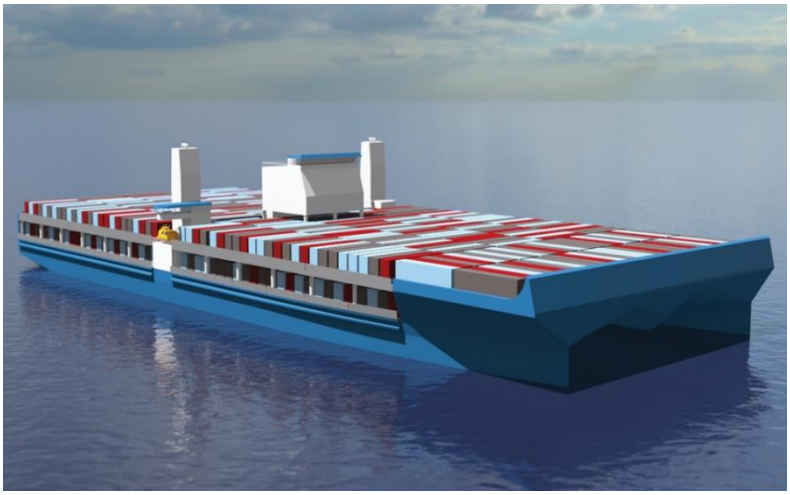
Blue INNOship

Trailer Cat

Blue INNOship Project #3

ANNEX TO FINAL PROJECT REP0RTING

Summary of Activities



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Client

Client Name	**Trailer Cat Service Holding APS**
Contact Persons	Anders Ørgård
Mail	anh@osk-shiptech.com
Phone	+45 4094 1391
Contact Persons	Arne Martinsen
Mail	arnejmartinsen@aol.com
Phone	+1 415 435 5833
Contact Persons	Claus Kruse
Mail	c.kruse@mail.dk
Phone	+45 4045 3388

Document Classification	none

Partners & Contributors

OSK-ShipTech A/S
Contact Person:
Carsten Fauner
cfa@osk-shiptech.com

Transmar Ltd
Contact Person:
Arne Martinsen
arnejmartinsen@aol.com

Claus Kruse Consult
Contact Person:
Claus Kruse
c.kruse@mail.dk

Bureau Veritas
Contact Person:
Alexander Bjørn Kleiman
alexander.kleiman@dk.bureauveritas.com

Technical University of Denmark
Contact Person:
Christian Bergreen
cbe@mek.dtu.dk

MOE A/S
Contact Person:
Michael Henriques
mh@moe.dk

Copenhagen Business School
Contact Person:
Carsten Ørts Hansen
ch.om@cbs.dk

Dansk Brand- og Sikringsteknisk Institut
Contact Person:
Carsten Møller
cam@dbi-net.dk

INTRODUCTION

Project Description

The project introduces a new concept of a Ro-Ro (Roll-on-Roll-off) vessel designed in a catamaran configuration for large-volume maritime transport of road trailers and other classes of rolling cargo.

The current operating Ro-Ro concepts have an increasing lack of competitiveness compared to alternative transport among others due to increasing environmental requirements.

The markets for Ro-Ro services have been assessed for potential routes, and two suitable routes have been selected for more intensive investigations.

An initial design of the vessel and a Link Span-solution has been drafted and analysed with regards to seakeeping, loading/discharging and other technical challenges. Fuel consumption and emissions have been estimated, and an optimisation process of the design and operation has been initiated.

Overall Vision & Criteria for Success

A large-capacity vessel results in low cost per transported unit (trailer), but a traditionally designed Ro-Ro vessel is very time consuming to load and discharge. For short routes, the traditional vessels face difficulties in achieving economy of scale. The Trailer Cat system offers highly efficient and rapid side-loading of trailers via a floating twin-deck Link Span.

The goal for the INNOship project was to confirm the task to achieve a cost reduction of 50% per trailer and a CO2 emission reduction of 70% per trailer compared with large conventional vessels in use today on a route of approx. 120 nautical miles.

The intention was also to develop a business case that will enable an operator and/or investor to start negotiations with partners as well as with customers, ports, shipyards, and authorities.

Executive Summary

Rotterdam – Harwich (UK) and Galveston (Tx) – Tuxpan (Mexico) have been selected as reference routes, and the technical and the market conditions have been investigated. The technical investigations have confirmed the viability to establish suitable terminal and harbor facilities for the Trailer Cat service. The extreme width of the vessel is, of course, challenging for smaller ports, but, in general, the Trailer Cat will not have other restrictions than other ships of the same length. This has been confirmed by the authorities in three of the ports. Only in Tuxpan the situation is not yet confirmed, but a positive clarification is expected. There is also, on the two routes, a market for utilization of the capacity of the Trailer Cats.

The layout of the Trailer Cat for the European service is not completely identical with the layout for the US – Mexico service. Primarily this is because the standard length of the trailers in USA are different compared to the standard length in Europa.

A feasibility study and initial design of the vessel has resulted in an outline specification and sufficient data to carry out a credible estimation of the building price of the vessel, operation costs, and emissions.

Classification regulations do not cover a catamaran design of a large Ro-Ro vessel and consequently these requirements have to be adapted.

An essential aim for the project has been to achieve a comprehensive reduction of the time and cost for loading and discharging. An ideal layout of a terminal area has been drafted and the loading and discharging operation analyzed. The analysis has shown that it is definitely possible to achieve a turnaround time in port of not more than three hours.

As a result of the fast turnaround in ports, we can reduce the speed at sea and combined with an optimized hull form and propulsion plant designed for the service, we have achieved very low fuel consumption and low emissions.

During the design process we have also focused on minimizing the required manning by automatic mooring of the vessel, optimized stevedore operation, and automatic lashing of trailers on board. The investigations indicate that the Trailer Cat system requires substantially lower manning than traditional vessels. However, it is a disadvantage that the short time in port means that all stevedore work is very concentrated in few hours each day.

Like other ro-ro vessels, the Trailer Cat is a relatively heavy vessel and therefore lighter materials have been considered as alternatives to parts of the steel structure. A thesis at DTU has investigated the possibility of building the trailer decks of lightweight concrete. The design was too heavy and seems not to be of interest to the project. Another DTU project has investigated the possibility of constructing the huge watertight bulkheads in the hull by composite. The results were not convincing.

The goal was to reduce the cost per transported unit with 50%. Our calculations show that the Trailer Cat project is reducing the cost with 41% compared to a service of traditional vessels on a 120 NM long route. Some of very first estimates on which the goal was based, were quite optimistic, but a significant fall in fuel prices in the market has reduced the economic advantage of the low fuel consumption.

A business case for each of the two routes has been developed. The European service is covering the service as the trailer arrives at and leaves the terminal in the other end of the route. The US business case is covering the complete transport for the trailer or container from shipper to receiver in a ‘door-to-door’ transport concept.

A risk analysis has been carried out for each of the two projects listing economical and technical risks that were identified by the partners. There does not seem to be any showstoppers, but some of the risk factors require further investigation and development of the design and concept.

Investor relations

We have been in contact with potential investors but no agreement about further development of the project has been reached yet.

Investors searching for a sustainable operation will find a system that incorporates highly efficient marine transport and shore logistics features combined with an extraordinarily low carbon footprint. Investing in the Trailer Cat Project should be of interest based on the following factors:

- Investment in a new transport concept with international maritime growth potential.
- Investment in a price-competitive and environmentally optimised transport system.
- Application of proprietary technology.
- The project development team's qualifications, network coverage, and broad maritime and transport industry background.
- Trends in environmental initiatives and legislation should support use of 'green' transport.
- Grant funds and subsidies should be available from the respective Governments affected by the new maritime transport services introduced.

PROJECT EVALUATION

(I) ROUTES, PORTS & MARKETS

1.01 Selection of Ports

Leading Partners

Transmar Ltd and Claus Kruse Consult.

Results, **Summary**

To analyse and design the new maritime transport system of trailers and other rolling cargo, we decided to develop a business case for two selected routes in order to be able to investigate the complete chain from the cargo arriving at port and leaving the port again in the other end of the service. The final selections made and the progresses reported in this section have been supported by the team's accomplishment in making the right contacts with key management for all the ports covering the selected two routes.

Results, EU Service

Early in the project development, it was decided to look at a Rotterdam-to-UK route potential because of a huge volume of year-around trailer traffic.

The opposite port site in the UK that was found to be best served out of Rotterdam was Harwich. The port's location would allow for a Trailer Cat 'dock-to-dock' transit of 8.5 hours in each direction. With 3.5 hours turn-around in each port, this route could be ideally scheduled for one (1) round-voyage per ship per 24 hours when operating with 2 Trailer Cat-vessels working opposite departures. The possible locations of the terminals have been investigated superficially.

Results, **US/Mexico Service**

The selection of ports for the US-Mexico service resulted from a plan based on structuring a 'marine highway corridor' to run parallel with the north-south highways connecting Mexico to the U.S. markets via Texas Border-Points.

Port of Galveston (Texas) is situated right on the Mexican Gulf with short distance to open water and has excellent highway and rail-connections to the U.S. hinterland.

Port of Tuxpan (State of Veracruz) is the Mexican selection also called 'Puerto de Ciudad de Mexico' because it is the port closest by highway to Mexico City and the surrounding industrial centres in Valle de Mexico and the central and southern parts of the country.

Drafted Documentation

Europe service:

1.01.01	Selection of routes and ports
1.01.02	Minutes of Meeting at Harwich International port 06.16.2015
1.01.03	Minutes of Meeting at Port of Rotterdam 06-15-15

US/Mexico service:

1.01.04	Selection of routes and ports

1.02 Technical Viability – investigation and identification of viability for establishing suitable terminal and harbour facilities in selected ports

Leading Partners

Transmar Ltd and Claus Kruse Consult

Results, Summary

The challenges of establishing technical and operational viability in the selected ports have been met in accordance with the results achieved for both projects as reported in this section. The huge development at Rotterdam's Maasvlakte II-complex is a natural location close to the North Sea, whereas the Port of Harwich has a tradition as a ferry port with space available for a Trailer Cat-facility. For the U.S./Mexico service the absolute shortest distance between the Houston area and Central Mexico is via the ports of Galveston and Tuxpan.

Results, EU Service

The Trailer Cat's development team travelled to the ports of Rotterdam and Harwich in June of 2015 based on indicated interest in the project from the respective port managements. In Rotterdam, it was recommended that the project would be best located in the (new) Maasvlakte II-area that has direct access to the North Sea. Ample land area is available around the port basin served by both highway and rail-tracks located near the potential terminal site.

In Harwich there is a site originally intended for a container terminal. From this location there is an adjacent large area that would serve as a trailer consolidation yard immediately next to the port's railyard. The possible use of this site was discussed with Port Management. The exchanges were expanded into details of loading and discharging operations.

The navigational issues concerning the wide Trailer Cat transiting the entrance channel to Harwich and Rotterdam did not seem to be of serious concern.

The restriction for passing other vessels in the channel to and from the port is expected to be the same as for other larger vessels

Results, US/Mexico Service

Trailer Cat's U.S. representative travelled to the ports of Galveston and Tuxpan in August 2015.

At the first stop in Galveston, the port officials became interested in the project and proceeded to suggest a terminal site at Berth 36. In follow up, preliminary Trailer Cat-terminal design (1.02.04: Trailer Cat – Port of Galveston Berth #36 Conceptual Terminal Design) was developed by the port's consultants, Lloyd Engineering, Inc of Houston.

During the subsequent visit to the Port of Tuxpan, the search for a terminal-site was aided by the port's Chief Pilot and his staff. After presenting the project in the pilot's office, several suitable sites were surveyed along the Tuxpan River's right descending bank. The sightings were initiated on the waterside from the Pilot Launch and then continued while driving along the waterfront-road behind existing terminals and potential new terminal sites. A specific site was not been targeted during the visit due to time constraints and non-availability of key port management staff on the day of the visit.

Drafted Documentation

Europe service:

1.02.01 Technical viability - investigating technical and operational viability to establish suitable 'Trailer Cat' terminal facilities in the selected ports

1.02.02 Minutes of Meeting with Harwich International Port June 16th 2015

1.02.03 Minutes of Meeting at Port of Rotterdam June 15th 2015

1.02.04 Minutes of Meeting at HUPAC rail operator, Rotterdam 06-15-15

1.02.05 Minutes of Meeting at Samskip logistic operator, Rotterdam 06.15.15

US/Mexico service:

1.02.06	Technical viability - investigating technical and operational viability to establish suitable 'Trailer Cat' terminal facilities in the selected ports
1.02.07	Plan 1.02.04: Port of Galveston Berth #36 Preliminary Terminal Layout
1.02.08	Plan 1.02.05: Port of Tuxpan Terminal Criteria

1.03 Preliminary Market Assessment

Leading Partners

Transmar Ltd and MOE

Results, Summary

The key condition for both of the Trailer Cat Projects is to service high volume trailer and container traffic corridors. In this regards the two project markets are very different in characteristics.

The Europe-market has an existing dense 'Cross-North Sea/Channel' maritime trailer flow that can only be approached with a highly efficient operation and lower unit costs.

The US/Mexico-market consists of steadily growing high-volume border traffic that is facing increased congestion and transport costs on the Mexican side of the border. The Trailer Cat 'marine highway corridor' running parallel to the Mexican highway system is considered to fill the need for relief of the border congestion and heavy traffic loads on the roads.

The market assessment findings described in the two report sections respectively support the original decision to focus on these particular two service corridors.

Results, EU Service

The market for the Europe services Rotterdam–Harwich 'shuttle' is focused on the growing number of un-accompanied trailers carried by the existing operators. The strong growth in un-accompanied trailers is partly caused by the shortage of qualified drivers on the international transport routes. Other cargoes that in particular will be pursued by the Trailer Cat services are continental 48' containers that are carried by rail on both the Continent and in the UK and by container barge services in Europe.

The present volume of un-accompanied trailer crossings in the immediate pure Ro-Ro short-sea lanes targeted by the Trailer Cat is about 1.0 million units annually. Mixed traffic of accompanied and unaccompanied trailers carried by Ro-Pax services add a total of about 390,000 units. In addition, there is the Calais – Dover mixed traffic of about 1.75 million units, for a grand total market potential of about 3.1 million. Once in regular service at an average of 75% capacity utilization, the Trailer Cat will annually carry 550,000 units or up to about 18% of the total traffic.

Results, US/Mexico Service

The market for the Trailer Cat service's Galveston–Tuxpan 'maritime highway corridor' consists of cross-border 53' trailer movements plus growing traffic of 53' domestic containers both moving on highway chassis and on double-stack railcars. The BCOs (Beneficial Cargo Owners) in this trade represent importers and exporters on both sides of the border that are shipping all types of packaged commodities. A large portion of the traffic is semi-finished industrial products for assembly lines both in Mexico and in the United States. A potentially large volume is ISO tank-containers carrying gasoline and diesel fuel imports into Mexico from Houston area refineries. In addition, due to significant imbalance of full and empty equipment with more than double the number of loaded equipment moving north bound, there is a significant potential for the Trailer Cat to focus on empty equipment moving back into Central Mexico. With extra system capacity due to the project's conservative annual projection of vessel utilisation, the empty container-programme could become particularly profitable.

The total 2017 cross border volume exceeded 7.8 million trailers and containers with more than 50% of the traffic at Texas border points. Out of this total, the targeted market for Central and South Mexico is about 1.8 million units annually of which the Trailer Cat system would carry 133,000 when at an average of 80% vessel utilization, or 9.6% of the total for that particular market.

Drafted Documentation

Europe service:

1.03.01 TC Europe Preliminary Market Assessment 12-13-2015

US/Mexico service:

1.03.02 Tex-Mex Market Assessment 09-30-2015

1.04 Possible Adjustments of Vessel Characteristics

Leading Partners

Transmar Ltd and Claus Kruse Consult

Results, Summary

At the outset of investigations of the operational parameters and of possible constraints on the two different service routes, there were numerous uncertainties to be addressed. The final results, however as reported in this section, indicate that there should be no major adjustment that need to be dealt with when implementing either of the two routes.

Results, EU Service

As reported from the mentioned visits and surveys at Rotterdam's Maasvlakte II-port and at the Port of Harwich, no constraints were discovered with respect to berthing and navigation of the Europe Trailer Cat-size. It was concluded that the market was existing for the huge capacity of the vessels. Therefore, there will not be a need for adjustments to vessel characteristics.

Results, US/Mexico Service

The U.S. (Americas) vessels are designed to slightly smaller dimensions than the EU prototype Trailer Cat. The vessel also has to fit the longer length of the US trailers. In discussion with Port Management in Galveston no concerns were raised with respect to the vessels dimensions. Despite the reduction of the size of the US/Mexico design, there may be some restrictions in the Tuxpan entry channel due to the wide beam of the Trailer Cat. On the other hand, Tuxpan Port

has considerable traffic of offshore drilling rigs coming in for repairs, therefore, established rules and procedures for one-way traffic at port entry and exit should be in place. On this basis, there should not be a need for adjustments to vessel characteristics.

Drafted Documentation

Europe service:

1.04.01	150580.0109.10C Conceptual General Arrangement.

US/Mexico service:

1.04.02	150580.0109.11 Conceptual General Arrangement – Tex - Mex.
1.04.03	Plan: General arrangement plan for the US/Mexico Trailer Cat
1.04.04	Plan: Terminal loading arrangement for the US/Mexico Trailer Cat Services

(II) OPERATIONS CRITERIA

2.01 Hinterland markets, terminals and transportation

Leading Partners

Transmar Ltd and MOE

Results, Summary

In the world of rapid developments in transportation and logistics both in Europe and in the Americas, the key to the success of both projects is with the inland transportation connections driven by the interior 'Dry Port' systems. This is where intermodal terminals serve distribution of inbound products and consolidation of outbound exports. With this background, the findings in these sections strongly support the Trailer Cat concept and both projects' excellent business potentials in the targeted hinterland market areas.

Results, EU Service

By locating the project base in the Port of Rotterdam, the Trailer Cat system is guaranteed efficient connections with the interior via a huge road system, steadily developing container-on-rail services, trailers on rail services and traditional but very efficient container barge transport to and from the interior. These transport modes are all connected to efficient inland distribution and consolidation terminals. The key advantages of the terminal systems in the hinterland are two-way cargoes made available for trailers and containers whenever discharged at or close to the inland terminals.

Results, US/Mexico Service

Early visions for the US/Mexico service were that the Trailer Cat vessels themselves would only serve as fast-moving platforms to shift large volumes of trailers and domestic containers port to port from Texas to Central Mexico and vice versa. The Trailer Cat Americas Service can only be profitable by using that platform as a vehicle to compete in 'door-to-door' services. This is where the hinterland connections are important components of the system. The transportation services will include 'door' deliveries/pickups as well as the services of an inland distribution and consolidation terminal near Mexico City. The system will connect with similar inland inter-modal terminals in the Dallas/Ft. Worth and in the Chicago-regions and with other interior hub points for distribution and consolidation of cargoes.

Drafted Documentation

Europe service:

2.01.01: Hinterland markets, terminals and transportation

US/Mexico service:

2.01.02: Hinterland markets, terminals and transportation

2.02 Market Assessment for cargoes 'other' than trailers

Leading Partners

MOE and Transmar Ltd

Results, Summary

During the course of development of the Trailer Cat design and the associated cargo handling and terminal operations concepts, the 'other' cargoes have taken an important position. At this stage of preliminary market assessment, it has been difficult to fully appraise the impact of these non-trailer movements on project results. This report section, however, provides the initial guidelines towards establishing a separate marketing activity as part of the organisation.

Results, EU Service

The Europe service is basically targeting unaccompanied highway trailers that will be supplemented by 'containers on chassis', double-stack 'containers on MAFIs' and other categories including refrigerated shipments.
The other cargoes will consist of special MAFI applications for non-containerized cargoes such as oversize machinery and equipment as well as non-overweight self-propelled rolling machinery and construction/agricultural equipment. A new 'cassette' system from port warehouse to port warehouse is already in use on several North European Ro-Ro services particularly in the Scandinavian forest products trades. The required fast loading and discharging will be a limitation on what cargo to be included.

Results, US/Mexico Service

The Trailer Cat Americas Service is primarily targeting the large cross-border volumes of trailers and domestic containers. There are, however, many other categories of cargo that often provide higher revenues per unit with only insignificant increase in operations costs. The Trailer Cat system projections are based on average at 80% vessel capacity utilisation, therefore ample extra capacity will be available to accommodate such other and extra cargoes. . A large southbound trade volume of non-overweight self-powered vehicles and machinery and tractor-trailer combinations excluding drivers will be seriously considered. Automobiles, though not specifically targeted due to the large dedicated staging areas required at both ends, may be a focus in the future.

Drafted Documentation

Europe service:

2.02.01	Cargoes other than unaccompanied trailers and containers (Europe)

US/Mexico service:

2.02.02	Cargoes other than highway trailers and domestic containers (Americas)

2.03 Draft Arrangement of Terminals

Leading Partners

OSK and Claus Kruse Consult

Results, Summary

An idealized layout of a terminal area has been drafted for analyzing of the loading and discharging operation. The aim with the principle lay–out of the terminal has been to identify the required area for the terminal and to outline a lay-out where the drive way from the trailer parked on the deck to the parking lot on the terminal area is as short as possible. Crossing traffic has to be minimized and width of driveways, turning circles etc. sufficient for fast driving. It has also to be efficient for the external truck driver to pick up the trailer. We have also indicated how

a rail track and gantry crane system can be arranged for loading railway wagons with trailers or containers. Also an area for handling of containers is allocated.

Results, EU Service

A terminal area of about 190.000 m2 is required including facilities for handling of a limited number of containers and a full track (600m) of rail wagons.

Results, US/Mexico Service

An identical terminal lay-out is outlined for the US service where the parking lots is adjusted to the US trailers and the area is adjusted to the less number of trailers. 180000 m2 is required.

Drafted Documentation

EU Service

- 150580.0194.01 Loading Arrangement – Pontoon & Link Span
  - Sheet 1 – Loading Arrangement
  - Sheet 2 – Pontoon & Link Span
- 150580.2033.01 Harbour Logistics Evaluation

US/Mexico Service

- 150580.0194.11 Loading Arrangement – Pontoon & Link Span
  - Sheet 1 – Loading Arrangement
  - Sheet 2 – Pontoon & Link Span

2.04 Loading and Discharging Operations Analysis

Leading Partners

OSK and DTU

Results, Summary

Based on a schedule as indicated below, OSK and DTU have assessed the loading and unloading process of trailers to determine the time required and number of tug masters and personnel required.

Schedule for EU service:

- 8½ hour voyage from mainland Europe to UK.
- 3½ hours for unloading and loading including mooring.

The logistic evaluation concludes a required number of tug masters and allocated personnel can solve the harbour logistics challenges. The OSK evaluation refer to an initial study made by a group of students at the Technical University of Denmark (in Danish), which is included in the reference document '150580.2033.01 Harbour Logistics Evaluation' as an attachment.

Assuming the 3-hour harbour stay will be fully utilized for loading and unloading of trailers, the study shows that a total of 18 tug masters and 6 additional personnel (24 persons in all) is required in order to handle the unloading and loading of the EU Service.

Results, EU Service

In addition, the evaluation concludes that the number of tug masters will not lead to any significant bottlenecks and the harbour logistics and related harbour arrangement are therefore deemed realistic.

Results, US/Mexico Service

The Loading and Harbour Arrangement and related Harbour Logistic Evaluation uses the EU Service as reference, and the results are as reflected in Summary above.

Drafted Documentation

EU Service

- 150580.0194.01 Loading Arrangement – Pontoon & Link Span
  - Sheet 1 – Loading Arrangement
  - Sheet 2 – Pontoon & Link Span
- 150580.2033.01 Harbour Logistics Evaluation

US/Mexico Service

- 150580.0194.11 Loading Arrangement – Pontoon & Link Span
  - Sheet 1 – Loading Arrangement
  - Sheet 2 – Pontoon & Link Span

(III) LOADING & DISCHARGING EQUIPMENT

3.01 Viability of Design Solution – Link Span / Mooring Arrangement

Leading Partners

OSK and Claus Kruse Consult

Results, Summary

The layout of the pontoon and Link Span has been optimised to achieve a fast and efficient transportation of the trailers.

Scantling requirements are investigated by partial analysis addressing specific scantling requirements, where scantlings and dimensions of plate panel area, plate thicknesses, etc., is conducted accordingly to Lloyd's Register rules.

See reference document '150580.0201.10 – Link Span Analysis'.

During loading and unloading operations, the Link Span is fixed to vessel by automatic mooring equipment while it is resting on the landing support structure.

As preparation for the loading and unloading operations, the Link Span is ballasted to the correct draught depending on the actual loading condition of the vessel. Ballasting is adjusted during the loading and discharging operation and controlled automatically.

The price for building the Link Span and ramps has roughly been estimated based on unit prices and assumed to be built in China and transported from China. Final assembly is envisaged done in Europe/on location.

Results, EU Service

The Link Span/Mooring Arrangement uses the EU Service as reference, and the results are as reflected in Summary above.

Results, US/Mexico Service

Findings relevant for the EU Service are also applicable to the US/Mexico Service with the only adjustment that the pontoon is slightly smaller due to the reduced length of vessel compared to the one for the EU Service. Building the linkspan in Mexico is probably very competitive The production cost is a little higher than in China, but presumably the less transport outweighs the higher building cost.

Drafted Documentation

EU Service

- 150580.0194.01 Loading Arrangement – Pontoon & Link Span
    - Sheet 1 – Loading Arrangement
    - Sheet 2 – Pontoon & Link Span
    - Memo: Vessel-Barge Interface principle, dated 20170607
    - Memo: Barge Cost Estimate, dated 20170607
- 150580.0135.02 – Link Span Stability
- 150580.0201.10 – Link Span Analysis (structural)

US/Mexico Service

- 150580.0194.11 Loading Arrangement – Pontoon & Link Span
    - Sheet 1 – Loading Arrangement
    - Sheet 2 – Pontoon & Link Span

(IV) VESSEL CHARACTERISTICS

4.01 Preliminary Lightweight and Body Plan

Leading Partners

OSK

Results, Summary

The lightweight and body plan has been optimised and adjusted during the design process.
Vessel characteristics:

The vessel's characteristic has been developed and documented in a conceptual design package comprising:

- Conceptual Specification
- Conceptual General Arrangement
- Conceptual Midship Section
- Conceptual Aft End Structure

The conceptual design package has been developed with the purpose of estimating the cost of the vessel. For that purpose, it has been submitted to 2 Chinese shipyards.

With a specified total deadweight of 16,600 metric tons at a draught of 8.0 m, the total displacement of the vessel is 34,200 tons.

Results, EU Service

The preliminary lightweight and hull form uses the EU Service as reference, and the results are as reflected in Summary above.

Results, US/Mexico Service

Findings relevant for the EU Service are also applicable to the US/Mexico Service with the only adjustment that the vessel is slightly smaller due to the reduced capacity of trailer/larger size of US trailers compared to the one for the EU Service. The displacement is estimated to 31,600 tons.

Drafted Documentation

EU Service

Specification and General Arrangement

- 150580.0131.01 – Conceptual Specification
- 150580.0109.10 – Conceptual General Arrangement
- 150580.0293.01 – Conceptual Paint Specification

Weight, Hull Lines and Stability

- 150580.0104.01 – Preliminary Weight Estimation
- 150580.0159.01 – Optimization of Hull Lines

US/Mexico Service

General Arrangement

- 150580.0109.11 Conceptual General Arrangement

Other issues

- Impact on US/Mexico Service not included at this stage

4.02 Seakeeping and Load Analysis

Leading Partners

Bureau Veritas

Results, Summary

Bureau Veritas has provided guidance on how their rules can be applied on this unusual type of vessel; including a study determining seakeeping and internal loads. The study has been based on the wave condition in the North Sea (North Sea scatter diagram). The study has also included calculations of the accelerations on the trailer decks, which has been basis for the lashing requirement. See section 4.05

Results, EU Service

The Seakeeping and load studies have been carried out for the North Sea and of course most relevant to the Rotterdam-Harwich route.

Results, US/Mexico Service

A similar study must be performed for US Gulf. The wave conditions in the Gulf are not considered to be significantly different from the conditions in the North Sea. Therefore, it is not expected that the service in the Gulf results in major changes in the structure of the vessel, lashing, etc. in relation to the European design. It is assumed that hurricanes can be ignored, which should not be a problem with the available weather reports.

Drafted Documentation

4.02.01 Sea-keeping and internal loads computation.

4.03 Selection of Alternative Materials

Leading Partners

DTU and Claus Kruse Consult

Results, Summary

It has been decided to investigate other materials as an alternative to the steel structure. The vessel has been designed as a steel structure and the lightweight, building price and fuel consumption is based on a complete steel design. However, some elements could be considered constructed by alternative materials if a competitive weight reduction can be achieved. The following parts have been selected:

Trailer decks - an extremely heavy construction due to wheel loads and alternative lighter materials must be of interest.

Deck house – has been looked into in the Compass Project.

Water tight bulkheads – a huge and heavy construction and lighter materials must be of interest.

Drafted Documentation

4.03.01 Minutes of meeting 150116 at DBI

4.04 Investigation of Alternative Materials

Leading Partners

DTU

Results, Summary

A master thesis at DTU supported by Jørgen Juncher Jensen investigated the possibility of building the trailer decks of lightweight concrete. The design was too heavy and seems not to be of interest to the project.

Another DTU project is investigating the possibility of constructing the huge watertight bulkheads in the hull by composite. The project has not yet been completed, but the preliminary results have not been too promising. A significant weight reduction has to be achieved before the additional production cost can be justified. However, the studies have indicated that, if a cost-effective composite construction can be developed, it might be interesting for this type of parts of ship construction.

Drafted Documentation

4.04.01 Design and structural optimization of a large trailer deck for an innovative Ro-Ro vessel dated 03.01.2016

4.04.02 Preliminary report “Summation of the dimensioning of sandwich bulkheads”.

4.05 Structural Design and Hull form

Leading Partners

OSK and DTU

Results, Summary

Structural:

A large catamaran as the Trailer Cat is a unique design, and comprehensive analysis have been and are necessary to carry out to estimate the weight and secure the feasibility of the structure. The weight is essential for estimating the building price and the fuel consumption.

A preliminary analysis of the hull structure has been carried out by two students at DTU supported by Professor Jørgen Juncher Jensen. The study focused primarily on the torsional strength of the tween hull.

The concept with transverse loading and unloading of trailers requires one side of the vessel to be open and without a conventional shipside, which is a global structural challenge.

To evaluate this within the possible framework of the INNOship project, scantling requirements have been investigated by partial analyses addressing specific scantling requirements conceptually as reflected in reference document ‘150580.0201.01 – Midship Section Analysis’.

To evaluate the primary structure, an FE model containing 15 frames has also been prepared in order to examine the transversal integrity of the structure. The FE model includes a watertight bulkhead.

As torsion of the hull girder is not part of the BV software, the hull girder has initially been considered by a hull section shear analysis and subsequent buckling check of hull main panels. It is recognised that this is a simplified approach.

To assess the global strength of the vessel, the ‘structural efficiency’ of the upper deck is important to evaluate due to the open ship side on starboard side and minimised structure

bonding main and upper deck together in the aft end of the vessel. For that reason, reference documents '150580.0207.01 – Conceptual Aft End Structure' and '150580.0201.02 – Aft Structure - Simplified FE analysis'.

A student at DTU supported by Professor Jørgen Juncher Jensen is in progress of estimating the strength of the aft end structure. The project is expected to be completed in June. At a later stage in the project, further analysis will be needed, and it is anticipated that a full hull girder finite element analysis is required to be carried out.
Bureau Veritas is participating in this part of the project providing guidance on how their rules can be applied on this unusual type of vessel; including a study determining seakeeping and internal loads, ref. appendix A in the reference document '150580.0201.01 – Midship Section Analysis'.

Based on the 'Midship Section Analysis' and 'Aft Structure - Simplified FE analysis' structural drawings have been developed.

Based on the structural analysis made and the external loads provided by BV, it is deemed realistic that the structural concept is feasible as no 'show-stoppers' have been identified. It is also acknowledged by OSK that much more detailed structural analysis will be required to ensure the structural challenges and related weight consequences are fully covered and implemented.

It is therefore essential to cover this in more detail in an eventual later phase of the project.

Stability:

A preliminary evaluation with considerations and calculations has been carried out to investigate the stability and loading conditions. The focus has been on verifying the amount of ballast needed to reduced trim and maintaining the propeller submerged.

Hull form:

An optimisation of the hull form has been carried out by comprehensive CFD analyses.

Lashing:

The required time for loading and unloading of trailers is essential for the concept. Therefore, the required extent of lashing of trailers has to be minimized. Additionally, manual lashing is extremely expensive and time consuming, therefore also has to be reduced to a minimum.

Based on accelerations provided by BV, OSK has therefore made lashing calculations to verify in which sea states lashing will be required, i.e. also the number of days lashing can be anticipated per year. See reference documents '150580.0154.01 Calculations of Lashing Requirements' and '150580.0154.10 – Expanded Lashing Calculations'.

It is assumed that the trestles can be hydraulically fixed to the deck, such as the trestles delivered by the company SRC in Gothenburg. The calculation has indicated that manual lashing is only required in 1% of the departures and only in the outermost parts of the upper deck; and more specific – the 48 trailers positioned longitudinally on the upper deck forward. These positions are only expected to be used at more than 90% utilisation of the capacity.

Results, EU Service

The structural design and hull form use the EU Service as reference and the results are as reflected in Summary above.

Results, US/Mexico Service

Findings relevant for the EU Service are also applicable to the US/Mexico Service with the only adjustment that the vessel is slightly smaller due to the reduced capacity of trailer/larger size of US trailers compared to the one for the EU Service.

Drafted Documentation

EU Service

Weight and Hull Lines

- 150580.0104.01 – Preliminary Weight Estimation
- 150580.0159.01 – Optimization of Hull Lines

Structural

- 150580.0202.11 – Conceptual Midship Section
- 150580.0201.01 – Midship Section Analysis
- 150580.0207.01 – Conceptual Aft End Structure
- 150580.0201.02 – Aft Structure - Simplified FE analysis
- "Statement of Conceptual Design Review" issued by Bureau Veritas.

Lashing

- Memo: 150580.0154.01 Calculations of Lashing Requirements, dated 14.06.2017
- 150580.0154.10 – Expanded Lashing Calculations
- Excel sheet: Stevedore costs 07.03.2018 riv.2

US/Mexico Service

The calculations and drawings are also relevant for the US service, but have to be adjusted due to the reduced capacity of trailers/larger size of US trailers.

4.06 Initial Design of Propulsion Plan

Leading Partners

OSK, DTU and Claus Kruse Consult

Results, Summary

Possible propulsion concepts have initially been evaluated and the selected propulsion concept as indicated below:

- The Vessel is LNG-dual fuel driven and includes the following main features:
  - Two (2) Slow Speed dual-fuel engines, Three (3) Aux. Engines, Two (2) Shaft Generators and Two (2) C/P Propellers
- Main Diesel Engines: MAN B&W 5S60ME-C10.5-GI-EGRBP or similar approx. 9800 kW
- Main engines will be operating according to the diesel-working principle in order to keep methane slip at a minimum and Tier III compliance will be achieved. The vessel will be arranged with aux. engines for boost of propeller shafts when steaming from 18-19 knots.

See reference document '150580.0159.02 Power Estimation', 'Analysis and reduction of energy costs for Trailer Cat Ro-Ro-cargo ship with Vmax = 19kn' and '5S60ME-C10.5-GI_105.0_rpm_9800_kW_EGRBP full report'.

A compressive study of the Power requirements has been carried out and 20 propulsion systems has been evaluated in corporation with a student at DTU and supported by assistant professor Anders Iversen.

The profile of the power demands for the crossing has been estimated taking into consideration manoeuvring, limited speed in and out of the ports, shallow water and wave and wind resistance.

Based on the power demand profile the alternative propulsion systems included utilisation of battery packages at manoeuvring and as additional power at sea have been evaluated.

In the analysis, we were focusing on the special operation profile for this type of service. For the European route, the vessel is in port about 30% of the time, manoeuvring in and out of a channel 20% of the time and at sea only 50% of the time.

The lowest fuel consumption for the service in question is achieved by the above described power plant also taking into consideration the required investments.

Results, EU Service

The initial design of the propulsion plan uses the EU Service as reference, and the results are as reflected in Summary above.

Results, US/Mexico Service

Findings relevant for the EU Service are to some extent also applicable to the US/Mexico Service, but the Partners have not assessed it in detail at this stage.

Drafted Documentation

EU Service

- Memo: 150580.0159.02 Power Estimation
- Report: 'Analysis and reduction of energy costs for Trailer Cat Ro-Ro-cargo ship with Vmax = 19kn', dated Oct 3rd 2017
- Report: 5S60ME-C10.5-GI_105.0_rpm_9800_kW_EGRBP full report, dated Sep 23rd 2017
- Analysis and reduction of energy costs for Trailer Cat Ro-Ro – cargo ship dated Aug 4th of 2017 including an appendix

US/Mexico Service

- Impact on US/Mexico Service not included at this stage.

4.07 HAZID related to LNG

Leading Partners

OSK and Bureau Veritas

Results, Summary

Over the last years, LNG fuel has become more and more common, and we do not consider any technically, safety-related nor economically serious challenges by LNG Fuel in relation to the Trailer Cat design. Consequently, we have decided not to carry out any comprehensive HAZID analysis. Both in Rotterdam and Galveston, LNG-supply by barge is available.

(V) INVESTMENT CRITERIA & BUSINESS CASE

5.01 Vessel and Terminal Main Characteristics

Leading Partners

OSK and Claus Kruse Consult

Results, Summary

This section refers to the results reported from the investigation of the four (4) ports, the market and the other studies of the concept. The conclusion is that, aside from the planned downsizing of the US (Americas) Service, there are no significant changes to be made to the layout of the vessels. The original terminal layout has gradually been improved during the studying of loading etc.

5.02 Investments and Operations Costs

Leading Partners

OSK, Transmar and Claus Kruse Consult

Results, Summary

The projected capital and operational costs for the two separate projects have been subject to constant review and discussions by the Trailer Cat team members OSK, Claus Kruse and Arne Martinsen. The final results reported in the respective document sections reflect costs at today's levels in the maritime and port industry.

Results, EU Service

CAPEX: In this section, the project team has developed the capital investment budget that will be an important document for potential investors in evaluating the project.
The budget is structured to lay out the capital needed, details of which will be key in search of project financing.
The budget incorporates pricing of the following: The completion of the project for the final execution, estimated pricing of the vessels built in China including construction supervision, and the mobilization and delivery of the vessels from the shipyard to the completed terminal.
OSK is in contact with Chinese shipyards, but due to the current very intense ordering situation in China with respect to Ro-Pax vessels and cruise vessels, the shipyards have unfortunately not yet responded with a cost indication. Consequently, the estimated cost of the vessels has not been verified. The price is estimated based on unit prices for some of the latest built Ro-Ro vessels in China.

The pricing for Link Span (mooring platform) construction has been estimated based on steel weight.

A budget for acquisition of all terminal operations rolling equipment.

OPEX: The estimated costs for operation of vessels, terminals and for company management have been addressed. This is a budget that covers operational costs from start-up in Year #1 and projected forward annually in line with growth in cargo volume projected to be transported.
The key OPEX items include the following: Vessel operations based on costs quoted by a ship management company, fuel consumption estimates and contract pricing assumptions, long-term leases of terminals, development of variable charges to be negotiated with ports for vessel berthing and cargoes' use of port infrastructure, details of terminal equipment operations

manning, fuel, and M&R. Terminal management expenses plus local taxes and fees have been incorporated in the OPEX calculations.

Results, US/Mexico Service

CAPEX: The structure of the US/Mexico Services investment budget is similar to that of the Europe Service write-up above. Separate CAPEX tables, as listed below, have been prepared for each service.

OPEX: The structure of the US/Mexico Services operations budget content is similar to the Europe Services write-up. Separate OPEX table, as listed below, has been prepared for each service.

Drafted Documentation

Europe service:

5.02.01	Trailer Cat Project investment budget – CAPEX (Europe)
5.02.02	Trailer Cat Service operations budget - OPEX (Europe)
5.02.03	PRICE ESTIMATION OF THE VESSELS 2018.03.31 (Europa and US)
5.02.04	Cost estimation of linkspan 27.03.2018- OPEX (Europa and US)
5.02.04	Energy consumption riv.

US/Mexico service:

5.02.06	Trailer Cat Project investment budget – CAPEX (US)
5.02.07	Trailer Cat Service operations budget - OPEX (US)

5.03 Risk Assessment

Leading Partners

Transmar and Bureau Veritas

Results, Summary

The risk analysis, as outlined and presented in the documents referred to below, has been evaluated in a committee setting consisting of representatives from OSK, Bureau Veritas, Claus Kruse Consult, and Transmar Ltd. The task has been developed and coordinated by Transmar Ltd in cooperation with Bureau Veritas. The final results have been prepared and presented by Transmar Ltd (Arne Martinsen).

Results, EU Service

The 'Risk Assessment', as concluded by the Trailer Cat team, will enable interested investors to assess potential risks prior to initiating negotiations with partners and subsequently with relevant port authorities and shipyards, and, most importantly, with targeted prospective shippers.

The first details of the assessment tasks have been to evaluate risks tied to market response and to the level of probability and likelihood that the new service can attract the major volumes projected from key shippers and transporters in the targeted trade corridor. Other risk factors evaluated include technical and operational risks arising with a new design involving the largest catamaran cargo vessels to date. The risk of not being able to secure the most optimal terminal facilities in the targeted ports and other factors include port labour issues. A multitude of other

factors possibly affected by changing environments and national/regional economic conditions are also incorporated in the assessment.

Results, US/Mexico Service

As noted under drafted documentation, separate analysis report tables have been prepared for the Europe and US/Mexico Services respectively. The general results as reported in the Europe Services section above also apply to the US/Mexico Service results.

Drafted Documentation

Europe service:

5.03.01	Risk assessment: commercial, implementation, operational and technical risks	
5.03.02	Risk tables:	Annex (I): Commercial and operational risk analysis
		Annex (II): Design and technical risk analysis

US/Mexico service:

5.03.01	Risk assessment: commercial, implementation, operational and technical risks	
5.03.02	Risk tables:	Annex (I): Commercial and operational risk analysis
		Annex (II): Design and technical risk analysis

5.04 Comparison

Leading Partners

Claus Kruse Consult

Results, Summary

The goal for the INNOship project was to confirm the task to achieve a cost reduction of 50% per trailer and a CO2 emission reduction of 70% per trailer compared with large conventional vessel in service today on a 120 nautical miles route. The Rotterdam – Harwich service is 114 Nm and has been used for the comparison. We have compared the Trailer Cats with a traditional vessel of 3800 LM operating on HFO. Newbuilding prices have been the prerequisite for the CAPEX cost of both type of vessels and the calculations have been based on identical conditions. The cost reduction has been estimated to 41% per trailer. The main reason for not reaching the 50% reduction was the reduced fuel prices resulting in a lower advantage of the lower fuel consumption.

The goal was also to achieve a CO2 emission reduction of 70% per trailer. This goal has been reached as the reduction has been estimated to 71,9 %

Drafted Documentation

5.04.01 Comparison between traditional Ro - Ro vessel and the Trailer Cat on a 120 nautical mile route.

5.04.02 Comparison of Emissions

5.05 The Business Case; an update

Leading Partners

Transmar and Claus Kruse Consult

Results, Summary

During the initial formation of the Trailer Cat project concept it became evident that the two routes selected needed a different market approach which subsequently affected how the studies were developed separately. The extensive market research targets described, combined with the logistics efficiency features of the Trailer Cat system, has produced positive results in terms of significant cost advantages compared to similar services with conventional vessels. A substantially reduced environmental impact per unit transported is a most important feature of the project.

Results, EU Service

The Europe service will compete directly with Ro-Ro operators in the Cross-Channel/Cross North Sea arena of ferry traffic between the UK and the Continent. The competitiveness of the Trailer Cat represents high-volume turn-around efficiencies combined with the fact that the system proves to achieve both low unit costs and low per-unit emissions.

The key characteristics of the Europe service is that it will strictly address shuttle traffic between a Continental terminal and a UK terminal serving a steady stream of trailers, containers, and other traffic in both directions.

Results, US/Mexico Service

The Texas–Mexico corridor targets the growing volume of cross-border trailer traffic for which 'TCSA' will offer a maritime highway by-pass relief corridor along the coast. The Trailer Cat system will re-route trailers and 53' domestic containers from the ever more congested cross-border traffic presently using the deteriorating highway systems in Texas and in Mexico.

Key end customers will be BCOs (Beneficial Cargo Owners) that control major volumes of cargoes using 53' trailers and 53' domestic containers as their primary transportation mode for the cross-border traffic.

The US/Mexico Service's business case has its major focus on 'door-to-door' traffic, meaning the Trailer Cats simply serve as fast-moving platforms carrying trailers between two identical port terminals from where the traffic is managed and directed under the 'through-bill-of-lading' concept.

Introducing Rail Intermodal moves between Galveston and Dallas/Ft Worth and on to Chicago would lower that overland segment of the transport operations costs as well as providing substantial reduction of greenhouse gas emissions.

Drafted Documentation

Europe service:

5.05.01 The Business Case; an update (Europe)

US/Mexico service:

5.05.02 The Business Case; an update (Americas)

END OF DOCUMENT