCCs) thus higher probability of creating substantial environmental pollution.

**Economic Impact:** The economic impact associated with accident scenarios can be connected to ship property loss and expected loss of human life. Other than that the economic impact coming from accident scenarios can also be linked to the environmental impact above. Fines for oil spillage pollution can be up to $25,000/tonne depending on the area and the circumstances.
3.2 VLCC Outline Specifications

The outline specification for the selected VLCC baseline is structured in 7 main topics from which we have selected the most prominent subtopics related to the crew and the human factors. The description of the topics is as per usual shipbuilding practice and the specifications are up to the latest regulations and technological standards for such ships. Only parts that are deemed necessary for the scope of the project are specified. The specification is structured as below:

1. General
2. Hull Structure
3. Ship’s Equipment and Outfit
4. Accommodation
5. Main Machinery Component
6. Automation System

3.2.1 General

The Vessel shall be designed as a single screw diesel engine direct driven “Crude Oil Tanker” (hereinafter called as the “Vessel”) with bulbous bow, transom stern and a continuous deck as shown on the General Arrangement (hereinafter called as the “G.A”)

All accommodation including Navigation, Bridge and Propulsion shall be located aft.

The Vessel shall have fore/aft peak tank, cargo oil tanks, water ballast tanks, fuel oil tanks and engine room as shown on the G.A.

The cargo area shall be constructed with double bottom and double hull, with five (5) triple cargo tanks, one (1) pair of slop tanks and six (6) pairs of segregated water ballast tanks. All Heavy fuel oil storage tanks shall be protected by double structure and the Pump room shall be protected by a void space arranged as shown on the G.A.

Intended cargoes: “Crude oil” having a flash point below 60 deg.C.

**General Particulars:**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all:</td>
<td>332.60 m</td>
</tr>
<tr>
<td>Length between perpendiculars:</td>
<td>320.00 m</td>
</tr>
<tr>
<td>Breadth moulded:</td>
<td>60.00 m</td>
</tr>
<tr>
<td>Depth moulded:</td>
<td>30.79 m</td>
</tr>
<tr>
<td>Design draft moulded:</td>
<td>21.00 m</td>
</tr>
<tr>
<td>Scantling draft moulded:</td>
<td>22.60 m</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DWT (at even Keel &amp; (\rho=1.025))</strong></td>
<td></td>
</tr>
<tr>
<td>At Design Draft Moulded:</td>
<td>~ 290,000 MT</td>
</tr>
<tr>
<td>At Scantling Draft Moulded:</td>
<td>~ 320,000 MT</td>
</tr>
</tbody>
</table>
Main engine:

<table>
<thead>
<tr>
<th>Type:</th>
<th>Any Maker (NOx Tier II)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCR:</td>
<td>29,340 kW x 76 RPM (De-rated)</td>
</tr>
<tr>
<td>NCR (90% MCR):</td>
<td>26,406 kW</td>
</tr>
</tbody>
</table>

Vessel's speed:

Service speed at moulded design draft and at NCR power of main engine with 15% sea margin: \( \text{Appx. 16.20 knots} \)

Fuel oil consumption (F.O.C) of main engine:

Specific F.O.C at MCR based on diesel oil of LCV of 10,200 Kcal/Kg under ISO 3046/1-2002 reference conditions: \( \text{Appx. 169.6 G/kW.HR} \)

Daily F.O.C at NCR based on diesel oil of LCV of 10,200 Kcal/Kg: \( \text{Appx. 106.16 MT/day} \)

Max. Cruising range (LCV of 9,800 kcal/kg) based on above service speed and daily F.O.C with three (3) days reserve: \( \text{Appx. 26,200 N.M} \)

Classification Society:

The Vessel shall be constructed in accordance with the Rules of the Classification Society and under survey of the Classification Society (hereinafter called as the “Class”) and shall be distinguished in register by symbol of: Lloyd's Register Asia(LR) +100 A1 Double Hull Oil Tanker ESP, CSR, ShipRight (CM, ACS(B)), LI, *IWS, +LMC, UMS, with descriptive notes “Pt. Ht., ShipRight (BWMP(S), SCM)” or DNV or ABS with equivalent notations to LR.

Rules and Regulations:

The Vessel shall comply with following Rules and Regulations (edition and amendments being in force as compulsory as of the date of Contract signing):

- International Convention for Preventing Collision at Sea, 1972 and related amendments.
- U.S Coast Guard’s Regulations for Foreign Flag Vessels operating in navigable waters of U.S.A (CFR Title 33 - Part 155, 156, 157, 159 and 164, CFR Title 46-Part 32.53, 34.05 and 39 without certificate and inspection)
- Suez Canal Navigation and Tonnage Measurement of Ships.
• ILO Convention No. 92 and 133 for Crew Accommodation (except mosquito door, mosquito window and swimming pool).
• IACS Common Structural Rules for Double Hull Oil Tankers.
• IMO PSPC (Performance Standard for Protective Coating of dedicated seawater ballast tanks)
• Maritime Regulations of the registered country.

Guidelines and Recommendations:

Following Guidelines and Recommendations shall be complied with:

• International Electro-Technical Commission (IEC) Publication No.60092 for Electrical Installations in Ship
• OCIMF Recommendations for Oil Tanker Manifolds and Associated Equipment (Fourth Edition 1991) Except 4.4 (Loading Arm Jacks) and 11.3 (Operating Criteria for Lifting Equipment).
• OCIMF Ship to Ship Transfer Guide (Petroleum), 2005 (for fixed fitting only).
• OCIMF Recommendations for cargo equipment employed in the mooring of ships at Single Point Mooring, 2007 (for fixed fitting only).
• Section 4.6: Marking of Mooring Fittings
• Section 6.2: Wire Mooring Lines
• Section 7.8.1: Recommendation for Ship Designs
• ISO 6954: 1984(E)- “Mechanical vibration and shock - Guidelines for overall evaluation of vibration in merchant ships”.
• IMO Resolution A.468(XII)- “Code on Noise Levels on board ships, 1981”.

IMO Resolution A.868(20)- “Guidelines for the control and management of ships’ ballast water to minimize the transfer of harmful aquatic organisms and pathogens” (Sequential method only shall be applied and the ballast water treatment plant shall not be provided).

Registration:

The Vessel shall be registered under a European Flag.

3.2.2 Hull Structure

The hull shall be constructed with mild and higher tensile steel approved by the Class. Higher tensile steel having 32kg/mm² and/or 36kg/mm² minimum yield stress shall be used for the parts where the Builder considers necessary.

TMCP (Thermo-Mechanical Controlled Process) steel may be used at the Builder’s discretion.
Scantlings of cargo tank’s structural members shall be in compliance with the requirements of the Class based on the S.G. 1.025 cargo full or partial loading in each cargo tank (P/S) and slop tank (P/S) up to full dead weight.

Scantlings not specified by the Class shall be in accordance with the Builder’s practice. The main hull girder which forms strength deck, inner hull and double bottom in cargo tank space shall be of longitudinal frame system.

Fore & aft ends of the Vessel and engine room area shall be transverse and/or longitudinal frame system.

Longitudinal bulkheads in cargo tank space shall be of plane type with longitudinal stiffeners.

Transverse bulkheads between cargo tanks shall be of plane type with vertical stiffeners.

Inner bottom shall be flat from centre line to hopper end. All stiffeners in way of cargo tank space shall be arranged in the double bottom, inner hull and under deck.

Rudder shall be of stream lined, semi spade type with one (1) pintle. Rudder horn shall be of weldable cast steel or fabricated with rolled steel plate according to the Builder’s practice and rudder stock shall be of forged steel and coupled to the rudder.

Exposed front, rear and side walls of deckhouse shall be of flat plate type with vertical stiffeners and inner walls shall be of stiffened plane or corrugated type according to the Builder’s practice.

3.2.3 Ship’s equipment and outfit

Manoeuvring equipment:

Steering gear:
One (1) set, electro-hydraulic type
Pump unit: 4 sets x 50% capacity each

Anchoring and mooring equipment:

Windlass combined: Two (2) sets, hyd. motor driven (high pressure) type with non-mooring winch auto-tension, split drum, manual band brake.

Mooring winch: Hyd. motor driven (high pressure) type with non-autotension, split drum, manual band brake, 30MT x 15 m/min

Electro-hydraulic power unit (high pressure type) shall be provided for operation of windlass and mooring winches.
- Forward power unit (located in bosun store) shall be operated to run one (1) cable lifter or three (3) mooring drums at rated load, which is bigger, and connected to the two (2)
windlass, one (1) mooring winch on fwd mooring deck and two (2) mooring winches on fwd mid deck.

After power unit (located in steering gear room) shall be operated to run three (3) mooring drum at rated load and connected to the three (3) mooring winches on aft deck and two (2) mooring winches on aft mid deck.

Each power unit shall consist of three (3) / three (3) hydraulic pumps (at fwd/ aft). Each power unit shall not be interconnected.

Emergency towing: Emergency towing equipment for forward and aft deck in system accordance with IMO Resolution.

Two (2) bow stoppers shall be provided on forward deck in accordance with OCIMF Single Point Moorings, 2007.

Bower anchor: Two (2) sets, HHP stockless type (no spare anchor)

Anchor chain: GRADE 3, Kenter type joining shackle.

Mooring rope: Galvanized steel wire rope, 20 sets x 42mm dia. x 275m each (6 x 36 IWRC, MBL appx. 115 ton

Cargo equipment and outfitting:

Cargo hose handling:

Two (2) sets, 20MT SWL, 5.0m outreach from the Vessel's crane extreme breadth, electro-hydraulic cylinder luffing, single jib type. Commonly used for Suez mooring boat handling.

Provision and machinery:

Two (2) sets, 10.0MT/3.0MT SWL, 3.0m outreach from the handling crane Vessel's extreme breadth.

Pump room davit:

One (1) set x 2.0MT SWL
Fixed jib, fixed air motor driven.

Steering gear room:
One (1) set x 0.9MT SWL davit Fixed jib, operated by manual chain block.

Suez Canal:
One (1) set x 0.2 MT SWL, operated by manual chain block. Search light davit.
Oil hose davit: Two (2) sets x 0.5 MT SWL
Fixed jib, one (1) air motor driven type (common use for P&S)
Injured person/sludge: One (1) set x 0.2 MT SWL, air motor driven type.
Accommodation: Two (2) sets, Al.-alloy ladder Fixed air motor driven, horizontal self-stowing and one (1) man operated type.
Deliverable n. 3.1

Wharf ladder: One (1) set Al.-alloy, 600mm x 15m length.
Pilot ladder: Two (2) sets, rope ladders with wooden step.
Ladder for cargo tank: One (1) ladder for each cargo tank.
Ladder for wing ballast: Two (2) vertical ladders for each ballast tank
Walk way to fwd.: Safety walkway with handrail.

Fire Fighting System:

Cargo tank deck: Foam system and sea water from fire main (fire hydrant, hose/nozzle).
Engine room and cargo Pump Room: Total flooding high expansion foam system, sea water from fire main (fire hydrant, hose/nozzle) and portable fire extinguisher.
Fixed water based local application fire-extinguishing system for engine room only.
Galley: Fixed fire-extinguishing system for deep fat fryer, if installed.
Others: Sea water from fire main (fire hydrant, hose/nozzle) and/or portable fire extinguisher.
Emergency fire pump: One (1) set, electric motor driven, vertical centrifugal with self-priming type, capacity as per Class Rule Requirement.

Life Saving Appliances:

Lifeboat: Two (2) sets x 24P, F.R.P, totally enclosed type.
Water cooled diesel engine driven.
One of these lifeboats shall be used as a rescue boat.
Lifeboat davit: Two (2) sets
Hinged gravity type, driven by fixed electric motor.
Life-raft: Two (2) sets x 25 persons
One (1) set x 6 persons
Other life-saving equipment shall be provided in accordance with the Rule and Regulation.

3.2.4 Accommodation

Complement and cabins:

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captain Class</td>
<td>2P Dayroom + Bed Room + Private Lavatory with a Shower</td>
</tr>
<tr>
<td>Senior Officer</td>
<td>2P Dayroom + Bed Room + Private Lavatory with a Shower</td>
</tr>
<tr>
<td>Junior Officer</td>
<td>7P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Petty Officer</td>
<td>3P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Crew Class</td>
<td>10P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Suez Crew</td>
<td>6P Commonly used with gymnasium</td>
</tr>
<tr>
<td>Total</td>
<td>24P + 6P Suez Crew</td>
</tr>
</tbody>
</table>

Layout:

Public space: Officer’s mess room, officer’s recreation room, crew’s messroom, crew’s recreation room, hospital, gymnasium.
Free height: appx. 2,100mm

Office space: Deck office, engine office.
Navigation and Control Space: Wheelhouse (incl. chart space and radio space), cargo
control room, ECR.

Catering space: Galley, Officers’ pantry.
Sanitary space: Officers’ laundry with drying room, crew laundry with drying room,
private/common lavatory, changing room

Provision space: Dry provision store, ref. chamber.

Other space: Em’cy generator room, air-condition room, engine foam room, bonded
store, foam room combined with fire control station, battery room, pump room.

Panel system:

<table>
<thead>
<tr>
<th>Divisional bulkhead:</th>
<th>50mm thick rock wool board with PVC film system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lining panel:</td>
<td>25mm thick rock wool board with PVC film on visible side.</td>
</tr>
<tr>
<td>Ceiling panel:</td>
<td>25mm thick rock wool board with baked enamel paint.</td>
</tr>
</tbody>
</table>

Deck covering:

| Captain class cabin: | Carpet on 7mm thick latex deck composition. |
| Other cabins, Public Spaces: | 2mm thick vinyl sheet on 7mm thick latex deck. |
| Fire insulation: | A-60/30/15 on bulkheads or between various spaces. |

Catering and laundry equipment:

Galley equipment: Galley range, baking oven, mixing machine, refrigerator, frying pan,
meat slicer, waste disposer, dish washing machine.
Pantry equipment: Coffee machine, toaster, water boiler, hot plate
Laundry and Drying room: Automatic washing machine, ironing board, iron, heater.

Refrigerated provision chamber:

| Meat room (-18°C): | ~ 15M3, Unit cooler |
| Fish room (-18°C): | ~ 5M3, Unit cooler |
| Vegetable (+4°C): | ~ 20M3, Unit cooler |
| Total: | ~ 40M3 |
| Lobby: | ~ 10M3, Un-cooled |

Two (2) sets of condensing unit (each 100% capacity), R-404a direct expansion type.

Air conditioning system:

Central, high pressure, single duct.

One (1) set of air handling unit. (100% capacity)
One (1) set of condensing unit. (100% capacity)
One (1) set of compressor (100% capacity)

Air conditioning: Cabin, public space, office, hospital.
Spot cooling/heat: Wheelhouse/chart space, dry provision store.
Separate unit cooler: Catering space.

**Design conditions:**

<table>
<thead>
<tr>
<th>Season</th>
<th>Temperature Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>From 35°C 70% R.H to 27°C 50% R.H</td>
</tr>
<tr>
<td>Winter</td>
<td>From -15°C to 20°C 50% R.H</td>
</tr>
<tr>
<td>Cooling water</td>
<td>36°C fresh water</td>
</tr>
<tr>
<td>Fresh air</td>
<td>~ 50%</td>
</tr>
<tr>
<td>Package type</td>
<td>(1) in ECR</td>
</tr>
</tbody>
</table>

**Ventilation system:**

Mechanical ventilation: Galley, laundry, steering gear room, engine room foam room, deck foam room, changing room, lavatory, paint store, lockers in accomm., pump room.
Natural ventilation: Stores and lockers, battery room, air-con. room, other spaces not provided with mechanical ventilation.

**Sanitary equipment:**

Sewage treatment plant: One (1) set, 24 persons/day, IMO approved type, combined with vacuum device

### 3.2.5 Main Machinery Components

**General:**

The main engine and the propulsive machinery including the shafting shall be so designed that the main engine is satisfactorily operated at the maximum continuous rating at sea water temperature of 32°C and engine room ambient air temperature of 45°C.

**Main engine:**

One (1) set, Two (2) stroke, single acting, airless injection, cross head, Alpha cylinder oil lubricator, direct reversible type marine diesel engine with high efficiency exhaust gas turbocharger, Nox emission approved type in accordance with MARPOL Annex VI, Regulation 13, based on NOx Tier II.

<table>
<thead>
<tr>
<th>Number of cylinder</th>
<th>Six (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder bore/stroke</td>
<td>~900/3,188mm</td>
</tr>
</tbody>
</table>

Cooling system of main engine shall be as follows:

<table>
<thead>
<tr>
<th>Lub. oil cooling</th>
<th>Fresh water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charge air cooling</td>
<td>Fresh water</td>
</tr>
<tr>
<td>Cyl. jacket cool.</td>
<td>Fresh water</td>
</tr>
<tr>
<td>Piston cooling</td>
<td>Lub. oil</td>
</tr>
<tr>
<td>Turbocharger</td>
<td>Acc. to M.E. manufacturer's standard</td>
</tr>
</tbody>
</table>
The main engine shall be designed for using heavy fuel oil having a viscosity of up to 600 cSt at 50°C.

**Propeller and shafting:**

Propeller: One (1) set, Ni-Al-Bronze, right handed, aerofoil section keyless, fixed pitch type.
Propeller cap.: According to the manufacturer’s standard.
Propeller shaft: One (1) set, forged steel with solid flange coupling on fore end.
Intermediate shaft: One (1) set, forged steel with solid flange coupling at both ends.

**3.2.6 Automation System**

**Alarm and monitoring system:**

The sensor for shut down shall be independent from the other system. Red indicating light shall be used for abnormal condition and this colour may not be used for other type of indication. In all normal conditions at sea, in manoeuvre or in port there shall be no red lights in the manoeuvring console. These mean that alarms must be automatically blocked when manually stopping the main engine or any auxiliary system.

The alarm and monitoring system shall be of modern microprocessor design for centralized observation to meet “unmanned engine room” operation.

The alarm and monitoring system shall be provided with dual communication network and extension alarm system.
When ER is unattended, the alarms shall be extended to the accommodation by the extension alarm panel.

The components of the system shall be as follows.
2 - 19 inches workstation and operation keyboard with tack ball in ECR
1 - Alarm printer in ECR
1 - Data logger in ECR
1 - UPS

**Main engine remote control system:**

**Bridge control**

Operation of the main engine such as starting, stopping, reversing, speed and load control shall be carried out safely and accurately according to the pre-set program by operation of the engine manoeuvring handle at the bridge control console after the control position shall be transferred from engine control room.

The manoeuvring handle shall be served as an engine telegraph order lever in addition to the above function in case of bridge control and shall be used only as an engine telegraph order lever in the other case.

If the main engine speed is given inside of the critical speed range, the automatic critical zone quick pass control shall be provided.
Control in engine control room
The engine is started, stopped, reversed and speed controlled by the operation of speed setting lever & telegraph receiver (commonly used as reversing handle) on the engine control console.

Emergency control at engine side
In emergency such as failure of governor and/or remote control system, main engine shall be controlled using the fuel handle and reversing lever on the emergency stand at engine side.
Emergency telegraph receiver shall be provided at the local control station.

Change-over of manoeuvring station
Change over from “BRIDGE CONTROL” to “ENGINE CONTROL ROOM CONTROL” or vice versa shall be carried out by operating the changeover switch in the engine control room with the mutual confirmation.

In bridge, no change-over switch but the confirmation button shall be provided.

The control shall be from one station only at any one time.
The control stations shall be provided with indicators showing which position is in control.
The engine control room shall at all times be able to override any remote control station.

3.2.7 Electrical, Navigation and Communication System

Electric system:
From generator: A.C. 450V, 3PH, 60Hz
Power circuits: A.C. 440V, 3PH, 60Hz
A.C. 220V, 3PH, 60Hz for minor power

Lighting circuits: A.C. 220V, 3PH, 60Hz for main circuits
A.C. 220V, 1PH, 60Hz for final sub circuits
Inter-comm. equip.: A.C. 220V, 3PH, 60Hz
D.C. 24V

Navigation and radio: A.C. 440V, 3PH, 60Hz
equipment A.C. 220V, 1PH, 60Hz
D.C. 24V

Electric power supply:
Alternator for main generator
1,562.5kVA (1,250kW), A.C.450V, 3PH, 60Hz, IP 23, brushless type driven by diesel engine.
Power management system for automatic synchronizing, load dependent starting/stopping, load sharing, automatic stand-by start and start blocking of heavy
motors shall be provided. The generators shall be capable of operating in parallel with each other continuously.

**Electric lighting:**

In general, the vessel shall be illuminated with fluorescent light and incandescent light and the high pressure sodium or incandescent type flood light shall be provided for exposed weather deck. The navigation and signal light shall be provided in accordance with concerned regulations.

**Internal communication, alarm and miscellaneous equipment:**

1) Public address with talk back system - 1 set
2) Automatic telephone system (50 lines) - 1 set
3) Common battery telephone system with intrinsically safe type - 1 set
4) Quartz crystal clock - 1 set
5) Communal aerial system - 1 set
6) Fire detection and alarm system (Addressable type) - 1 set
7) Foam release alarm - 1 set
8) Engineer call system - 1 set
9) Hospital call system - 1 set
10) Ref. chamber alarm system - 1 set
11) E/R alarm system (Signal light column) - 1 set
12) Bridge Navigational Watch Alarm System - 1 set
13) Rudder angle indication system - 1 set
14) M/E rpm indication system - 1 set
15) Loading computer (On-line type) - 1 set
16) LAN network system (Buyer’s supply: computers and software) - 1 set

**Navigation equipment:**

1) Auto pilot - 1 set
2) Gyro compass (incl. ROT indicator) - 1 set
3) Magnetic compass - 1 set
4) X-band radar (23” TFT display) with ARPA - 1 set
5) S-band radar (23” TFT display) with ARPA - 1 set
6) E.C.D.I.S (Electric chart display and information system, 23” TFT display) - 1 set
7) DGPS navigator - 2 sets
8) Doppler or acoustic correlation Speed log - 1 set (dual axis, water and bottom tracking)
9) Echo sounder - 1 set
10) A.I.S. (automatic identification system) - 1 set
11) Weather facsimile - 1 set
12) V.D.R. (Voyage data recorder) - 1 set
13) Anemometer and anemoscope - 1 set
14) Whistle - 1 set
Radio equipment:

The radio system shall comply with GMDSS requirements for sea area A1, A2 and A3, and be based on the duplication of equipment.

1) Radio plant - 1 set
   - MF/HF transmitter (250W)
   - MF/HF receiver
   - DSC terminal
   - DSC watch receiver
   - NBDP with a display and a printer
   - Battery charger for radio em’cy battery
   - Set of aerials

2) V.H.F radio telephone - 2 sets

3) Satellite Communication (Inmarsat-C) - 1 set

4) Satellite Communication (Inmarsat-FB 500) - 1 set

5) Satellite EPIRB - 1 set

6) Search and rescue locating devices - 2 sets (9 GHz, radar transponder)

7) Portable VHF transceiver - 3 sets

8) Navtex receiver - 1 set

9) Ship security alert system - 1 set (Incorporated with Inmarsat-C)

10) Long Range Identification and Tracking system (L.R.I.T system)
    - 1 set (Incorporated with Inmarsat-C)
3.3 Determination of Design Particulars: Tankers

Tanker design is influenced by a number of diverse factors. Many tanker operators have their ships mostly on the spot market and they tend to build flexible vessel designs relative to the market conditions. This practice has led to a commonality in sizes and configurations, particularly for the large crude carriers. Upper range VLCCs (320,000 DWT) can offer good flexibility for using terminals, since many can accommodate their draft. They are also used in some ports with depth limitations, mainly around the Mediterranean, West Africa and the North Sea. They can be ballasted through the Suez Canal. Loaded VLCCs going westbound from the Persian Gulf can only transit the Suez Canal by discharging part of their cargo to the SUMED pipeline for collection by themselves at the northern end of the canal. The very limited diversity in main dimensions related to recent build VLCCs can also be found in the database below. This is also the reason for having such a short sample. The 320,000 DWT VLCC is the prominent design for the last decade on that range of tankers and its dimensions are standardized.

The vessels on the database come from references provided by AMC and NAP. The mean values of the design particulars can be seen on the following table. Also the refined database is displayed below

<table>
<thead>
<tr>
<th>Vessel No.</th>
<th>LOA</th>
<th>LBP</th>
<th>BREADTH MLD</th>
<th>DEPTH</th>
<th>DRAFT (Design)</th>
<th>DRAFT (Scantling)</th>
<th>DWT</th>
<th>Main Engine kW</th>
<th>Main Engine RPM</th>
<th>Crew</th>
<th>Service Speed (Kn)</th>
<th>Year Built</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>333.00</td>
<td>320.00</td>
<td>60.00</td>
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<td>28460</td>
<td>75.3</td>
<td>41</td>
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<td>3</td>
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<td>30.50</td>
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<td>22.50</td>
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<td>60.00</td>
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<td>76.00</td>
<td>39</td>
<td>16.20</td>
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<tr>
<td>Mean</td>
<td>332.00</td>
<td>319.00</td>
<td>60.00</td>
<td>30.50</td>
<td>22.06</td>
<td>22.50</td>
<td>315806</td>
<td>29283</td>
<td>76.00</td>
<td>38</td>
<td>16.20</td>
<td>2009</td>
</tr>
</tbody>
</table>
3.3.1 Criteria for data entry

For the collection of data as displayed above we had established a set of entry criteria:

- Modern Designs representing the state of the art
- No entry of vessels that are more than 10 years old
- Separated Deckhouse from the Funnel Casing
- No entry of vessels that do not have all main particulars available
- Entry of vessels that their particulars can be retrieved by credible sources. (Final Dwg’s & Doc’s)

3.3.2 Baseline General Arrangement: VLCC

Fig. 9: VLCC Baseline General Arrangement [NAP’s Archive].

<table>
<thead>
<tr>
<th>Other Particulars</th>
<th>Main Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of double skin sides</td>
<td>3.35 m</td>
</tr>
<tr>
<td>Cargo Oil Tk.</td>
<td>353000 m³</td>
</tr>
<tr>
<td>Double bottom height</td>
<td>3.00 m</td>
</tr>
<tr>
<td>Slop Tk.</td>
<td>7500 m³</td>
</tr>
<tr>
<td>Propeller Diameter</td>
<td>10.00 m</td>
</tr>
<tr>
<td>Water Ballast Tk</td>
<td>99000 m³</td>
</tr>
<tr>
<td>No. of Cargo Tanks</td>
<td>15.00</td>
</tr>
<tr>
<td>H.F.O &amp; Settl., Serv.</td>
<td>8100 m³</td>
</tr>
<tr>
<td>No. of Slop Tanks</td>
<td>2.00</td>
</tr>
<tr>
<td>F.W Tk.</td>
<td>500 m³</td>
</tr>
</tbody>
</table>

Technical Data: For the aim of the project, further technical data will provided to the partners in order to allow calculation of motion responses and identification of other risks related to the ship’s particulars, such as: Lines Plan or Offsets, 3D Hull-Form geometry (.stl or .dxf), Mass Distribution (where possible), Loading Conditions (with GM values), Hydrostatics with main hull-form coefficients, Deck Layouts and Engine Room Arrangement.
3.4 AFRAMAX Outline Specifications

The outline specification for the selected AFRAMAX baseline is structured in 7 main topics from which we have selected the most prominent subtopics related to the crew and the human factors. The description of the topics is as per usual shipbuilding practice and the specifications are up to the latest regulations and technological standards for such ships. Only parts that are deemed necessary for the scope of the project are specified. The specification is structured as below:

8. General
9. Hull Structure
10. Ship’s Equipment and Outfit
11. Accommodation
12. Main Machinery Component
13. Automation System

3.4.1 General

The Vessel shall be designed as a single screw diesel engine direct driven “Crude Oil Tanker” with bulbous bow, transom stern and a continuous deck as shown on the General Arrangement.

All accommodation including Navigation Bridge and propulsion shall be located aft.

The Vessel shall have fore/aft peak tanks, cargo oil tanks, water ballast tanks, fuel oil tanks and engine room as shown on the G.A. The cargo area shall be constructed with double bottom and double hull, with six (6) pairs of cargo tanks, one (1) pair of slop tanks and six(6) pairs of segregated water ballast tanks. All heavy fuel oil storage tanks in engine room shall be protected by cofferdam. One (1) combined signal and radar mast on the top of wheelhouse and one (1) foremast on the forward upper deck shall be fitted. The Pump room shall be arranged in way of engine room as shown on the G.A.

Intended cargoes: “Crude oil” having a flash point below 60 deg.C.

General Particulars:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all:</td>
<td>250.00 m</td>
</tr>
<tr>
<td>Length between perpendiculars:</td>
<td>239.00 m</td>
</tr>
<tr>
<td>Breadth moulded:</td>
<td>44.00 m</td>
</tr>
<tr>
<td>Depth moulded:</td>
<td>21.00 m</td>
</tr>
<tr>
<td>Design draft moulded:</td>
<td>13.60 m</td>
</tr>
<tr>
<td>Scantling draft moulded:</td>
<td>14.90 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DWT (at even Keel &amp; ρ=1.025)</th>
</tr>
</thead>
<tbody>
<tr>
<td>At Design Draft Moulded:</td>
</tr>
<tr>
<td>At Scantling Draft Moulded:</td>
</tr>
</tbody>
</table>
Main engine:

Type: Any Maker (NOx Tier II)
MCR: 13,50 kW x 150 RPM (De-rated)
NCR (90% MCR): 12,360 kW

Vessel’s speed:

Service speed at moulded design draft and at NCR power of main engine with 15% sea margin.: Appx. 15.00 knots

Fuel oil consumption (F.O.C) of main engine:

Specific F.O.C at MCR based on diesel oil of LCV of 10,200Kcal/Kg under ISO 3046/1-2002 reference conditions: Appx. 125.0 G/kW.HR

Daily F.O.C at NCR based on diesel oil of LCV of 10,200 Kcal/Kg.: Appx. 49.14 MT/day

Max. cruising range (LCV of 9,800 kcal/kg) based on above service speed and daily F.O.C with three(3) days reserve: Appx. 14,380 N.M.

Classification Society:

The Vessel shall be constructed in accordance with the Rules of the Classification Society and under survey of the Classification Society (hereinafter called as the “Class”) and shall be distinguished in register by symbol of:

Lloyd’s Register Asia (LR)
+100 A1 Double Hull Oil Tanker ESP, CSR, ShipRight (CM, ACS(B)), LI, *IWS, +LMC, UMS, with descriptive notes “Pt. Ht., ShipRight (BWMP(S), SCM)” or DNV or ABS with equivalent notations to LR

Rules and Regulations:

The Vessel shall comply with following Rules and Regulations (edition and amendments being in force as compulsory as of the date of Contract signing)

- International Convention for Preventing Collision at Sea, 1972 and related amendments.
- U.S Coast Guard’s Regulations for Foreign Flag Vessels operating in navigable waters of U.S.A (CFR Title 33 - Part 155, 156, 157, 159 and 164, CFR Title 46-Part 32.53, 34.05 and 39 without certificate and inspection)
- Suez Canal Navigation and Tonnage Measurement of Ships.
- ILO Convention No. 92 and 133 for Crew Accommodation (except mosquito door, mosquito window and swimming pool).
- IACS Common Structural Rules for Double Hull Oil Tankers.
- IMO PSPC (Performance Standard for Protective Coating of dedicated seawater ballast tanks)
- Maritime Regulations of the registered country.

Guidelines and Recommendations:

Following Guidelines and Recommendations shall be complied with:

- OCIMF Ship to Ship Transfer Guide (Petroleum), 2005 (for fixed fitting only).
- OCIMF Recommendations for cargo equipment employed in the mooring of ships at Single Point Mooring, 2007 (for fixed fitting only).
- Section 4.6: Marking of Mooring Fittings
- Section 6.2: Wire Mooring Lines
- Section 7.8.1: Recommendation for Ship Designs
- ISO 6954: 1984(E) - “Mechanical vibration and shock - Guidelines for overall evaluation of vibration in merchant ships”.
- IMO Resolution A.468(XII) - “Code on Noise Levels on board ships, 1981”.

IMO Resolution A.868(20)-“Guidelines for the control and management of ships’ ballast water to minimize the transfer of harmful aquatic organisms and pathogens” (Sequential method only shall be applied and the ballast water treatment plant shall not be provided).

Registration:

The Vessel shall be registered under a European Flag.

3.4.2 Hull Structure

The hull shall be constructed with mild and higher tensile steel approved by the Class. Higher tensile steel having 32kg/mm2 and/or 36kg/mm2 minimum yield stress shall be used for the parts where the Builder considers necessary.

TMCP (Thermo-Mechanical Controlled Process) steel may be used at the Builder’s discretion.
Scantlings of cargo tank’s structural members shall be in compliance with the requirements of the Class based on the S.G. 1.025 cargo full or partial loading in each cargo tank (P/S) and slop tank (P/S) up to full dead weight.

Scantlings not specified by the Class shall be in accordance with the Builder’s practice. The main hull girder which forms strength deck, inner hull and double bottom in cargo tank space shall be of longitudinal frame system.

Fore & aft ends of the Vessel and engine room area shall be transverse and/or longitudinal frame system.

Centre line longitudinal and transverse bulkheads between cargo tanks shall be of plane type with stiffeners. Three (3) horizontal stringers shall be applied to transverse bulkheads.

Side longitudinal bulkheads forming double hull in cargo tank space shall be of plane type with longitudinal stiffeners and have inclination at bottom and deck.

Inner bottom shall be flat from centre line to hopper end. All stiffeners in way of cargo tank space shall be arranged in the double bottom, inner hull and under deck.

Rudder shall be of streamlined, semi spade type with one (1) pintle. Rudder horn shall be of weld-able cast steel or fabricated with rolled steel plate according to the Builder’s practice and rudder stock shall be of forged steel and coupled to the rudder.

Exposed front, rear and side walls of deckhouse shall be of flat plate type with vertical stiffeners and inner walls shall be of stiffened plane or corrugated type according to the Builder’s practice.

3.4.3 Ship’s Equipment and Outfit

Manoeuvring equipment:

Steering gear:
One (1) set, electro-hydraulic type
Pump unit: 2 sets x 100% capacity each

Anchoring and mooring equipment:

Windlass combined: Two (2) sets, hyd. motor driven (high pressure) type with non-mooring winch auto-tension, split drum, manual band brake.

Mooring winch: Hyd. motor driven (high pressure) type with non-autotension, split drum, manual band brake, 30MT x 15 m/min

Electro-hydraulic power unit (high pressure type) shall be provided for operation of windlass and mooring winches.
- Forward power unit (located in bosun store) shall be operated to run one (1) cable lifter or three (3) mooring drums at rated load, which is bigger, and connected to the two (2) windlass, one (1) mooring winch on fwd mooring deck and two (2) mooring winches on fwd mid deck.
- After power unit (located in steering gear room) shall be operated to run three (3) mooring drum at rated load and connected to the three (3) mooring winches on aft deck and two (2) mooring winches on aft mid deck.

- Each power unit shall consist of three (3) / three (3) hydraulic pumps (at fwd/ aft).
- Each power unit shall not be interconnected.

Emergency towing: Emergency towing equipment for forward and aft deck in system accordance with IMO Resolution.

Two (2) bow stoppers shall be provided on forward deck in accordance with OCIMF Single Point Moorings, 2007.

Bower anchor: Two (2) sets, HHP stockless type (no spare anchor)

Anchor chain: GRADE 3, Kenter type joining shackle.

Mooring rope: Galvanized steel wire rope, 16 sets x 36mm dia. x 250m each (6 x 37 IWRC, MBL appx. 75.1 ton)

Cargo equipment and outfitting:

Cargo hose handling:
Two (2) sets, 15MT SWL, 5.0m outreach from the Vessel’s crane extreme breadth, electro-hydraulic cylinder luffing, and single jib type. Commonly used for Suez mooring boat handling.

Provision and machinery:
Two (2) sets, 4.0 MT SWL, 3.0m outreach from the handling crane Vessel’s extreme breadth.

Pump room davit:
One (1) set x 0.9MT SWL
Fixed jib, fixed air motor driven.

Steering gear room:
One (1) set x 0.5MT SWL davit Fixed jib, operated by manual chain block.

Suez Canal:
One (1) set x 0.2 MT SWL, operated by manual chain block. Search light davit.

Oil hose davit: Two (2) sets x 0.5 MT SWL
Fixed jib, one (1) air motor driven type (common use for P&S)

Injured person/sludge: One (1) set x 0.2 MT SWL, air motor driven type.

Accommodation: Two (2) sets, Al.-alloy ladder Fixed air motor driven, horizontal self-stowing and one (1) man operated type.

Wharf ladder: One (1) set Al.-alloy, 600mm x 15m length.

Pilot ladder: Two (2) sets, rope ladders with wooden step.

Ladder for cargo tank: One (1) ladder for each cargo tank.
Ladder for wing ballast: Two (2) vertical ladders for each ballast tank
Walk way to fwd.: Safety walkway with handrail

Life saving appliances:
Lifeboat: Two (2) sets x 24P, F.R.P, totally enclosed type.
- Water cooled diesel engine driven.
- One of these lifeboats shall be used as a rescue boat.
Lifeboat davit: Two (2) sets
- Hinged gravity type, driven by fixed electric motor.
Life-raft: Two (2) sets x 25 persons
- One (1) set x 6 persons

Fire fighting system:
Cargo tank deck: Foam system and sea water from fire main (fire hydrant, hose/nozzle).
Engine room and cargo: Total flooding high pressure CO2 system, sea water from fire pump room main (fire hydrant, hose/nozzle) and portable fire extinguisher.
Fixed water based local application fire-extinguishing system for engine room only.
Galley: Fixed fire-extinguishing system for galley exhaust hood.
Others: Sea water from fire main (fire hydrant, hose/nozzle) and/or portable fire extinguisher.
Emergency fire pump: One (1) set, electric motor driven, vertical centrifugal with self-priming type, capacity as per Class Rule Requirement.

3.4.4 Accommodation

Complement and cabins:

<table>
<thead>
<tr>
<th>Class</th>
<th>Accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captain Class</td>
<td>2P Dayroom + Bed Room + Private Lavatory with a Shower</td>
</tr>
<tr>
<td>Senior Officer</td>
<td>2P Dayroom + Bed Room + Private Lavatory with a Shower</td>
</tr>
<tr>
<td>Junior Officer</td>
<td>5P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Petty Officer</td>
<td>3P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Crew Class</td>
<td>12P Single berth room + private lavatory with a Shower</td>
</tr>
<tr>
<td>Suez Crew</td>
<td>6P Commonly used with gymnasium</td>
</tr>
<tr>
<td>Total</td>
<td>24P + 6P Suez Crew</td>
</tr>
</tbody>
</table>

Layout:
Public space: Officer’s mess room, officer’s recreation room, crew’s mess-room, crew’s recreation room, hospital, gymnasium.
Free height: appx. 2,100mm
Office space: Deck office, engine office.
Navigation and Control Space: Wheelhouse (incl. chart space and radio space), cargo control room, ECR.
Catering space: Galley, Officers’ pantry.
Sanitary space: Officers’ laundry with drying room, crew laundry with drying room, private/common lavatory, changing room.
Provision space: Dry provision store, ref. chamber.
Other space: Em’cy generator room, air-condition room, engine foam room, bonded store, foam room combined with fire control station, battery room, pump room.

Panel system:

<table>
<thead>
<tr>
<th>Divisional bulkhead:</th>
<th>50mm thick rock wool board with PVC film system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lining panel:</td>
<td>25mm thick rock wool board with PVC film on visible side.</td>
</tr>
<tr>
<td>Ceiling panel:</td>
<td>25mm thick rock wool board with baked enamel paint.</td>
</tr>
</tbody>
</table>

Deck covering:

<table>
<thead>
<tr>
<th>Captain class cabin:</th>
<th>Carpet on 7mm thick latex deck composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other cabins, Public Spaces:</td>
<td>2mm thick vinyl sheet on 7mm thick latex deck</td>
</tr>
<tr>
<td>Fire insulation:</td>
<td>A-60/30/15 on bulkheads or between various spaces.</td>
</tr>
</tbody>
</table>

Catering and laundry equipment:

Galley equipment: Galley range, baking oven, mixing machine, refrigerator, frying pan, meat slicer, waste disposer, dish washing machine.
Pantry equipment: Coffee machine, toaster, water boiler, hot plate
Laundry and Drying room: Automatic washing machine, ironing board, iron, heater.

Refrigerated provision chamber:

<table>
<thead>
<tr>
<th>Meat room (-18°C):</th>
<th>~10M3, Unit cooler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish room (-18°C):</td>
<td>~10M3, Unit cooler</td>
</tr>
<tr>
<td>Vegetable (+4°C):</td>
<td>~20M3, Unit cooler</td>
</tr>
<tr>
<td>Total:</td>
<td>~50M3</td>
</tr>
<tr>
<td>Lobby:</td>
<td>~10M3, Un-cooled</td>
</tr>
<tr>
<td>Two (2) sets of condensing unit (each 100% capacity), R-404a direct expansion type.</td>
<td></td>
</tr>
</tbody>
</table>

Air conditioning system:

Central, high pressure, single duct.
One (1) set of air handling unit. (100% capacity)
Two (2) set of condensing unit. (50% capacity)
Two (2) set of compressor (50% capacity)

<table>
<thead>
<tr>
<th>Air conditioning:</th>
<th>Cabin, public space, office, hospital.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot cooling/heat:</td>
<td>Wheelhouse/chart space, dry provision store.</td>
</tr>
<tr>
<td>Separate unit cooler:</td>
<td>Catering space.</td>
</tr>
</tbody>
</table>

Design conditions:

<table>
<thead>
<tr>
<th>Summer:</th>
<th>From 35°C 70% R.H to 27°C 50% R.H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter:</td>
<td>From -15°C to 20°C 50% R.H</td>
</tr>
</tbody>
</table>
Cooling water temp.:........36°C fresh water
Fresh air supply:..............Appx. 50%
Package type unit:.........One (1) in ECR.

Ventilation system:

Mechanical ventilation: Galley, laundry, steering gear room, engine room foam room, deck foam room, changing room, lavatory, paint store, lockers in accomm., pump room.
Natural ventilation: Stores and lockers, battery room, air-con. room, other spaces not provided with mechanical ventilation.

Sanitary equipment:

Sewage treatment plant: One (1) set, 24 persons/day, IMO approved type, combined with vacuum device

3.4.5 Main Machinery Components

General:

The main engine and the propulsive machinery including the shafting shall be so designed that the main engine is satisfactorily operated at the maximum continuous rating at sea water temperature of 32°C and engine room ambient air temperature of 45°C.

Main engine:

One (1) set, Two (2) stroke, single acting, airless injection, cross head, Alpha cylinder oil lubricator, direct reversible type marine diesel engine with high efficiency exhaust gas turbocharger, Nox emission approved type in accordance with MARPOL Annex VI, Regulation 13, based on NOx Tier II.

Number of cylinder:.......Six (6)
Cylinder bore/stroke:.....~600/2,400mm

Cooling system of main engine shall be as follows:

| Lub. oil cooling:............Fresh water |
| Charge air cooling:.......Fresh water |
| Cyl. jacket cool:............Fresh water |
| Piston cooling:.............Lub. oil |
| Turbocharger:...............Acc. to M.E. manufacturer’s standard |

The main engine shall be designed for using heavy fuel oil having a viscosity of up to 600 cSt at 50°C

Propeller and shafting:

Propeller: One (1) set, Ni-Al-Bronze, right handed, aerofoil section keyless, F.P. type.
Propeller cap.: According to the manufacturer’s standard.
Propeller shaft: One (1) set, forged steel with solid flange coupling on fore end.
Intermediate shaft: One (1) set, forged steel with solid flange coupling at both ends.

**Generator diesel engine:**

No. of set: Three (3) sets (Any Manufacturer, 5L21/31)
Type: Four cycle, single acting, trunk piston type water cooled, exhaust gas turbocharged marine diesel engine with air cooler, Nox emission approved type in accordance with MARPOL Annex VI, Regulation 13.

<table>
<thead>
<tr>
<th>Generator output: 900 KW x 900 RPM, AC 450V, 3PH, 60HZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting system: Compressed air motor starting (7kg/cm² service air)</td>
</tr>
<tr>
<td>Fuel oil: Heavy fuel oil, viscosity up to 380 cSt &amp; 50°C for normal operation</td>
</tr>
</tbody>
</table>

Marine diesel oil (DMC, ISO 8217) shall be used at cold starting and low load of engine.

### 3.4.6 Automation System

**Alarm and monitoring system:**

The sensor for shut down shall be independent from the other system. Red indicating light shall be used for abnormal condition and this colour may not be used for other type of indication. In all normal conditions at sea, in manoeuvre or in port there shall be no red lights in the manoeuvring console. These mean that alarms must be automatically blocked when manually stopping the main engine or any auxiliary system.

The alarm and monitoring system shall be of modern microprocessor design for centralized observation to meet “unmanned engine room” operation.

The alarm and monitoring system shall be provided with dual communication network and extension alarm system.

When ER is unattended, the alarms shall be extended to the accommodation by the extension alarm panel.

The components of the system shall be as follows.
2 - 17 inches workstation and 2 operation keyboard with tack ball in ECR
1 - Alarm printer in ECR
1 - Data logger in ECR
1 - UPS

**Main engine remote control system:**

**Bridge control**

Operation of the main engine such as starting, stopping, reversing, speed and load control shall be carried out safely and accurately according to the pre-set program by operation of the engine manoeuvring handle at the bridge control console after the control position shall be transferred from engine control room.
The manoeuvring handle shall be served as an engine telegraph order lever in addition to the above function in case of bridge control and shall be used only as an engine telegraph order lever in the other case.

If the main engine speed is given inside of the critical speed range, the automatic critical zone quick pass control shall be provided.

**Control in engine control room**
The engine is started, stopped, reversed and speed controlled by the operation of speed setting lever & telegraph receiver (commonly used as reversing handle) on the engine control console.

**Emergency control at engine side**
In emergency such as failure of governor and/or remote control system, main engine shall be controlled using the fuel handle and reversing lever on the emergency stand at engine side.
Emergency telegraph receiver shall be provided at the local control station.

**Change - over of manoeuvring station**
Change over from “BRIDGE CONTROL” to “ENGINE CONTROL ROOM CONTROL” or vice versa shall be carried out by operating the changeover switch in the engine control room with the mutual confirmation.

In bridge, no change-over switch but the confirmation button shall be provided.

The control shall be from one station only at any one time. The control stations shall be provided with indicators showing which position is in control. The engine control room shall at all times be able to override any remote control station.

### 3.4.7 Electrical, Navigation and Communication System

**Electric system:**

From generator: A.C. 450V, 3PH, 60Hz

Power circuits: A.C. 440V, 3PH, 60Hz
A.C. 220V, 3PH, 60Hz for minor power

Lighting circuits: A.C. 220V, 3PH, 60Hz for main circuits
A.C. 220V, 1PH, 60Hz for final sub circuits
Inter-comm. equip.: A.C. 220V, 3PH, 60Hz
D.C. 24V

Navigation and radio: A.C. 440V, 3PH, 60Hz
equipment A.C. 220V, 1PH, 60Hz
D.C. 24V
**Electric power supply:**

Alternator for main generator
900 kW, A.C.450V, 3PH, 60Hz, IP 23, brushless type driven by diesel engine.
Power management system for automatic synchronizing, load dependent starting/stopping, load sharing, automatic stand-by start and start blocking of heavy motors shall be provided. The generators shall be capable of operating in parallel with each other continuously.

**Electric lighting:**

In general, the vessel shall be illuminated with fluorescent light and incandescent light and the high pressure sodium or incandescent type flood light shall be provided for exposed weather deck. The navigation and signal light shall be provided in accordance with concerned regulations.

**Internal communication, alarm and miscellaneous equipment:**

1) Public address with talk back system - 1 set
2) Automatic telephone system (50 lines) - 1 set
3) Common battery telephone system with intrinsically safe type - 1 set
4) Quartz crystal clock - 1 set
5) Communal aerial system - 1 set
6) Fire detection and alarm system (Addressable type) - 1 set
7) Foam release alarm - 1 set
8) Engineer call system - 1 set
9) Hospital call system - 1 set
10) Ref. chamber alarm system - 1 set
11) E/R alarm system (Signal light column) - 1 set
12) Bridge Navigational Watch Alarm System - 1 set
13) Rudder angle indication system - 1 set
14) M/E rpm indication system - 1 set
15) Loading computer (On-line type) - 1 set
16) Lan network system (Buyer’s supply: computers and software) - 1 set

**Navigation equipment:**

1) Auto pilot - 1 set
2) Gyro compass (incl. ROT indicator) - 1 set
3) Magnetic compass - 1 set
4) X-band radar (23” TFT display) with ARPA - 1 set
5) S-band radar (23” TFT display) with ARPA - 1 set
6) E.C.D.I.S (Electric chart display and information system, 23” TFT display) - 1 set
7) DGPS navigator - 2 sets
8) Doppler or acoustic correlation Speed log - 1 set
9) Echo sounder - 1 set
10) A.I.S. (automatic identification system) - 1 set
11) Weather facsimile - 1 set
12) V.D.R. (Voyage data recorder) - 1 set
13) Anemometer and anemoscope - 1 set
14) Whistle - 1 set
Radio equipment:

The radio system shall comply with GMDSS requirements for sea area A1, A2 and A3, and be based on the duplication of equipment.

1) Radio plant - 1 set
   - MF/HF transmitter (250W)
   - MF/HF receiver
   - DSC terminal
   - DSC watch receiver
   - NBDP with a display and a printer
   - Battery charger for radio emergency battery
   - Set of aerials

2) V.H.F radio telephone - 2 sets

3) Satellite Communication (Inmarsat-C) - 1 set

4) Satellite Communication (Inmarsat-FB 500) - 1 set

5) Satellite EPIRB - 1 set

6) Search and rescue locating devices - 2 sets (9 GHz, radar transponder)

7) Portable VHF transceiver - 3 sets

8) Navtex receiver - 1 set

9) Ship security alert system - 1 set (Incorporated with Inmarsat-C)

10) Long Range Identification and Tracking system (L.R.I.T system)
    - 1 set (Incorporated with Inmarsat-C)
3.4.8 Baseline General Arrangement: AFRAMAX

![AFRAMAX Baseline General Arrangement](AMC's Archive)

**Fig. 10:** AFRAMAX Baseline General Arrangement [AMC’s Archive].

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length over all</td>
<td>250.00</td>
</tr>
<tr>
<td>Deadweight</td>
<td>115000.00</td>
</tr>
<tr>
<td>Length between perpendiculars</td>
<td>239.00</td>
</tr>
<tr>
<td>Main Engine kW</td>
<td>13735.00</td>
</tr>
<tr>
<td>Breadth moulded</td>
<td>44.00</td>
</tr>
<tr>
<td>Main Engine RPM</td>
<td>105</td>
</tr>
<tr>
<td>Depth moulded</td>
<td>21.00</td>
</tr>
<tr>
<td>Crew</td>
<td>30.00</td>
</tr>
<tr>
<td>Design draft moulded</td>
<td>13.60</td>
</tr>
<tr>
<td>Service Speed</td>
<td>15.00</td>
</tr>
<tr>
<td>Scantling draft moulded</td>
<td>14.90</td>
</tr>
<tr>
<td>Average Age</td>
<td>2006</td>
</tr>
</tbody>
</table>

### Other Particulars

<table>
<thead>
<tr>
<th>Particular</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width of double skin sides</td>
<td>2.18 m</td>
</tr>
<tr>
<td>Cargo Oil Tk.</td>
<td>131000 m³</td>
</tr>
<tr>
<td>Double bottom height</td>
<td>2.30 m</td>
</tr>
<tr>
<td>Slop Tk.</td>
<td>2700 m³</td>
</tr>
<tr>
<td>Propeller Diameter</td>
<td>8.00 m</td>
</tr>
<tr>
<td>Water Ballast Tk.</td>
<td>41300 m³</td>
</tr>
<tr>
<td>No. of Cargo Tanks</td>
<td>12.00</td>
</tr>
<tr>
<td>H.F.O &amp; Settl., Serv.</td>
<td>2400 m³</td>
</tr>
<tr>
<td>No. of Slop Tanks</td>
<td>2.00</td>
</tr>
<tr>
<td>F.W Tk.</td>
<td>320 m³</td>
</tr>
</tbody>
</table>

### Technical Data

**Technical Data:** For the aim of the project, further technical data will be provided to the partners in order to allow calculation of motion responses and identification of other risks related to the ship’s particulars, such as: Lines Plan or Offsets, 3D Hull-Form geometry (.stl or .dxf), Mass Distribution (where possible), Loading Conditions (with GM values), Hydrostatics with main hull-form coefficients, Deck Layouts and Engine Room arrangement.
3.5 Selection of Routes

The aim of this part is to specify the operational requirements of the baseline designs and mainly the selection of routes that will be used in order to determine economic aspects as well as to set up the Bridge and Engine Room simulations of HSW later on and aid Task 3.2 related to the synthesis of the effect of ship motions.

For VLCC vessels the assigned routes worldwide are more or less standardized and follow the pattern of oil trade between major suppliers and consumers.

There are two proposed routes, however it will be decided later if both or one of them will be further utilized.

3.5.1 First Route

UAE to JAPAN

![Port Rashid (UAE) to Chiba (Japan) route](image)

**Port Rashid to Chiba**

<table>
<thead>
<tr>
<th>Distance:</th>
<th>6,400 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Voyage Duration:</td>
<td>16.66 Days</td>
</tr>
<tr>
<td>Bunkers:</td>
<td>1.083 HO, 17 DO</td>
</tr>
</tbody>
</table>

**PORT RASHID**

- Pilots
- Quoins - E bound
- Dondra Head - E bound
- Rondo - Northern Entrance To The Malacca Strait
- Singapore West (The Brothers) - SE Bound
- Batu Berhanti
- Buffalo Rock Lt. buoy
- Singapore East (Horsborough) E bound
- Balintang Channel
- Pilots

**CHIBA**
Significant Wave Height Data for the relevant Crossing.

Fig. 12: Significant Wave Height of Specific areas [10].

The main objectives of this route is for the vessel to have a long crossing through the ocean, thus the crew considered to be affected by deep sea environmental conditions. Then the vessel will have to go through the busy and confined Singapore Strait and continue through the South China Sea.

3.5.2 Second Route

Nigeria to Louisiana Terminal or Copenhagen to Louisiana Terminal

Fig. 13: LOOP (USA) to Copenhagen (Denmark) and LOOP (USA) to Lagos (Nigeria) route [9].

<table>
<thead>
<tr>
<th>Copenhagen to LOOP Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance:.........................5,147 nm</td>
</tr>
<tr>
<td>Total Voyage Duration:.........13.40 Days</td>
</tr>
<tr>
<td>Bunkers:..............................871 HO, 13 DO</td>
</tr>
</tbody>
</table>

LOOP TERMINAL
Florida Strait
Fair Isle - South Passage
Skaw
The Sound (Helsingor) - S bound
Pilots
COPENHAGEN
Nigeria to LOOP Terminal

<table>
<thead>
<tr>
<th>Distance:</th>
<th>5,906 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Voyage Duration:</td>
<td>17.40 Days</td>
</tr>
<tr>
<td>Bunkers:</td>
<td>1050 HO, 16 DO</td>
</tr>
</tbody>
</table>

These routes are intended to be used in order to investigate the different environmental conditions of the Atlantic Ocean as well as possible strait crossings.

Significant Wave Height Data for the relevant Crossings.

Fig. 14: Significant Wave Height of Specific areas [10].
4. ROPAX VESSELS ANALYSIS

This chapter discusses the development of the RoPax fleet and it gives an insight on the potential impacts from operating such ships. Further it presents an outline specification of a large RoPax vessel and a detailed dataset for the selection of the main particulars. In order to capture the more complex design determinants of such vessels, a more thorough statistical analysis was required. The chapter concludes with the presentation of an additional outline specification for a smaller type, Handy-Size RoPax vessel.

4.1 Potential Impact: Ropax Fleet

The ROPAX concept has constantly evolved in Europe and now is established as a major mover for combined passenger, car and cargo traffic. The ROPAX type started to develop during the 60’s in the Baltic and rapidly spread to the North Sea and to the Mediterranean routes. The design of such vessels is a compromise between the space and access demands created from passengers, cars and the freight vehicles; depending also on the market the vessel is serving and the route is occupying.

According to ShipPax, in 2004, more than 1.3 billion passengers, 188 million cars, 856,000 buses and 28.7 million trailers were carried on 5.9 million crossings globally. The total number of ferries worldwide at 1 January 2006 (excluding ferries less than 1,000 gross tonnage) was 1,162, with a combined capacity of 1.15 million passengers and 226,210 cars or 769,210 lane meters of commercial vehicles. Combined gross tonnage was 12.8 million and the average age of the fleet was 21 years [4].

Pre-1960: The Pioneers Generation.

The first Ferries in this era are developed from liner vessels and still had remnants from them in both interior and exterior design. Capacities were still limited but passengers were fascinated. Travelling by ferries and carrying their own car was a new experience.

1960’s: The Decade of Scandinavian car Ferries.

Numerous new-buildings were delivered, with greater interest in comfort speed and capacity than before. Large dummy funnels, slim lines and comfortable and dark interiors characterize the 1960’s ferries. Drive through technology becomes the Scandinavian standard.

1970’s: The Jumbo Ferries Generation.

From the early 1970’s sizes increase dramatically as a result of fast growing demand. The Ferry design is concentrated on massively increasing capacities for vehicles and passengers. Facilities reach a very high standard and people interact more with the interior and generally with the Ferry concept. The new SOLAS 1974 Regulations lead to improved safety standards and influence new designs.
1980’s: The Cruise Ferry Decade.

Cruise-like luxury, gigantic dimensions and huge passenger capacities characterize some Ferry designs that arose in the 1980’s. Mini-cruise offers contribute operator’s results and ensure together with cargo and tourist traffic in the summer a profitable year-round capacity use. The anticipated end of duty-free sales, however, indicates the forthcoming end of this design trend.

1990’s: The ROPAX Invention.

In light of the end of duty free sales within the EU in 1999, operators vote against further cruise-ferry new-buildings. Instead the Baltic ROPAX is invented. Well-equipped and comfortable, but focusing more on freight than on passengers, these vessels provide an efficient year-round operation and ensure the operators’ future even in light of decreasing onboard revenues. Entertainment is clearly more limited than on previous Ferry designs, but spacious high standard cabins and attractive public spaces contribute to the acceptance of this new design.

Post-2000: ROPAX goes fast.

Following the path of Greek Superfast Ferries several operators initiate fast ROPAX tonnage with speeds above 25 knots. Lane meters have clear preference towards passenger capacity, but the standards of cabins and publics spaces remain very high. This concept has nothing to do anymore with what was once considered RO-RO vessels with increased passenger capacity. Designers and yards rediscover slim and classic lines. Some fast ROPAX vessels look much more elegant than the 1980’s cruise-ferries.

The ROPAX ferry is determined as a passenger ferry vessel with large and extended Ro-Ro decks and limited passenger facilities onboard. More precisely according to the ShipPax magazine register, if the driver capacity exceeds a factor of 0.25 multiplied with the lanemetre capacity, the vessel is categorized as a ROPAX vessel and belongs to the ferry register instead of the RORO. These types of vessels usually have a lower deck for RoRo cargo and the deckhouse is lengthened to accommodate space for passengers. Ropax vessels combine a large ro/ro freight capacity (from 100 to around 200 units, or more) and a moderate passenger capacity (below 500 passengers). They carry both accompanied and unaccompanied freight. Loading may be drive-through or stern only which is more convenient for unaccompanied freight. As in the case of car/passenger ferries, tourist and vehicle capacity are interchangeable. Ropax ship are usually used for services where a heavy freight bias is combined with a need to carry unaccompanied freight and significant numbers of freight drivers and tourists (on holiday seasons mostly).
4.1.1 Sub-Categories in the Market

Ro-Ro ferry:

Ro-Ro freighters are freight only vessels that are licence to carry not more than 12 passengers and have very limited on-board facilities. They typically have a capacity of 60 to 170 freight units. As they intended to carry unaccompanied freight, they use stern only loading. These vessels often have deck heights in excess of 6.2 metres to enable them to carry double-stacked containers on specially build trailers.

PaxCar ferry:

Ferries that have passenger facilities intended for longer routes are usually considered as passenger-car ferries or PaxCar ferries. Vessels of this kind can be easily recognized from their full length superstructure to accommodate cabins and public spaces. They have the ability to carry ro/ro freight and more passengers and passenger cars.

Cruise ferry:

Is the only category that diverges more from the Ropax design. Ferries with cabin space for all passengers and large public spaces, restaurants and entertainment lounges are often called Cruise ferries. They usually operate overnight routes and carry a significant amount of ro/ro freight and passenger cars.

Fig. 15: Composition of the Ferry market [7].

The project concentrates on Ropax vessels that are a mixture of all the described types. The size and capacity of Ropax vessels has been increasing in order to accommodate the increasing demand of short sea transport dedicated to mixed vehicle cargo and passengers within European waterways.
4.2 Large RoPax Outline Specifications

The outline specification for the selected ROPAX baseline is structured in 7 main topics from which we have selected the most prominent subtopics related to the crew and the human factors. The description of the topics is as per usual shipbuilding practice and the specifications are up to the latest regulations and technological standards for such ships. Only parts that are deemed necessary for the scope of the project are specified. The specification is structured as below:

1. General
2. Hull Structure
3. Ship’s Equipment and Outfit
4. Accommodation
5. Main Machinery Component
6. Automation System

4.2.1 General

This technical description refers to the construction of a Ro-Ro/Passenger vessel for short international routes in the Baltic Sea. The vessel is to be characterized as category B EUROSOLAS and shall comply with all the requirements concerning IMO/SOLAS regulations.

The vessel is equipped with vehicle garages designed at the level of the main deck and extends along the length of the vessel, on the upper deck accessed via internal ramp and below main deck in the forward part of the vessel. The Main and upper garage spaces is appropriately designed in order to load trucks vehicles while the lower garages are designed for cars and vans. The trucks can roll on/off from the vessel with the aid of two independent ramps installed at the after end of the vessel.

Passenger and crew cabins and public spaces are situated above main deck. Further on, public spaces consist of lounges, shopping centre, disco, restaurants etc. located in decks 5, 6 and 7 are specious enough to accommodate the economy class and distinguished class passenger capacity with comfort and safety. At the open decks,
Deliverable n. 3.1

shaded and seats are installed for passengers who wish to seat outside as well as swimming pool, Jacuzzi and bar.

Main particulars:

<table>
<thead>
<tr>
<th>L.O.A</th>
<th>Approx.</th>
<th>$L_{OA} = 200.65 \text{ m}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.B.P</td>
<td>-/-</td>
<td>$L_{BP} = 185.40 \text{ m}$</td>
</tr>
<tr>
<td>Beam</td>
<td>-/-</td>
<td>$B = 25.80 \text{ m}$</td>
</tr>
<tr>
<td>Height of Main Deck</td>
<td>-/-</td>
<td>$D = 9.80 \text{ m}$</td>
</tr>
<tr>
<td>Deadweight</td>
<td>-/-</td>
<td>$DW = 5745 \text{ T (About)}$</td>
</tr>
<tr>
<td>Lightweight</td>
<td>-/-</td>
<td>$LT = 13683 \text{ T (About)}$</td>
</tr>
<tr>
<td>Design Summer Draught</td>
<td>-/-</td>
<td>$T = 6.80 \text{ m}$</td>
</tr>
<tr>
<td>Scantling Draught</td>
<td>-/-</td>
<td>$T_s = 6.90 \text{ m}$</td>
</tr>
<tr>
<td>Service Speed</td>
<td>-/-</td>
<td>$V_s = 26.40 \text{ Knots (at 85% of MCR + 10 \text{ %} sea margin)}$.</td>
</tr>
<tr>
<td>Main Engine Power</td>
<td>-/-</td>
<td>$4 \times 11120\text{ kw.}$</td>
</tr>
<tr>
<td>Displacement</td>
<td>-/-</td>
<td>$19430 \text{ MT (About)}$</td>
</tr>
<tr>
<td>Passengers number</td>
<td>-/-</td>
<td>1500</td>
</tr>
<tr>
<td><strong>Main &amp; upper Garage Cargo</strong></td>
<td>-/-</td>
<td>$2100 \text{ lane meters (About)}$</td>
</tr>
<tr>
<td>Lower hold car decks</td>
<td>-/-</td>
<td>$86 \text{ cars}$</td>
</tr>
</tbody>
</table>

Free Heights for Passenger & Crew areas.......................2.10 m
Trailer Decks........................................................................4.40 m
Car Decks.............................................................................2.50 m

Tank Capacities (100\% volume):

<table>
<thead>
<tr>
<th>Fuel oil</th>
<th>Approx.</th>
<th>$1158.9 \text{ m}^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel oil</td>
<td>-/-</td>
<td>$82.0 \text{ m}^3$</td>
</tr>
<tr>
<td>Lub oil</td>
<td>-/-</td>
<td>$230.2 \text{ m}^3$</td>
</tr>
<tr>
<td>Fresh water</td>
<td>-/-</td>
<td>$914.7 \text{ m}^3$</td>
</tr>
<tr>
<td>Water ballast</td>
<td>-/-</td>
<td>$2988.1 \text{ m}^3$</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>-/-</td>
<td>$400.4 \text{ m}^3$</td>
</tr>
</tbody>
</table>
Classification Society:

The vessel, including hull, machinery, and equipment and outfitting, shall be constructed in accordance with the Rules and Regulations of the Classification society under survey which is to be Lloyds Register (LR), the vessel is to be built in accordance with the rules in force at the time of signing the contract.

The distinguishing class notation shall be:

Lloyds Class +100 A1 +1AS+LMC UMS + LMC Ro-Ro Passenger and Vehicle Ferry, Unrestricted navigation, ICE Class 1AS

Rules and Regulations:

The Vessel shall fly a European flag and shall be designed and built according to EU rules and regulations.

International Conventions:
In a summary the following rules and regulations shall be considered for building and outfitting the Vessel:

- International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS) as amended up to the date of signing of the Contract
- SOLAS Regional Agreement (Stockholm Agreement) Wave height 2.5 m
- EU Directive 2009/45 as amended up to the date of signing of the Contract
- IMO Safe return to port regulation.
- 1978 Protocol relating to the MARPOL 1973 (MARPOL PROT 1978) all Annexes applicable to this type of vessel as amended up to the date of signing of the contract together with national requirements.
- Convention to the International Regulations for Preventing Collision at Sea, 1972 (COLREG 1972) with latest amendments.
- National Rules on Tonnage Measurement of Ships
- IMO Res. A. 468 (XII) Noise levels on Board Ships
- ILO: Convention no. 92 and 133: Convention concerning Crew Accommodation on Board Ship (except for swimming pool for crew)
- ILO Code of Practise, Safety and Health in Dock Work
- ISO rules 9367-1, Edition 1989 (E), to form minimum requirement on lashing and securing arrangement onboard
- Requirements of International Pilot Association.
- Lifts according to EN 81.
- ISO 8468 Ship’s Bridge Layout and Associated Equipment requirements and Guidelines (as far as applicable in what regards aft view).
- ISPS Code

Powering and Speed:

The mean speed of the Vessel on trials with a clean bottom, calm water, hull fitted with bilge keels at a mean draught of 6.80 m, 5745 tons deadweight at 85 % of MCR and with 10% sea margin is to be 26.4 knots in smooth deep water and in calm weather.

Certificates:

All necessary certificates for the proper operation of the ship as Passenger ship with maximum persons on board be supplied including:
- Classification Society Certificate for:
  - Hull
  - Machinery
  - Boilers
  - Automated installation
  - Refrigerating installations for provision
  - International Tonnage Certificate
  - Load Line Certificate with the survey report and the stability file
  - Passenger Ship Safety Certificate
  - IOPP Certificate (MARPOL)
  - SEEMP Certificate
  - Certificate of compliance with MARPOL (all Annexes)
  - Register of cargo gears
  - Builder’s Certificate.
- Certificates for anchors, anchor chains, cables, davits, lifeboats and all other mandatory certificates required for this type of vessel in compliance with relevant regulations.
- De-rating exemptions Certificate.
- Panama and Suez Certificates.

Further to the above listed certificates, all equipment and materials used in the construction of the vessel shall be MED certified.

Other documents:
- Report of survey of lifts or elevators.
- Drinking water analysis, chlorination-de-chlorination analysis
- Deviation curves for magnetic compass.
- File compiling the assembling parameters of the ship and ship’s equipment, in particular: stabilizer clearance values, resilient mount setting values, diesel engine stresses and insulation readings.

Standards:

Following standards to be applied to the construction of the vessel, besides the fittings especially described hereinafter.
4.2.2 Hull Structure

The Steel Hull shall be constructed in accordance with Classification Society’s rules. In order to avoid the risk of stress concentrations and deformations in the hull and the superstructure, 3D Finite Element Analysis shall take place.

Materials:

As a guide, the steel hull quality to be according to the Production standard on the IACS N° 47 Shipbuilding and Repair Quality Standard, Part A and to Yard Standards concerning particularly the tolerances of flatness. Particular attention is granted to the flatness of the decks and bulkheads made of thin plates, less than or equivalent to 6 mm thick.
Concerning the hull strength structure, the plates and sections are made of steel approved by the Classification Society, and are delivered with a certificate issued by the Classification Society.
Plate thicknesses shall not be less than 6mm on Decks except Deckhouse and superstructure external walls shall be no less than 5 mm.

Welding:

The hull is to be welded throughout corresponding to the requirements of the Classification society. The builder is to avoid shell deformation on topsides considering the aesthetic profile of the vessel.
Welds are subjected to inspection, in compliance with the rules set forth by the Classification Society. All steel plates and sections are shot blasted, and coated with a primer.

4.2.3 Hull Outfitting

Anchors and chains
Two (2) high holding power anchors will be supplied. Anchors shall be fully balanced. The anchors must be connected by pendants with swivel links to the anchor chain.
One (1) spare anchor will be supplied.

Chain lockers, Chain pipes, Hawse pipes, Anchor pockets
Two self stowing chain lockers with flush inside shall be provided. Gratings of perforated galvanized steel plate to be installed about 700 mm above the bottom of chain lockers. Access must be provided below the grating with manholes and with hatchway in upper part of lockers.

Chain pipes to be made of rolled steel plate and to have a diameter not less than 8 times the chain diameter. Lower end of pipes to have conical shape and round steel bar fitted around the lower edge.

Mooring:

Bollards are of the fabricated, heavy thickness tube construction. They are provided with loops for stoppers. The fairleads and rollers are provided with bronze bushings, with
grease nipples and flexible pipes to connect the crow’s foot of the rollers inside the bulwark (case of hardly accessible grease nipples).

Permanent mooring Equipment:

Aft:

| 4 fairlead with 9 rollers each type NP109 |
| 4 fairlead with 4 rollers each type NP104 |
| 4 bollards nominal size 400 dia. According to NS2584 |

Fwd:

| 2 fairlead with 9 rollers each type NP109 |
| 2 fairlead with 4 rollers each type NP104 |
| 6 bollards nominal size 400 dia. According to NS2584 |
| 18 Rollers 250 diam. according to NS2584 |

Hydraulic deck machinery:

The system consists of hydraulic pressure system with capacities according to class requirements. Two windlasses each with one cable lifter one mooring drum and one warping end. Break power of about 120T. Six mooring winches each with one mooring drum and one warping end, winches with auto tension.

Steering Gear:

Two electro-hydraulic rotary vane type rudder actuators shall be provided in the steering gear room. The synchronous operation of rudders must be performed electrically. Rudders must be possible controlled independently during manoeuvring.

Bow Thrusters:

Two bow thrusters of controllable pitch with estimated power of 1200 kW each to be installed. The thrusters are working through the main switchboard with a frequency converter and can be started from the bridge, or from the engine control room.

Zero speed retractable type Fin Stabilizers:

One (1) pair of active type folding fin plant is to be installed to ensure good sea keeping ability and passenger comfort in bad weather conditions.

Stabilizing equipment shall be sized for 80% roll reduction at 22 knots and effective wave slope capacity of 4 degrees.

The control system will provide remote control from the bridge. Local control and roll response simulation to be arranged from the local control unit.
Stern Ramps:

Two stern ramps/doors giving access to Main Deck shall be provided. The ramps are to be operated by directly acting cylinders. In stowed position the ramps serve as a watertight door, hydraulically locked with cleats by means of lashing devices. Leakage control and monitoring system as mentioned in section 4.01 shall be provided. Optical indication for closed/locked position will be provided in the control board, the mimic panel and on the bridge.

Control of operations from a combined control stand positioned near the ramps (opening, closing, locking with cleats), also from Deck 5 by means of portable push button controls.

The ramp shall be equipped with railings and flaps on the shore side. The edges of the flaps to be smoothly rounded as well as the corners shall be arranged with radio. In stowed position, the shore side flaps to be folded. Under normal working conditions the ramp inclination not to exceed 6°. Width=12.20m, Length (excl. flaps)= 15m

Tiltable Ramp

One tiltable ramp is arranged in 2nd deck. The tiltable ramp shall consist of a single main section with hinged end flaps. When closed the ramp forms a water tight hatch a 2nd deck and becomes a vehicle ramp when lowered and one end rests on 3rd deck. Ramps are arranged for fire insulation A60.

Ramp cover 3rd deck

One fixed ramp is to be installed on main deck and connects the main garage deck with the upper garage deck. One end pivoting ramp cover consisting of one end panel will be built into 3 deck. The ramp cover is operating by hydraulic cylinders.

Shell doors

Pilot / bunkers doors hydraulically operated and cleated.

Life Saving Equipment:

The vessel shall be equipped with LSA equipment’s according the regulation for short int. voyages and the number of persons onboard. The Lifeboats to be built in GRP and to be partly enclosed type approved for passenger ships and to have inboard diesel engines. The Rescue & Fast rescue boats to be of certified type, with outboard motor of sufficient power.

Life Boats: 2x150pers. + 2x100pers.

Life-Rafts: Two Marine Escape Systems (MES) to be installed, each side with capacity 450pers. In addition davits for lowering type life-rafts to be installed with capacity 110 pers. for each side of the ship. Additionally, 8 spare rafts of 50 persons to be included as per regulation.

Additional Lifesaving equipment e.g. Lifejackets, Lifebuoys, rockets, ect. to be delivered and placed onboard according to the rules.
Fire & Emergency Alarm Systems:

All accommodation and service spaces, stairway enclosures and corridors to be equipped with a fixed automatic addressable smoke detection and alarm system. A combined general/fire alarm system to be arranged all over the ship by loudspeakers. The system to utilize the P.A. announcement system.

Fire-fighting systems:

Vessel to be equipped with the following fixed fire-fighting systems:
- Fire hydrants connected to Fire line throughout the ship.
- Drencher system for cargo holds, one drencher pump 330cu.m/h to be installed.
- CO2 & local application systems in engine room. Bottles of sufficient number to be installed according to rules.
- Water fog automatic system to be installed to cover accommodation spaces. Additional portable fire-fighting equipment to be installed onboard according to F.C. plan.

4.2.4 Accommodation

Accommodation space shall consist of European standard public spaces, private cabins spaces, air type seat spaces, office space, catering space, laundry space, sanitary space and machinery space. Furniture and fixtures all of heavy duty type, shall be provided according to the interior design of the Builder’s architect in accordance with the requirements of Rules and Regulations.

Partitions, Linings and Ceilings:

Lining shall consist of rock-wool incombustible panels, with single face metal sheet, 25 mm thick or composite material, with PVC or painted metal faces.

Depending on the type of panels, may be with anti-squeaking noise fabric or equivalent system fitted on galvanized steel sections, and are in compliance with the rules. The ceilings must be of the groove joint design, easily removable, made of electrically zinned steel or aluminium panels.

Easily reachable inspection covers shall be provided to access valves, fire dampers and other devices located behind the ceiling. In general, the thickness of insulation in the ceiling panels to be of 25 mm.
Passenger Cabins:

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>NUMBER</th>
<th>TYPE</th>
<th>MARK</th>
<th>PAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>Twin bed (Disabled)</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Twin bed (window)</td>
<td>A</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Twin bed (deluxe)</td>
<td>A</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Four bed (window)</td>
<td>A</td>
<td>92</td>
</tr>
<tr>
<td>AB</td>
<td>113</td>
<td>Four bed (inner)</td>
<td>AB</td>
<td>452</td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>Four bed (inner)</td>
<td>B</td>
<td>76</td>
</tr>
<tr>
<td>Total</td>
<td>197</td>
<td></td>
<td></td>
<td>704</td>
</tr>
</tbody>
</table>

Lounges (1195 m²)
- Air type seats: 181
- Armchairs, sofas: 544
Total No. of available seats: 725

Restaurants (430 m²)
- Distinguish class: 131 seats
- Economy class (Self-service): 238 seats
Total No. of available seats: 369

Open decks (1850 m²)
- Shaded with available seats: 840 m²
- Open: 1010 m²

Crew Accommodation:

Crew quarter should be constructed taking into account the ILO regulations in force. Crew spaces consist of:
- Officers Cabins: 30x1pers. = 30
- Crew cabins: 38x2pers. = 76 All cabins with separate sanitary rooms (WC & shower).
- Staff cabins: 10x2pers. = 20
- Ships Office
- Laundry (washing machine with spin-dryer, stumble dryers, washing benches)
- Linen room
- Mess / Day room for crew with pantry
- Mess / Day room for officers
- Infirmary
Climatic Conditions:

Except if otherwise stated, the vessel and the equipment are designed for operation under the following conditions:

<table>
<thead>
<tr>
<th>Condition</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea water temperature</td>
<td>+0°C</td>
<td>+34°C</td>
</tr>
<tr>
<td>Outside air temperature</td>
<td>+5°C</td>
<td>+38°C</td>
</tr>
</tbody>
</table>

The design should be made for 100% fresh air supply but the system should give the opportunity for 100% recirculation. Relative Humidity: 75%

Air-conditioning & Ventilation:

Air conditioning & ventilation system designed to be in accordance with the following conditions:
- Summer: outside 35°C, 70%RH, Inside 28 °C, 50%RH, Sea water 32 °C
- Winder: outside -5°C, inside +22 °C, 55%RH, seawater 0 °C.

The vessel will be fully ventilated in all accommodation and public spaces for passenger and crew. Providing 50% fresh air and with the ability of recycling 100%. The A/C units to be of the heat recovery type. A/C central to have preheating battery and zone batteries for each public room. During the cold season, the air to be preheated by a heating coil unit. During the warm season the air to be cooled by cooling unit.

Noises and Vibrations:

Noise levels in the design condition not to exceed the following

<table>
<thead>
<tr>
<th>Space</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cabins</td>
<td>55 dB (A)</td>
</tr>
<tr>
<td>Public Spaces</td>
<td>60 dB (A)</td>
</tr>
<tr>
<td>Outside passenger decks</td>
<td>70 dB (A)</td>
</tr>
</tbody>
</table>

In all other spaces (crew, service…), the noise level limits, given by the resolution IMO A 468 (XII) “Code on noise levels on board ships”, should be met.

Required levels must be obtained in at least 85% of the space, in each category of space.
For the definition of the vibration levels limits, reference is made to International Standard ISO 6954 (1984), Guidelines for the overall evaluation of vibrations levels in Merchant ships”.

Provision rooms:

a) Dry provision rooms
   Two dry stores of about 40m² & 14m² walls and ship sides to be insulated and covered with thin galv. Steel plates. Racks with shelves to be arranged.

b) Refrigerated & freezing rooms
Following departments to be installed: 4 Freezing rooms (-18 degr. C) & 2 cooling rooms (+4 degr. C) to be used for storage (Meat, Fish, Cheese, Vegetables, milk, wines, ect.)

**Galley & Pantries:**

To be designed and equipped for full restaurant services for the specific number of passengers and crew. Catering equipment is of marine type, made of stainless steel. All service spaces and stores to be fitted with furniture and equipment of fire redundant materials.

Galley compartments to be equipped with necessary benches, shelves and racks. To be arranged as indicated on G.A. plan.

Stainless steel to be used for lining and ceilings. Floor to have tiles.

Typical Pantry equipment's consist of: Ice well, ice crusher, ice cube module, ice cream cabinet, refrigerated counter, Beer machine, coffeemaker, dishwasher, cash register, back bar counter, back bar shelf, ect.

**Lifts & Escalator:**

Three lifts operated by electrical winches to be installed:

One galley lift with lifting capacity SWL=100kg, one provision lift with lifting capacity SWL=1000kg and one passenger lift with lifting capacity SWL=1000kg.

Two pair of escalators to be installed (free passage approx. 1000mm), one pair for aft passenger entrance and one for fwd entrance.

**Black & Grey water systems:**

The black water from toilets to be led to the vacuum collecting by vacuum ejector suction. From vacuum collecting 25m³ tank the black water to be pumped to the sewage treatment plants. After purification the clear and disinfected water to be discharged overboard or to ashore connections.

Vacuum equipment consist of: 3 pumps, 3 vacuum ejectors, valves & controls.

Sewage treatment plan for about 1600 pers. Consist of treatment tank and a sedimentation section, one aeration blower a chlorinating system, one discharge pump and instrumentation. The whole system to be of approved type according to Marpol regulations.

Grey water drains to be gathered into main lines and collected into grey water collecting tanks. Grey water discharged pump to be arranged for empting the tank either direct overboard or shore connection.

**4.2.5 Machinery**

Design conditions for engine room machinery and equipment shall be based on the following ambient conditions unless otherwise specified:
A heat and sound insulated and air conditioned engine control room to be arranged. In the control room a main switchboard and control panels for remote controlled equipment and monitoring of machinery to be arranged.

Max. viscosity of HFO (Heavy Fuel Oil) for main engines and boiler to be 380cSt/50°C.

Main diesel engines:

For the service speed of 26.4 knots, the vessel will accommodate four main engines four stroke cycle, single acting, trunk piston, non-reversible, turbo charged, medium speed type marine diesel engine, 8L58/64 with the ability of running on heavy fuel oil from port to port.

Main Data for specified Diesel Engine:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder Bore</td>
<td>580mm</td>
</tr>
<tr>
<td>Piston Stroke</td>
<td>640mm</td>
</tr>
<tr>
<td>No. of Cylinders</td>
<td>8</td>
</tr>
<tr>
<td>Max cont. Output</td>
<td>11120kw at 428rpm</td>
</tr>
<tr>
<td>Mean effective pressure</td>
<td>23bar</td>
</tr>
<tr>
<td>Fuel consumption</td>
<td>179g/kW.h + 3% tolerance</td>
</tr>
</tbody>
</table>

Nox emissions according to MARPOL, Annex VI regulation.

Propellers:

Two controllable pitch four-blade highly-skewed propellers to be provided. The propellers shall have maximum diameter about 5200mm and satisfactory clearances between hull and propeller.

The direction of rotation: inwards

Propeller speed is to be about 140rpm.

Hub material & blade material of: Stainless steel

Shafting:

Two propeller shafts to be installed, each line of shafting will comprises one tail shaft and two intermediate shafts. Tail shafts coupled to the intermediate shaft by an hydraulically fitted sleeve coupling.

Shaft diameter at bearings to be 10mm in excess of the requirements of the classification society.
Reduction gear and couplings:

Two (2) double-input/single-output low noise reduction gears with built in thrust bearings and built in oil distribution (OD) box to be installed between the main engines and the propeller shaft. Gear ratio must be determined according to propeller design. Each gear to be fitted with a secondary driven P.T.O. capacity max: 1500kW – 1500rpm.

Auxiliary Engines:

Three auxiliary diesel engines, type 6L28/32H, 6 cylinders, four stroke single acting, forced lubricated, turbocharged and intercooled, trunk-piston, in line type. Each engine able to develop sufficient power at 750rpm as continues service rating to drive the generator.

Normal max. continues rating: 1795 BHP on flywheel at 750rpm., 1320kW on flywheel, 1265kW on terminals of alternator at 50 Hz, Voltage: 3x380V.

Fuel Oil: HFO max. 380oSt at 50degr. C.

Additionally one emergency diesel driven generator set to be installed in a separate room on upper deck with the following capacity: 200kW, 3x380V, 50Hz 1500rpm, type Volvo penda or equivalent.

Two shaft generators (Any Manufacturer), 1500kW, 3x380V, 50Hz, P.F. 0.8 to be installed to take load of bow thrusters when starting.

4.2.6 Automation

The machinery installation should comprise of a system of automation and instrumentation to meet classification requirements of LR-UMS Class. The remote control stand for main engines and CPP must be provided in the engine control room and the wheel house. An emergency control stand shall be provided at the engine side. The necessary gauges, thermometers, etc. to be furnished for the main engine, CPP, generating engines, boiler etc. as specified in the various section of this specifications and as required for proper operation. Local gauges, thermometers, etc. for the main engine and auxiliaries to be furnished in compliance with each Subcontractor's standard, where as those on piping to be of builder's standard. An integrated alarm, monitoring and control system (IAS) to be provided for reliable operation of the main propulsion machinery and the ship form the bridge with an unattended engine room. There will be arranged possibility to transfer data from the monitoring system ashore and vice versa.

System configuration consist of:
- 6 pc operator stations, each consisting of one 19" monitor, operator control panel with tracker-ball and main computer unit
- 2 pc alarm/log printers.
- 8 pc alarm panels
- 7 pc process stations/units
- 2 pc uninterruptible power supply units (UPS)

Communication:
Redundant Local Area Network (LAN) for communication between operator stations and process control stations/units
Two serial interfaces, one to maintenance computer and one to loading computer

4.2.7 Electrical, Navigation and Communication System

Electric Equipment:

The electric equipment and installations to comply with rules and regulations and further to comply with IEC 92 recommendations. The three phase electric power networks are arranged as 3-wire systems with insulated neutral. The electric system to be supplied and fitted to connect all electrical equipment related to hull, machinery and electrical sections. All electrical installation, including machinery fittings, switch gear, wiring etc. to comply in all respects with this Specification as well as all class requirements, and furthermore the rules and regulations mentioned in this Specification. All kinds of electrical and automation components are standardized as far as practicable with regard to capacity, type, size, make etc. in order to simplify design, spare parts, service and maintenance. For automation of power supply networks with diesel gen sets, shaft generators, bus-bar tie circuit breaker and heavy consumers a Power Management System is to be installed. The electric installations consist of: Three Aux. Generators: 3phase, 380V 50Hz, 1265kW, two shaft generators: 3phase, 380V 50Hz, 1500kW, one emergency generator: 3phase, 380V 50Hz, 200kW. Two Lighting transformers: 3phase, 380/230V 50Hz, 150kVA for supplying lighting and minor equipment. Two Emergency Lighting transformers: 3phase, 380/230V 50Hz, 50kVA for supplying lighting and minor equipment for emergency Switchboard. One transformer is spare. Two cabling socket transformers: 3phase, 380/230V 50Hz, 99kVA. Batteries and a UPS system 25kVA to be installed.

Navigation systems:

The following systems shall be installed:
- One fully adaptive autopilot system with the following function/ performances.
- Two radars one X-band & one S-band with raster scan daylight colour 16 "effective raster scan ARPA radar colour screen, including performance monitor.
- One 50 kHz navigation echo sounder with 0 -1000 m measuring range.
- One dual axis speed log for relative (water track) and true (bottom track) speed simultaneously measurement.
- One wind- velocity and direction measuring system.
- INS and ECDIS shall be provided with capability to perform automatic steering along the pre-planned route in straight and curved lines.
- One set of AIS shall be installed for automatic providing/receiving the information such as ship’s name, position, speed, heading, etc. with ship-to-shore mode and ship-to-ship mode.
- Two sets of 12 channels DGPS navigator with alarm for arrival and cross track error shall be provided on the chart table, and antennas on the wheelhouse top.
- Gyro compass: One Master compass built in the steering stand & One Slave compass with comparator built in the electric equipment room.
- One set of voyage recorder (VDR) shall be installed in the electric equipment room.

Radio Equipment:

GMDSS Radio Equipment. Battery low voltage alarm must alarm and indicate on radio battery charger according to GMSI.
According to the GMDSS rules for AREA 3, the following equipment to be installed in the wheelhouse:
One complete GMDSS MF/HF DSC radio system (including radio telex).
One Inmarsat Standard "C" satellite communication according to GMDSS rules to be installed in the wheelhouse. Complete with antenna and printer.
Navtex Receiver: One Navtex receiver, frequency 518 kHz. Complete with antenna.
Inmarsat Standard
One Inmarsat Fleet 77 satellite communication SES with 12 lines to be installed with connection to ships PABX, for telephone fax and data communication. To be interfaced with Owners' telephone company.

Ship/Shore Satellite Communication System
Owner's supply and installation after Vessel's delivery.

VHF Radio Telephones and VHF DSC
Two Maritime VHF telephones installed in Navigation console with all international VHF channels including USCG channels, dual watch. Power supply 230 VAC and 24 VDC with automatic change-over. Handsets for bridge wing operation port and starboard and loudspeakers, connected to other VHF.
Two VHF DSC, one with Ch. 70 Watch keeping receiver.

Emergency Radio Equipment
Two EPIRP 406 MHz free float emergency beacon.
Two Radar Transponder 9 GHz.
Three Portable GMDSS VHF and one (1) aeronautical, incl. battery, charging unit and emergency lithium battery. Hands-free (water-proof) facilities must be provided approved by the Flag Authorities.

Mobile telephones
One mobile telephone to be permanently installed with antenna as follows:
- Wheelhouse System to be GSM or as otherwise stated by the Owner.
4.3 Determination of Design Particulars

As previously described the complex design of Ropax vessels needs certain attention. The design of such vessels in terms of dimensions vary according to their operational profile, but sometimes even if the operational profile is similar vessels tend to vary due to the diverse and contradicting factors leading the design of the vessel. The database was carefully collected again with a certain set of criteria. The majority of the vessels in the database represent the fleet of Tallink Group and NAP's database.

4.3.1 Criteria for Data Entry

For the collection of data as displayed above we had established a set of entry criteria:

- Modern Designs representing the state of the art
- No entry of vessels that are more than 10 years old
- Substantial Passenger Carrying Capacity
- Engaged in European Routes
- No entry of vessels that do not have all main particulars available
- Entry of vessels that their particulars can be retrieved by credible sources. (Final Drawings, Ship's Doc.)

The database along with market statistics has allowed us to determine an average GT number for vessels with the above characteristics in Europe. The average determined GT is 30,700. Based on that figure we have undertaken a regression analysis correlating GT with the main ship particulars, L, B, D, T.

As it is understood the sample size is limited, however it is representative of the dominating modern designs in the European market. In addition to that the quality of the dataset is high, since data are coming from Operator and Design Office, this will also enable us to go back and retrieve further data if needed during the course of the project.

The regression is based on the following principles:

\[
L_{OA} = \alpha + \beta \times (GT) + \gamma \times (GT)^2 + \varepsilon
\]

\[
B_{max} = \alpha + \beta \times (GT) + \gamma \times (GT)^2 + \varepsilon
\]

\[
T_{max} = \alpha + \beta \times (GT) + \gamma \times (GT)^2 + \varepsilon
\]

\[
Age = \alpha + \beta \times (GT)^{-1} + \varepsilon
\]

The database consists of 35 vessels which are all in operation in European Waters. The operational profile of the vessels is a mixture of long and short routes from the Baltic and Mediterranean Sea. The average age is 10 years, the average Passenger Number is 1900 persons and the average crew number 100 persons.
Results of Main Particulars Regression Analysis

REGRESSION RESULTS

MAIN DIMENSIONS

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LOA</td>
<td>195</td>
</tr>
<tr>
<td>BREADTH</td>
<td>26</td>
</tr>
<tr>
<td>DRAUGHT</td>
<td>6.63</td>
</tr>
<tr>
<td>Ves. No.</td>
<td>LOA</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
</tr>
<tr>
<td>1</td>
<td>227.01</td>
</tr>
<tr>
<td>2</td>
<td>227.01</td>
</tr>
<tr>
<td>3</td>
<td>227.01</td>
</tr>
<tr>
<td>4</td>
<td>227.01</td>
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<tr>
<td>5</td>
<td>227.01</td>
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<tr>
<td>6</td>
<td>227.01</td>
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<tr>
<td>7</td>
<td>227.01</td>
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<tr>
<td>8</td>
<td>227.01</td>
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<tr>
<td>9</td>
<td>227.01</td>
</tr>
<tr>
<td>10</td>
<td>227.01</td>
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<tr>
<td>11</td>
<td>227.01</td>
</tr>
<tr>
<td>12</td>
<td>227.01</td>
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<tr>
<td>13</td>
<td>227.01</td>
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<tr>
<td>14</td>
<td>227.01</td>
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<tr>
<td>15</td>
<td>227.01</td>
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<tr>
<td>16</td>
<td>227.01</td>
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<td>17</td>
<td>227.01</td>
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<tr>
<td>18</td>
<td>227.01</td>
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<td>19</td>
<td>227.01</td>
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<tr>
<td>20</td>
<td>227.01</td>
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<tr>
<td>21</td>
<td>227.01</td>
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<tr>
<td>22</td>
<td>227.01</td>
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<td>23</td>
<td>227.01</td>
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<td>24</td>
<td>227.01</td>
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<td>25</td>
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<td>227.01</td>
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<td>27</td>
<td>227.01</td>
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<td>28</td>
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<tr>
<td>29</td>
<td>227.01</td>
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<tr>
<td>30</td>
<td>227.01</td>
</tr>
<tr>
<td>31</td>
<td>227.01</td>
</tr>
<tr>
<td>32</td>
<td>227.01</td>
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<tr>
<td>33</td>
<td>227.01</td>
</tr>
<tr>
<td>34</td>
<td>227.01</td>
</tr>
<tr>
<td>35</td>
<td>227.01</td>
</tr>
</tbody>
</table>
4.3.2 Baseline General Arrangement: Large Ropax

Fig. 17: ROPAX Baseline General Arrangement [NAP’s Archive].

**Technical Data:** For the aim of the project, further technical data will provided to the partners in order to allow calculation of motion responses and identification of other risks related to the ship’s particulars, such as: Lines Plan or Offsets, 3D Hull-Form geometry (.stl or .dxf), Mass Distribution (where possible), Loading Conditions (with GM values) and Hydrostatics with main hull-form coefficients.
4.4 Handy-Size RoPax Outline Specifications

The present specification is referring to the construction of a Ropax ship for voyages within European waters. The ship is to be constructed for category Α EUROSOLAS. All the requirements relative to IMO/SOLAS are fulfilled.

4.4.1 General

The General Arrangement layout is to provide effective and fast cargo loading/unloading, easy orientation for passengers and good simultaneous flow of cargo, passengers, stores and necessary services.

For entrance of cars and trailers there are stern ramp as well as bow door and ramp. The vessel can load trailers on Deck 3. Private cars can be loaded to upper garage on Deck 5, to hoistable car decks above the trailer deck and in the lower hold on two levels.

The upper garage loading is arranged from main deck via a tiltable ramp. The lower hold is arranged for cars on two levels. To the upper level there is access along lower-able ramp. Between the levels a fixed ramp is arranged. Passengers embark the vessel on deck 3 (main deck) at stern via passenger ramps in the stern and at the sides or through passages on the main ramp. Crew cabins and 17 passenger cabins are located on Deck 5, forward part. Crew public spaces are located on Deck 7.

Passenger deluxe cabins, most of the standard passenger cabins and cabins for senior officers are located on Deck 7. All cabins are provided with private toilet facilities. Passenger public spaces are concentrated on Deck 6 there are lounges, shop etc. On Deck 7 there is an outdoor cafe as well as a large Sun Deck area with toilets and bar service. On Deck 8 there are covered seating areas aft and behind the wheelhouse with toilets.

The vessel has two shaft lines with controllable pitch propellers, each driven by two diesel engines through a gearbox. Power is generated with three diesel engine generators and two shaft generators. An emergency diesel-generator is provided as per rules. There is also one auxiliary oil fired thermal oil heater. For each pair of main engines is provided one exhaust gas heater.
Main Particulars:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Overall</td>
<td>( L_{OA} = 142,00 \text{ m} )</td>
</tr>
<tr>
<td>LBP</td>
<td>( L_{BP} = 132.6 \text{ m} )</td>
</tr>
<tr>
<td>Breadth</td>
<td>( B = 21,0 \text{ m} )</td>
</tr>
<tr>
<td>Depth (up to Main Deck)</td>
<td>( D = 7,5 \text{ m} )</td>
</tr>
<tr>
<td>Deadweight</td>
<td>( T_s = 5,3 \text{ m} )</td>
</tr>
<tr>
<td>Max Summer Draught</td>
<td>( T = 5,3 \text{ m} )</td>
</tr>
<tr>
<td>Scantling Draught</td>
<td>( V_s = 26 \text{ knots} )</td>
</tr>
<tr>
<td>Service Speed</td>
<td>( 14700 )</td>
</tr>
<tr>
<td>GRT</td>
<td>( 1890 \text{ summer and 1400 winter} )</td>
</tr>
<tr>
<td>Number of passengers</td>
<td>( 530 \text{ LM Trucks + 170 cars.} )</td>
</tr>
<tr>
<td>Lower Vehicle Space capacity</td>
<td>( 58 \text{ private cars} )</td>
</tr>
</tbody>
</table>

Deadweight Breakdown:

<table>
<thead>
<tr>
<th>Category</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailers</td>
<td>865 t</td>
</tr>
<tr>
<td>Cars</td>
<td>140 t</td>
</tr>
<tr>
<td>Passengers and crew</td>
<td>170 t</td>
</tr>
<tr>
<td>Stores and miscellaneous</td>
<td>80 t</td>
</tr>
<tr>
<td>Fresh water</td>
<td>180 t</td>
</tr>
<tr>
<td>Heeling water</td>
<td>100 t</td>
</tr>
<tr>
<td>Heavy fuel oil</td>
<td>300 t</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>50 t</td>
</tr>
<tr>
<td>Lubricating oil</td>
<td>40 t</td>
</tr>
</tbody>
</table>

Regulations:

The ship, the machinery and her equipment in general shall fulfil the following regulations:
1. SOLAS 1974 as amended till the keel-laying date as a two compartment ship with SOLAS '90.
2. EU Directives
3. Flag Administration (HSMIGD) Regulations
4. Class Rules
5. Stockholm Agreement.
6. IMO, Resolution A.468 (XII), Code on Noise Levels on Board Ships, adopted 1981

Classification:

The vessel, including hull, machinery, and equipment and outfitting, shall be constructed in accordance with the Rules and Regulations of the Classification society under survey
which is to be Lloyds Register (LR), the vessel is to be built in accordance with the rules
in force at the time of signing the contract.
The distinguishing class notation shall be:

Lloyds Class +100 A1 +1AS+LMC UMS + LMC Ro-Ro Passenger and Vehicle Ferry,
Unrestricted navigation, ICE Class 1AS

Flag:

European Flag Administration

Vehicle Spaces:

The capacity of the vehicle space (main) will be approx. 530 LM for trucks and 170 units of private cars in the upper garage and main deck platforms.
In addition, in the lower vehicle space can take 58 units of private cars.

Permissible axle load 15 tons for trucks and 1 ton for private cars.

Free Heights:

<table>
<thead>
<tr>
<th>Description</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trailer deck below hoisted car decks</td>
<td>4.6</td>
</tr>
<tr>
<td>Below hoistable decks when lowered</td>
<td>2.5</td>
</tr>
<tr>
<td>Above hoistable deck</td>
<td>2.1</td>
</tr>
<tr>
<td>Upper garage</td>
<td>2.5</td>
</tr>
<tr>
<td>Lower hold (both levels)</td>
<td>2.0</td>
</tr>
</tbody>
</table>

4.4.2 Accommodation

Officer and Crew Cabins:

<table>
<thead>
<tr>
<th>Deck 8</th>
<th>berth</th>
<th>cabins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Officer single cabin</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deck 7</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Officer suite</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Officer single cabin</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deck 5</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew two pers. cabin</td>
<td>64</td>
<td>32</td>
</tr>
<tr>
<td>Crew three pers. cabin</td>
<td>6</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total number of officer and crew cabins**

<table>
<thead>
<tr>
<th>Spaces</th>
<th>Area (m²)</th>
<th>Seats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Officer &amp; crew mess room</td>
<td>70</td>
<td>42</td>
</tr>
<tr>
<td>Recreation room(s)</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>
Passenger Accommodation:

<table>
<thead>
<tr>
<th>Deck 7</th>
<th>berths</th>
<th>cabins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deluxe cabins (1+1 berth)</td>
<td>17+17</td>
<td>17</td>
</tr>
<tr>
<td>Standard outside cabin (2+2 berth)</td>
<td>44+44</td>
<td>22</td>
</tr>
<tr>
<td>Standard inside cabin (2+2 berth)</td>
<td>26+26</td>
<td>13</td>
</tr>
<tr>
<td>Disabled cabin (2+1 berth)</td>
<td>4+2</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Deck 5</th>
<th>berths</th>
<th>cabins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard outside cabin (2+2 berth)</td>
<td>24+24</td>
<td>12</td>
</tr>
<tr>
<td>Standard inside cabin (2+2 berth)</td>
<td>20+20</td>
<td>10</td>
</tr>
</tbody>
</table>

**Total number of pax cabins**

268 76

Passenger Public Rooms:

*Deck 7*
Outdoor Cafe and sun deck

*Deck 6*
- Restaurants
- Children’s play room
- Bar
- Lounges amidships
- Shop
- Video games
- 1st class lounge
- Air type seats
- Info and purser’s office

**All public decks:**
- Passenger Stair-halls
- Public Toilets

Total inside public spaces to have about 1100 seats. For the balance up to the maximum passenger capacity seats on outer decks to be provided: about 200 shall be fixed seats and the rest chairs.

**Shaded area:**
Located in the aft part of Boat deck, having an area of 330 m² approx.

**Rest of public spaces:**
- Reception
- Bar: the ship is foreseen to have three (3) bars, one for each lounge and one in open deck.

**Embarkation – Disembarkation:**
Through an escalator (in combination with a fixed staircase), aft port side and through a fixed staircase, aft starboard side.
Air conditioning:
The ship will be fully air-conditioned in all the accommodation spaces and in all public
spaces (for crew and for passengers) with 80 % fresh air and 100 % recirculation ability.

Food Provisions Stores:
A space for storing food provisions is foreseen (on tank top level), having a total area of
200 m² approx.

Galley:
A Galley is foreseen, having a total area of 100 m² approx.

4.4.3 Hull Structure

The Steel Hull shall be constructed in accordance with Classification Society’s rules. In
order to avoid the risk of stress concentrations and deformations in the hull and the
superstructure, 3D Finite Element Analysis shall take place.

Materials:

As a guide, the steel hull quality to be according to the Production standard on the IACS
N° 47 Shipbuilding and Repair Quality Standard, Part A and to Yard Standards
concerning particularly the tolerances of flatness. Particular attention is granted to the
flatness of the decks and bulkheads made of thin plates, less than or equivalent to 6 mm
thick.
Concerning the hull strength structure, the plates and sections are made of steel
approved by the Classification Society, and are delivered with a certificate issued by the
Classification Society.
Plate thicknesses shall not be less than 6mm on Decks except Deckhouse and
superstructure external walls shall be no less than 5 mm.

4.4.4 Hull Outfitting

Anchor winches and mooring winches:

Fore part:
One (1) electro-hydraulic system for anchors and one (1) mooring winch.

Aft part:
Two (2) electro-hydraulic systems, preferably of low pressure type, for stern mooring.
All the winches of the ship to be AUTOTENTIONING type.

Stabilizers:
Aft folding fins, with 90 % damping ability for speed of 20 knots.

Rudders:
Two (2)
Propellers:
Two (2) High Skew, CPP

*Cooling machinery in air-condition system:*
Three (3) cooling machines in air-condition system – open type, using an ecological cooling agent, which fulfil 150 % of the required output.

*Boiler system:*
One (1) steam boiler with an automatic burner using heavy fuel oil, which will fulfill the heating requirements and one (1) economizer which will operate using the exhaust gases of the diesel generators.

*Anti-heeling system:*
A classic system is foreseen

*Thrusters for transverse move:*
Two (2) bow thrusters are foreseen, with appropriate output for manoeuvring (approx. 600 kW each).

*Cooling system for engines:*
Central cooling system for main engines and auxiliary engines, using fresh water

*Drainage and sewage treatment plant:*
The drainage system will be of vacuum type, with biological treatment installation

*Fire-Fighting:*
The fire-fighting system for the accommodation spaces and for the machinery spaces will be using fresh water under high pressure (HI-FOG type or equivalent). For cargo spaces an open drencher system using sea water will be installed. The ship will be equipped with a smoke detection system too.

*Navigation System:*
Preferably an automatic safe navigation system, based on a person in service on Bridge, according to the principle of FULLY INTEGRATED NAVIGATION SYSTEM. However, this subject will be re-discussed, so that other suggestions will be examined.

*Radio-communication:*
System of A2 Code, according to the international standards which are relative to the area of service and GMDSS.

*Automations:*
Preferably the main engine room, the auxiliary engine room and the pump room will be designed so that they will be able to work automatically in a 24-hour basis, without the presence of any men (24h-UMS), following a specific agreement. The status and operation indications will be transmitted to the control room and to the Bridge automatically. However, it is possible that other suggestions will be discussed.

*Electric plugs in vehicle spaces:*
There will not be any plugs in vehicle spaces
Tank capacities:

<table>
<thead>
<tr>
<th></th>
<th>Approx.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy fuel oil</td>
<td></td>
<td>490 m$^3$</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>-//-</td>
<td>96 m$^3$</td>
</tr>
<tr>
<td>Lub oil</td>
<td>-//-</td>
<td>165 m$^3$</td>
</tr>
<tr>
<td>Fresh water</td>
<td>-//-</td>
<td>250 m$^3$</td>
</tr>
<tr>
<td>Water ballast</td>
<td>-//-</td>
<td>780 m$^3$</td>
</tr>
<tr>
<td>Bilge water tank</td>
<td>-//-</td>
<td>35 m$^3$</td>
</tr>
<tr>
<td>Sludge tank</td>
<td>-//-</td>
<td>47 m$^3$</td>
</tr>
<tr>
<td>Grey-water tank</td>
<td>-//-</td>
<td>35 m$^3$</td>
</tr>
<tr>
<td>Overflow F.O.T.</td>
<td>-//-</td>
<td>31 m$^3$</td>
</tr>
</tbody>
</table>

Life Saving Appliances:

The minimum number of life boats required by the regulations for the specific type of voyages (for the minimum number of crew members), following communication with the ship owning company.

Stern Ramps:

- Two (2) stern ramps for loading / unloading of vehicles are foreseen, having permissible axle load 15 tons and 15 m length x 5 m breadth (approx.) each.
- Two (2) passenger ramps for embarkation / disembarkation, having dimensions 5,5 m x 1,8 m.

4.4.5 Machinery

Main Engines:

The ship is a twin screw vessel. The main machinery consists of four resiliently mounted medium speed diesel engines driving the propeller shafts and controllable pitch propellers (CPP’s) in pairs through reduction gears which are provided with secondary PTO’s for driving shaft generators. The main engines and reduction gears are situated in one watertight compartment.

Total installed propulsion power is 31,680 kW. The specification concerning the propulsion machinery with auxiliaries is based on 12V38 main engines and electric generating plant on 6L20 auxiliary engines. If another engine types will be chosen, the specification to be revised accordingly.

The machinery to be designed for operation in tropical climate conditions.

The engines to be designed for start, running, manoeuvring and stopping on heavy fuel oil viscosity up to 380 cSt at 50 oC (3500 sec Redwood at 100 oF).

Ambient conditions

The engines and the auxiliary equipment are designed for the following
Ambient conditions:

- Maximum ambient air temperature: 45 °C
- Maximum barometric pressure: 100 kPa
- Maximum relative humidity: 60%
- Max. cooling water temperature before engine: 38 °C
- Max. sea water temperature: 32 °C

Technical particulars:

<table>
<thead>
<tr>
<th>Number of engines</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation of engine</td>
<td>12V38</td>
</tr>
<tr>
<td>Cylinder number</td>
<td>12 in V</td>
</tr>
<tr>
<td>Max. continuous rating</td>
<td>7920 kW</td>
</tr>
<tr>
<td>Engine speed</td>
<td>600 rpm</td>
</tr>
<tr>
<td>Cylinder bore</td>
<td>380 mm</td>
</tr>
<tr>
<td>Piston stroke</td>
<td>475 mm</td>
</tr>
<tr>
<td>Mean effective pressure</td>
<td>24.5 bar</td>
</tr>
<tr>
<td>Mean piston speed</td>
<td>9.5 m/s</td>
</tr>
<tr>
<td>No. of engines rotating clockwise</td>
<td>2 acc. to machinery arrangement</td>
</tr>
<tr>
<td>No. of engines rotating counter clockwise</td>
<td>2 acc. to machinery arrangement</td>
</tr>
</tbody>
</table>

The power stated is valid at conditions in accordance with ISO 3046/I.

The engine to be tested at vendor’s workshop in accordance with the requirements of the classification society and vendor’s standard based on max. continuous rated power stated above. After test run the fuel rack position to be limited to 100 percent power.

Fuel oil consumption:

Based on fuels having a lower caloric value of 42 700 kJ/kg (10 200 kcal/kg):

- at 100% MCR: 181 g/kWh, tolerance ±5%
- at 85% MCR: 180.6 g/kWh, tolerance ±5%

The specified fuel oil consumption is based on the output of the diesel engine at ISO 3046/I conditions, with engine driven pumps (LT-, HT- and lubrication oil). Engine driven pumps will increase specific fuel oil consumption by about 3 g/kWh at full load and nominal speed.

The fuel consumption rate shall be measured on diesel fuel according to ISO 8217, Class F specification of Marine Fuels, Class DMX or DMA at the prevailing ambient conditions on the test bed. Corrections in accordance with ISO 3046/I - 1986 (E) specification.
**Diesel generators:**

Three (3) diesel generators with an output of 1000 kW (approx.) each at 720 or 900 RPM max, able to operate using heavy fuel oil and D.O., in the same way with the main engines. In addition to these, one emergency diesel generator with an output of 150 kW, according to the regulations. Two shaft generators are also foreseen for exclusive use of bow-thruster 2 x 600 kW.

**Shafting system:**

According to the regulations, with an additional diameter thickness of 8 mm, automatically oil-lubricated bearings with automatic temperature indications, and sealing with oil-lubricated shaft seals of divisive type front and back (SIMPLE COMPACT).

**Propellers:**

Two controllable pitch propellers with skewed blades, equipped with an emergency system, which will set up the propellers to full ahead in case of damage (diameter of propellers approx. 3,8 - 4 m)

**4.4.6 Noise and Vibration**

The noise and vibration values of the vessel to be within those defined in Det Norske Veritas Comfort class rules. Notation COMF-V(2 3) to be applied. For crew areas IMO Res. A468(XII) should also be followed.

The noise and vibration measurements to be carried out according to DNV Comfort class procedures and requirements.

Noise and vibration assessment to be made at early stage of design.

Special attention shall be paid in the design and construction of the vessel to limit noise, which may result in discomfort and annoyance to passengers and crew. The builder shall take all necessary measures by providing the best and most effective airborne and structure borne sound insulation devices to prevent the transmission of noise of any kind which might disturb the comfort of passengers and crew. This applies especially to passenger and crew cabins, public rooms and other spaces used by passengers.

For cabins, public spaces and passenger recreation areas, the following upper limits of noise levels are to be met as set for DNV comfort class 2 3:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cabins</td>
<td>55 dB (A)</td>
</tr>
<tr>
<td>Passenger public areas</td>
<td>62 dB (A)</td>
</tr>
<tr>
<td>Open decks in recreation areas (no wind)</td>
<td>70 dB (A)</td>
</tr>
<tr>
<td>Near ventilation inlet/outlet</td>
<td>75 dB (A)</td>
</tr>
</tbody>
</table>
Sound Reduction:

The acoustic insulation between accommodation spaces should be according to Comfort class

<table>
<thead>
<tr>
<th>Space</th>
<th>Lp +RW dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>- cabin to cabin (passenger)</td>
<td>90</td>
</tr>
<tr>
<td>- cabin to corridor</td>
<td>87</td>
</tr>
<tr>
<td>- cabin to stairway</td>
<td>100</td>
</tr>
<tr>
<td>- cabin to public space</td>
<td>100</td>
</tr>
</tbody>
</table>

Vibration

Special attention shall be paid to the design and construction of the vessel to minimize vibration which may result in discomfort and annoyance to passengers and crew or which may cause damage to structure, machinery and any other installed equipment.

The following upper limits of vibration levels are to be met as set for DNV comfort class 2 3. (mm/s peak for single frequency components between 5 and 100 Hz):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Passenger cabins</td>
<td>4.0</td>
</tr>
<tr>
<td>- Passenger public areas</td>
<td>4.0</td>
</tr>
<tr>
<td>- Open decks in recreation areas (no wind)</td>
<td>5.0</td>
</tr>
<tr>
<td>- Crew cabins and mess rooms</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Technical Data**: For the aim of the project, further technical data will provided to the partners in order to allow calculation of motion responses and identification of other risks related to the ship’s particulars, such as: Lines Plan or Offsets, 3D Hull-Form geometry (.stl or .dxf), Mass Distribution (where possible), Loading Conditions (with GM values) and Hydrostatics with main hull-form coefficients.
4.4.7 **Baseline General Arrangement: Handy-Size RoPax**

Fig. 18: Handy ROPAX Baseline General Arrangement [NAP’s Archive].
4.5 Selection of Routes

The selection of routes for the Ropax baseline is a complicated matter that shall encompass a wide variety of operational characteristics, intermediate ports and environmental conditions. There are many Ropax routes across Europe; however we will focus on the one with greater navigational difficulty, increased traffic and worst environmental conditions. This directs us to the Baltic and North Sea routes.

4.5.1 First Route

Helsinki – Rostock – Travemunde

Fig. 15: Baltic Sea Route [11].

Helsinki to Rostock
Distance: 558 nm
Rostock to Travemunde
Distance: 45 nm

Departing from Helsinki the vessel will have to undertake a big crossing of the Baltic Sea area with the highest significant wave height $H_s = 3.1$ m. Then the vessel in order to arrive in Rostock will have to pass through the Kadetrinne channel which is an incident-prone, narrow fairway, with high probability of collisions and relevant historical events. Taking into consideration that usually ferries involve intermediate ports we have added the segment of Rostock to Travemunde. This is a relatively small crossing, requiring for the crew to be alert, traveling mostly in coastal waters. The addition of an intermediate port is also indented to replicate the possible effect of short port calls.

Fig. 19: Baltic Sea Significant Wave Height and the Kadetrinne Channel [12].
4.5.2 Second Route

Ijmuiden – Newcastle

North Sea crossing (Hs: 3.8 m). Ijmuiden – Newcastle suggested as an alternative or complementary route.

Fig. 20: North Sea Route and Significant Wave height map [11], [12].

Ijmuiden to Newcastle

Distance: 308 nm
Hs: 3.8 max
5. Uncertainties in Design and Operational Parameters

Having defined the baselines designs and their relevant technical and operational characteristics, it is also necessary to identify the uncertainties associated with them. In this context, the uncertainty, as a lack of certainty, is defined as a probability/frequency distribution associated with each design/operational parameter in question. In simple terms, such a distribution indicates a range of possible values for that parameter, including the minimum and maximum values, along with their likelihoods. This information will be useful during the physical and virtual experiments in WP4 and also in WP6 where the selected baseline design will be optimised.

Additionally, uncertainties in design and operational requirements (e.g., required index of subdivision “R”) should be described, taking into account upcoming regulations and trends in fuel etc. prices within typical lifetimes of the vessels (e.g., 30 years for a Ropax ship).

1) Uncertainties in Design Variables

- Main Particulars

Descriptive Measures, (ROPAX dataset).

<table>
<thead>
<tr>
<th>STATISTICS</th>
<th>LOA</th>
<th>BREADTH</th>
<th>DRAUGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE</td>
<td>185.54</td>
<td>25.78</td>
<td>6.43</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>199.90</td>
<td>25.80</td>
<td>6.50</td>
</tr>
<tr>
<td>MAX</td>
<td>214.00</td>
<td>32.00</td>
<td>7.30</td>
</tr>
<tr>
<td>MIN</td>
<td>123.80</td>
<td>18.90</td>
<td>5.10</td>
</tr>
<tr>
<td>RANGE</td>
<td>90.20</td>
<td>13.10</td>
<td>2.20</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>839.54</td>
<td>11.09</td>
<td>0.39</td>
</tr>
<tr>
<td>ST.DEVIATION</td>
<td>28.97</td>
<td>3.33</td>
<td>0.62</td>
</tr>
<tr>
<td>CLASSES</td>
<td>6.00</td>
<td>6.00</td>
<td>6.00</td>
</tr>
</tbody>
</table>

Fig. 21: Relative Frequencies of Main Dimensions from the Ropax Database.

- Deterioration of Systems, Maintenance Practices.

Voyage Repair: On-going activity carried out by ship’s crew.
Annual Survey: Floating Repairs carried in port of call.
Dry-Docking: A minimum of two Docking Surveys are to be held in each five-year Special Survey period and the maximum interval between successive Docking Surveys is not to exceed three years. Nowadays the option of extending that to 7.5 year exists under certain conditions.
During Dry-Docking extensive repair of underwater hull takes place as well as overhauling of equipment and machinery. Steel renewals and major refits are also carried out during that time. There is big uncertainty regarding the schedule and the works to be carried out in a dry-dock.

Damage Repair: This is done in the event of a collision/grounding or other type of accident.

2) Uncertainties Operational Conditions

- Weather Conditions (Sea States, Changing Weather Patterns)

Sea state conditions for different regions can be traced from various sources and global wave statistics. However the uncertainty of changing operating conditions, through various seasons and climatic conditions might be balanced by distribution of significant wave heights for the regions of operation. According to DNV’s recommended practice, the distribution of significant wave heights in a region can be represented by a Weibull distribution.

Fig. 19: Weibull distribution for Hs in the Baltic Region [14].

Relevant data can be found in scatter diagrams provided in ref. [14] for regions relative to the nautical zone displayed below.

Fig. 20: Nautical Zones for Long Term wave distribution parameters [13].

- Sea Routes (Optimal Routing Practices, Development of New Routes)

The sea routes previously described in this report are long established routes for these particular types of ships and routine operations apply for big segment of each route. The
development of new routes to meet future demand can pose some uncertainty. It is often for Operators nowadays to utilize onboard software for Optimal Routing. This is used to meet specific energy management targets through avoiding rough weather passages.

- Operation speed

Ropax Vessels

<table>
<thead>
<tr>
<th>STATISTICS</th>
<th>SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVERAGE</td>
<td>25.09</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>25.50</td>
</tr>
<tr>
<td>MAX</td>
<td>29.50</td>
</tr>
<tr>
<td>MIN</td>
<td>18.50</td>
</tr>
<tr>
<td>RANGE</td>
<td>11.00</td>
</tr>
<tr>
<td>VARIANCE</td>
<td>9.37</td>
</tr>
<tr>
<td>ST. DEVIATION</td>
<td>3.06</td>
</tr>
</tbody>
</table>

Fig. 21: Descriptive Statistics and Frequency of Operational Speeds [NAP’s Dataset].

Ship speeds are significantly reduced when prior to entering the port or passing near urban coast areas according to the Port or Coast Guard recommendations. The usual service speed of ROPAX vessels is that required to complete a round trip in the scheduled time with an average ship utilisation. Sometimes increase of average ship speed are required to compensate unscheduled delays in ports. Unscheduled delays associated with bad weather are also taken into consideration by increasing the times allocated for certain sea passages.

Tankers

<table>
<thead>
<tr>
<th>Speed (knots)</th>
<th>VLCC</th>
<th>Suezmax</th>
<th>Aframax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballast</td>
<td>13</td>
<td>12-12.5</td>
<td>12-12.5</td>
</tr>
</tbody>
</table>

Fig. 22: Typical Operating Speeds. [8]

3) New regulations and future trends

- Change in Operational Procedures

Environmental regulations that will impose retrofitting of ships with emission control devices for sailing in SECA areas will add new operational procedures for the crew.

- Fuel Oil Prices, Market Demand

Even before the current economic crisis, crude oil prices have been rising continuously – between 1982 and 2007 by 11% on annual average. Since its low in March 2009 the price of oil has once again increased to far over 100 USD. Experts expect oil prices to
the International Energy Agency (IEA) assumes that the price of oil will rise once more to 200 USD by the year 2013. As a natural consequence, there is an increase in the cost of ship fuels (bunker oil) as well. This development places tremendous financial pressure on the shipping industry as fuel costs often account for more than half of a ship’s operating expenses at only 500 USD per ton of bunker fuel in the past. Prices are much higher today; the table below gives an indication of the latest bunker prices in major ports around the world.

<table>
<thead>
<tr>
<th>Port/Type</th>
<th>IFO380</th>
<th>IFO180</th>
<th>MDO</th>
<th>MGO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singapore</td>
<td>$732.50</td>
<td>$742.50</td>
<td>-</td>
<td>$1,007.50</td>
</tr>
<tr>
<td>Houston</td>
<td>$725.50</td>
<td>$763.50</td>
<td>$1,050.00</td>
<td>-</td>
</tr>
<tr>
<td>Rotterdam</td>
<td>$716.50</td>
<td>$740.50</td>
<td>$1,012.00</td>
<td>$1,017.00</td>
</tr>
<tr>
<td>Fujairah</td>
<td>$747.50</td>
<td>$772.50</td>
<td>-</td>
<td>$1,052.50</td>
</tr>
</tbody>
</table>

Fig. 23: Latest Bunker Prices in major ports [17].

Experts believe that fuel prices will continue a rising pattern in the future, triggered also by the restrictions on heavy fuel oil. The reason is that refinery capacities are too limited to cover the demand. The demand for fuel is based on a balance between consumers; ships will be competing with cars, trucks, heating oil and all other onshore oil consumers in the future. It is therefore expected that fuel costs for shipping companies will double or even triple in the future compared to today’s level. Thus, in the future ship operating costs will predominantly be determined by the cost of fuel.

In order to compensate for the risk associated to fuel price risk a +30% increase margin shall be taken into account.

Fig. 24: Projection of Fuel Price Development [18].

- New stability requirements

*Intact Stability Criteria*

The IMO has recognized that the traditional intact stability calculations do not adequately address all intact stability failure. The work under development in the SLF...
Sub-Committee addresses new vulnerability criteria that reflect the physical phenomena of the four stability failure modes of parametric roll, pure loss of stability, surf-riding/broaching and the dead ship condition. These are known as the new generation intact stability criteria and IMO has planned a 3 tier approach to their assessment. Level 1 (simple calculation), Level 2 (more advanced) and Level 3 (direct assessment). Conventional existing ships will have to pass Level 1 while other types and new designs will have to be assessed through Level 2 and 3. The criteria are under development and therefore none of the ship provided in the dataset take them into account. However the assessment of Level 1 is easy to implement on new designs if required.

Damage Stability Criteria

The current revision of SOLAS chapter II-1 regarding the harmonization of subdivision and damage stability for passenger and cargo ships has introduced a revised probabilistic method of determining damage stability. However current work under EU funded project GOALDS is expected to deliver new findings and suggest revisions to the current formulation of ‘A’ attained index for ROPAX and Cruise Ships through the improvement of the survival factor. A certain uncertainty can also be accounted for the ‘R’ required index, as described in the current SOLAS 2009 regulations. The required index for passenger vessel is dependent on the provided capacity of life-saving appliances and the total number of passenger onboard.

- New environmental requirements

The new regulatory regime concerning the reduction of ship emissions has introduced the energy efficiency design index (EEDI) as a metric. According to the regulations this is mandatory for new ships and it also excludes some specific categories. Ferries and Ropax vessel are excluded, since further studies need to be conducted on the validity of the applied formula of the index. The EEDI applies on tanker vessels and thus most of the vessels in our dataset were selected to be newly-build in order to comply with EEDI regulations. There are currently many sources in the literature providing statistical analysis of EEDI values for different ship types and a simplified method for accessing the range of the index after optimization can be utilized. The machinery in the specification can be used as a basis. The dataset of newly build vessels minimizes significantly that uncertainty.

\[
EEDI = \frac{\text{CO}_2 \text{ emission (g)}}{\text{transport work (tonne}\cdot\text{nm)}}.
\]
6. Conclusions

The scope of Task 3.1 has been covered by this deliverable, through the selection of 4 baseline vessels, 2 Ropax and 2 Tankers each of different size and operational category. Along with this, the selection of the actual vessels, routes and operational conditions have been identified. Careful consideration has been taken for matters that can directly or indirectly affect the human factors and assumption that have been made will be refined during the course of the project and mainly during the experiments (WP4) and the optimization process (WP6). The geometries of the baseline vessels and the operational parameters will be further used for the development of the parametric models and analysis in WP6. Parts of the baseline design model in a 3D environment will be used for the virtual reality developments in WP4 and WP7.
7. Bibliography and References

3. IMO Website (http://www.imo.org/ourwork/safety/regulations/pages/ro-roferries.aspx)
8. Fleet Statistics provided by FAROS Partner: AMC, Tanker Operator Representative.
12. Agreement Concerning Specific Stability Requirements for Ro-Ro passenger ships, Circ. No. 1891.