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MEASURING SHIP ENERGY PERFORMANCE

Real-world case studies, performance data, and engineering insights driving measurable decarbonisation

THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

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SHIP ENERGY EFFICIENCY CONFERENCE 2026

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CONTENTS

BALTIC QUEEN	5
BERGE OLYMPUS	7
CARNIVAL JUBILEE	10
HIGH SEAS	13
OCEANBEAUTY	15
PYXIS ALFA	19
SYLVIA	21
VERTOM	23
VILLE DE BORDEAUX	25
NOTES PAGE	27

BALTIC QUEEN

1. VESSEL PARTICULARS

Builder	STX Europe, Rauma, Finland
IMO number	9443255
Vessel's name	*Baltic Queen*
Owner/operator	Tallink Group
Flag State	Estonia
Classification Society	Bureau Veritas
Delivery Date	2009
Total number of sister ships (including those completed for other owners if possible)	3 (MS *Galaxy*, MS *Romantica*, MS *Baltic Princess*)

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Replacement of propellor blades for lower ship speed propeller, new bulbous bow, other ESD, etc	Kongsberg Maritime Sweden AB	Following a reduction of service speed the ship's propellers were no longer optimal. Hence the ship owner contracted Kongsberg to redesign and supply new propellers. Fuel consumption and underwater radiated noise were measured before and after the reblading.

2.1 SELECTION OF EFFICIENCY MEASURE(S) – CONTINUED

Noting the progressive nature of the IMO GHG regulations, the shipowner has adopted a forward looking approach to energy efficiency by reducing the ship speed to the extent practical within the operational constraints. Thereby enabling just two of the ship's four engines to be utilised for the normal operation. Resulting from this, the propeller design became sub-optimal and hence the propeller manufacturer was contracted to design new propeller blades for the reduced speed.

The new propeller blades were fitted in early September 2023.

Both fuel consumption and underwater radiated noise before and after the modification were measured. An average fuel saving of 17% was achieved and a broadband reduction in underwater radiated noise (URN) of about 8 decibels.

This is a good example of the co-benefit of URN reduction that can be achieved by taking a holistic approach and considering the impact on URN when selecting energy efficiency measures.

2.2 IMPLEMENTATION PROCESS

The fuel consumption was measured using the ship's Coriolis flow meters. Hydrophones were deployed adjacent to the ship's normal route and measurements were taken according to the standard ANSI-ASA S12.64-2009.

2.3 VERIFICATION AND OUTCOMES

Significant fuel savings were achieved. The IAPH ESI environmental incentive scheme is expected to incorporate a new URN reduction module later this year and if such ship modifications are carried out as part of a noise management plan, ports participating in the scheme may award reductions in port dues.

2.4 LESSONS LEARNED AND REPLICABILITY

It is important to simultaneously consider energy efficiency improvements and their impact on URN through a noise management plan. Most efficiency measure reduce URN and hence URN reduction can readily be achieved if this holistic approach is taken. Increasingly environmental incentive schemes are including URN reduction and therefore such an approach can yield financial benefit.

3. TECHNICAL PARTICULARS

Length Overall (LOA)....................212m
Length Between Perpendiculars (LBP)....................194.4m
Breadth, Moulded....................29m
Gross Tonnage....................48,915
Design Draught.................... 6.4m

CAPACITIES

Design Deadweight....................6,287tonnes
Capacity....................2,800 passengers
2,500 berths[1]
420 cars [1]
1,130 lanemeters

MAIN ENGINE

Manufacturer....................4 × Wärtsilä 16V32 diesels[2]
combined 32,000kW (43,000hp)

PERFORMANCE MONITORING

Flow meters (yes/no).................... Yes
Flow meter type (volumetric/mass)....................Coriolis

[1]. www.ship-technology.com/projects/baltic-queen/?cf-view
[2]. https://en.wikipedia.org/wiki/MS_Baltic_Queen#cite_note-FoF-2

BERGE OLYMPUS

1. VESSEL PARTICULARS

Builder	Bohai Heavy Shipbuilding
IMO number	9750957
Vessel's name	*Berge Olympus*
Owner/operator	Berge Bulk
Flag State	Isle of Man
Classification Society	DNV
Delivery Date	25 January 2018
Total number of sister ships (including those completed for other owners if possible)	7

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Advanced rudder, propeller duct	Shipyard	Propeller duct
Hull Coating	Nippon	Fastar XII
Ultrasonic Antifouling	Alfa Laval	Sonihull
Wind propulsion	Bar Tech	Rigid Wing- 4 pcs
Optisave	DESMI	Variable frequency drive on main electrical consumer
Shaft Generator	Wärtsilä	In-Line Shaft Generator. Electrically excited
Voyage Optimisation	SoFar Wayfinder	

2.1 SELECTION OF EFFICIENCY MEASURE(S) – CONTINUED

We selected this retrofit package using Berge Bulk's Maritime Marshall Plan portfolio logic: prioritise immediate, verifiable emissions reduction (Pillar 1–2) while building readiness for tighter carbon rules. The vessel's operational profile – long ocean passages, steady power demand, and favourable wind exposure on key routes – made WASP the anchor: four BAR Tech Wind Wings offer the largest step-change in fuel/CO_2 reduction without changing fuel. We paired WASP with voyage optimisation (Wayfinder) to systematically seek beneficial wind angles and to evidence savings with consistent weather/route baselining.

Supporting measures to work on the foundation of the WASP benefit: advanced rudder/duct, premium hull coating and ultrasonic anti fouling; Finally we retrofitted a shaft generator and DESMI VFDs to cut auxiliary/electrical fuel requirement.

2.2 IMPLEMENTATION PROCESS

The project was managed as an engineering change programme, with the Wind-Assisted Ship Propulsion (WASP) installation treated as the primary driver and the other efficiency measures aligned to support it.

The starting point was an operational review of the intended trading pattern, including route characteristics and associated wind statistics, to estimate expected fuel-saving potential and decide on the most advantageous combination of technology upgrade.

A feasibility design was then completed to confirm physical integration, identify operational impacts, and define constraints for port calls and cargo operations. This feasibility phase formed the basis for structured engagement with key stakeholders, including fleet management, HSSQE, port authorities, the charterer, flag administration and class, to ensure early alignment on operability, risk, and compliance expectations.

Following stakeholder agreement, detailed engineering progressed into structural design and system integration. This included foundation, interface requirements with shipboard systems, and a detailed compliance review with class and flag, with particular focus on SOLAS-related considerations such as visibility/line-of-sight, safe access, and operational safety.

Installation and commissioning were executed within a planned drydock window and depended on close coordination well before arrival and throughout the yard stay to keep overall shipyard time to a minimum. Multiple parties were involved, including the owner's technical team and superintendent, the shipyard and key subcontractors, the WASP OEM, and electrical/automation vendors, alongside the necessary class/flag interfaces.

To shorten the critical path, work was sequenced for parallel execution wherever possible – foundations and local reinforcement, equipment installation, cabling and system integration – followed by aligned inspection, testing, and sign-off activities. Commissioning typically moved from quay-side functional checks to final sea trials to confirm safe operation, fail-safe performance, alarms/interlocks, and agreed operating limits. The programme emphasis was on completing design finalisation, approvals, procurement, and test planning in advance so the dock period could be used mainly for execution rather than problem-solving.

Training and change management were treated as essential to safe adoption. A dedicated course was developed for engineers and watchkeeping crew, and bridge simulation training was created to prepare navigators for operational changes, particularly those affecting field of vision and bridge workload. After delivery, the work continues through maintenance analysis and structured performance review, with route optimisation remaining an ongoing activity to refine operating practices and maximise realised benefits.

2.3 VERIFICATION AND OUTCOMES

Implementation delivered measurable reductions in main-engine fuel consumption and associated CO_2 emissions. The most direct evidence came from structured on–off testing, where the wings were alternately enabled and disabled over comparable operating windows. These trials provide a high-confidence snapshot of performance in specific conditions and were primarily used to validate and calibrate the WASP thrust curves (thrust contribution as a function of apparent wind angle and speed). Peak of over 25t/day fuel savings were observed during those tests.

Because on–off trials cannot practically cover the full range of real-world conditions, the vessel then transitioned to long-term monitoring. Berge Bulk developed an in-house performance monitoring system that applies the calibrated thrust curves from the on–off programme to operational data. This enables continuous estimation of WASP contribution and ongoing verification of fuel and emissions savings across voyages. This approach also supports performance trending (e.g., identifying degradation or abnormal behaviour), and helps separate WASP effects from other factors such as hull condition, and operational changes.

2.4 LESSONS LEARNED AND REPLICABILITY

Overall, the implementation has been successful, and we have since delivered two further vessels with wind-assisted propulsion. On subsequent projects, we placed greater emphasis on detailed front-end engineering and early interface freeze, alongside tighter coordination across all parties involved in the shipyard period to minimise off-hire time and risk of late rework. A key lesson was also to treat telemetry and measurement-and-verification as a project in its own right, with clear data requirements, installation scope, and commissioning tests, to ensure reliable and timely availability of post-retrofit performance data.

3. TECHNICAL PARTICULARS

Length Overall (LOA)....300m
Length Between Perpendiculars (LBP)....294m
Breadth, Moulded.... 49m
Depth, Moulded.... 25.3m
Gross Tonnage....109,716
Displacement....240,813
Design Draught....18.62m

CAPACITIES

Design Deadweight....211,153
Lightweight....31,911.00
Capacity....Grain 225,443; Segregated Ballast 91,217
Service Speed .....14.7 Ballast and 13.4 Laden at 85% MCR

MAIN ENGINE

Manufacturer....Dalian Marine Diesel Co. Ltd
Model.... DMD Wärtsilä W6X72
Installed Power (kW)....17,500
RPM....82.6
Propeller diameter (m)....8.8
Low load tuning (yes/no)....N
Continuous low load operation....N
NOx Tier....II
Scrubber (yes/no)....Y
Scrubber manufacturer....Pureteq
Fuel Type(s)....Heavy Fuel Oil, Diesel Oil, Gas oil

PERFORMANCE MONITORING

Flow meters (yes/no)....Y
Flow meter type (volumetric/mass)....Mass
Flow meter installation....ME and AE Separate
Flow meter manufacturer.... Yokogawa
Digital solution (description + manufacturer)....Metis Cyberspace

OTHER ENVIRONMENTAL EQUIPMENT

Ballast water treatment type.... Filtration + Electro-Catalysis + Neutralisation
Ballast water treatment capacity....n/a
Ballast water system manufacturer....Sunrui Balclor
Weather routing and voyage optimisation manufacturer/supplier....SoFar Wayfinder

REGULATORY INDICATORS

Applicable EEDI phase....II
Required EEDI....2.79
Attained EEDI....1.94
EEDI Pme (kW).... 12,562.5
EEDI Vref (knots).... 14.25
Required EEXI....2.37
Attained EEXI....1.94
EEXI Pme(kW).... 12,562.5
EEXI Vref (knots):.... 14.25
EEXI compliance method.... Compliant
Attained CII (2025)....1.944 (Unverified)
CII rating (2025)....B (Unverified)

CARNIVAL CORPORATION & PLC

CARNIVAL JUBILEE

1. VESSEL PARTICULARS

Builder	Meyer Werft
IMO number	9851737
Vessel name	*Carnival Jubilee*
Owner/operator	Carnival Corp / Carnival Cruise Lines
Flag State	Panama
Classification Society	RINA
Delivery Date	04 December 2023
Total number of sister ships (including those completed for other owners if possible)	9 + 2 in build

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
High-performance coating	Hempel	Hempaguard X8 (Vertical sides & flat bottom).
Air lubrication	Silverstream	Proprietary protected information.
Voyage optimisation	Carnival Corporation	In-house developed voyage optimisation software proposing optimised route, trim & propellers rotational speed on the basis of computer model fed with multiple sensors, external predictions such as wind, current, sea-state & main ship systems current performances.
EGB	SAACKE	Exhaust Gas Boilers
HVAC Automation	Wärtsilä APSS	Overall ship integrated automation systems including HVAC systems.
VFD	ABB JEUMONT Danfoss	ACS 6080 (Azipod propulsion) Main chillers Main auxiliairies

2.1 SELECTION OF EFFICIENCY MEASURE(S) (CONTINUED)

Large cruise ships are operated in highly varying conditions through seasoned deployments.

Carnival Jubilee is the 9th ship of the Excellence class, which was first inaugured in 2018 with *AIDAnova*. This class of ships has been designed for an optimised efficiency in a compromise combining operations in either or northern Europe, Mediterranea or tropical zone.

Ship operation profile varies from low average speed itinerary to mixed ones with first & last fast legs, followed by archipelago low-speed night navigation alternated with daily port calls of about 10 hours.

Design decisions are driven by a proportionally important hotel load inherent to passenger ships. Energy saving philosophy is set to optimise a high and almost stable hotel load combined with intermittent energy demand for sailing periods. Direct hotel load savings are prioritised primarily on HVAC functions, lighting and rotative machines with extensive use of variable speed drives, engines sophisticated heat recovery loops and also cold recovery from the very low temperature primary fuel (Liquefied Natural Gas @-163deg C). The latter is utilised either to feed provision cooling plant or for load shedding of main chillers.

2.2 IMPLEMENTATION & VERIFICATION PROCESS

Specific challenge in cruise shipbuilding performance demonstration lies in the combination of operational constraints requiring ship to be fully occupied and geared in operations into very different climate environment. Design full proof requires to reach most demanding climate conditions (combined humidity, water and ambient air high/low temperatures).

It takes months, sometimes a year, to reach all those extreme cases. These are required to test systems at their maximum capacity. In addition, day-to-day operations shall demonstrate ability of safety, control and automation systems to deliver optimised energy savings 'at a glance'. It goes from optimisation of control cascades between fluids flows, heating and cooling through widely varying sequences. All this can obviously not be fully achieved during building and commissioning periods. Shipyard and key OEMs remain involved through years-long guarantee period, followed by in-service termed services.

A comprehensive process is deployed from contract start. It involves key design & control philosophies choices based on return on involved parties experiences (OEMs, Shipyard, Owner). It drives initial decisions on equipment sizing, redundancy, operating and maintenance philosophies. Those are carefully engineered around a permanent focus on performance continuity and total cost of owner ship (capital expenditure + operational expenses including spares inventories, consumables and services including preventive measures and regular overhauls).

Extensive recourse is made to advanced maintenance philosophies involving condition-based monitoring (CBM), computerised maintenance management systems (CMMS) anticipating advanced preventive maintenance. Significant statistics methodologies are used based on field-proven records of key equipment such as Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR). Given a 30 years-plus lifetime, specific attention is also made to anticipate obsolescence matters especially in regards of electronics and software dependant systems.

Cruise ship design shall allow to cover optimised performances in extreme cases including overhaul of equipment while entire function remains operational. Critical configurations such as Safe Return to Port prescriptions are also to be permanently available with no notice.

Progressive proving is deployed through an early engineered Inspection and Testing Plan.

Key equipment is subject to design verification, inspection and factory acceptance tests. When systems are completed on board at shipyard they are functionally proven (cold commissioning) and progressively brought to live. They are then tested starting with safety functions. Along ship commissioning they are primarily brought to life and further tested after initial balancing often experience based (hot commissioning). Tests are here indeed limited by available loads in shipyard conditions.

One or two sea trial periods (a few days each) are undertaken to demonstrate performances (to class, authorities and owner) within the limits of system loads accessible (limited personnel on board, etc). In such pre-operative conditions some hotel functions cannot be fully tested (galley, laundries, wastes, heat loads being capped).

Extensive training programmes are also deployed and covering 'academic' training by vendors, familiarisation on sisterships when available and also rotation of personnel toward the fleet to maximise experience transmission.

The proving programme of a cruise ship is a long but exciting period, involving all and a lot of progressive tuning loops to reach optimised settings.

Thanks to long class of ships, *Carnival Jubilee*, despite new features brought by previous ships in the class, has also benefitted from all predecessors experience to reach to her best performances faster.

2.3 LESSONS LEARNED AND REPLICABILITY

The main lesson learnt in cruise ship building is obviously that we are in a never-ending improvement programme. On a 10-plus ship class, closing the loop of the prototype takes around eight years. Equipment are continuously evolving bringing the naval architect into a permanent evolution loop, eventually supported by the experience gained ship on ship. Intrisically, things are different but better at each loop and permanent change is involved.

3. TECHNICAL PARTICULARS

Length Overall (LOA)....345.4m
Length Between Perpendiculars (LBP)....320.1m
Breadth, Moulded....42m
Depth, Moulded....11.8m
Gross Tonnage....182,000
Displacement....87,300
Design Draught....8.80m

CAPACITIES

Design Deadweight....12,500
Lightweight....71,600
Capacity....2,600 cabins about
Service Speed (at 85 % MCR)....20knots

MAIN ENGINE

Manufacturer....MAK Caterpillar
Model....4 x 16VM46DF
Installed Power (kW)....67,200kW
RPM....514
Propeller diameter (m)....5.95
NOx Tier....Tier III (Dual Fuel)
Scrubber (yes/no)....N
Fuel Type(s)....Dual fuel LNG & MGO

PERFORMANCE MONITORING

Flow meters (yes/no)....Y
Flow meter type (volumetric/mass)....Mass
Flow meter installation (Total only, ME only, ME and AE separate)....ME only
Flow meter manufacturer....Emerson

OTHER ENVIRONMENTAL EQUIPMENT

Weather routing and voyage optimisation manufacturer/supplier....In-house system
Shore power capable (yes/no)....Y
Shore power equipment manufacturer....ABB Oy

REGULATORY INDICATORS

Applicable EEDI phase....Phase 1
Required EEDI....12.15
Attained EEDI....6.59
Required EEXI....Covered by EEDI
Attained EEXI....Covered by EEDI

HIGH SEAS

1. VESSEL PARTICULARS

Builder	HMD
IMO number	9455703
Vessel's name	*High Seas*
Owner/operator	D'Amico tanker DAC
Flag State	Liberia
Classification Society	ABS
Delivery Date	30 March 2012
Total number of sister ships (including those completed for other owners if possible)	2

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
PBCF	MOL	PBCF retrofitting while in dry dock

The retrofit decision was primarily driven by compliance with the IMO EEXI framework, with the objective of minimising engine power limitation while maintaining propulsion efficiency prior to the installation of an EPL. Several efficiency improvement measures were assessed, and the combination of a Propeller Boss Cap Fin (PBCF) with an eco nozzle was selected due to its short payback period, limited CAPEX, and ease of installation without the need for extensive hydrodynamic studies or major structural modifications.

The vessel operates worldwide under a diversified operational profile, making this solution robust across a wide range of speeds and loading conditions. In addition to propulsive efficiency gains, the PBCF provided a positive contribution to underwater noise reduction, aligning with emerging environmental considerations. The solution was also evaluated for compatibility with a Mewis duct already fitted on the selected Vessel, with no significant hydrodynamic interference identified. At fleet level, the strategy foresees replication across the fleet to achieve cumulative CO_2 reductions along with other ESDs equivalent to 6 (Six) zero tank to wake emission vessels.

2.2 IMPLEMENTATION PROCESS

The implementation process began with a comprehensive assessment phase aimed at identifying solutions that could be easily integrated into the existing fleet without creating interference with energy efficiency technologies already installed on board. The evaluation combined three key criteria: implementation cost, ease of application, and the projected performance benefit. Particular attention was given to ensuring that any modification would not negatively affect previously introduced efficiency measures.

A dedicated technical review was carried out to analyse the impact of proposed solutions on both vessel performance and regulatory compliance. In this context, the team conducted a detailed assessment of the vessel's EEXI and the potential engine power limitation (EPL) required to meet statutory thresholds. The analysis led to an integrated approach that combined the installation of a PBCF with an eco nozzle. The two technologies were selected for their complementary effect: the PBCF improves propeller efficiency and reduces required propulsive power, while the eco nozzle decreases specific fuel consumption. Together, they offered an optimised balance between regulatory compliance and operational performance.

Following the design and feasibility confirmation, installation activities were scheduled during the vessel's dry dock period to minimise operational disruption. The maker provided full technical support throughout the process. The propeller, PBCF elements were all treated with silicone coating to preserve hydrodynamic performance and maintain efficiency gains over time.

Once the initial implementation was validated, the retrofit programme was extended to the entire fleet. To maximise environmental and commercial value, all retrofitted ships were enrolled in a Gold Standard carbon credit programme, which required certification of the fuel savings achieved relative to performance recorded prior to the dry dock. This certification process involved independent verification of data collection methods, calculation models, and the quantification of CO_2 reductions.

Throughout the implementation, collaboration among key stakeholders – including the technical department, vessel crew, makers, classification bodies, and performance monitoring teams – was essential to ensure seamless execution.

2.3 VERIFICATION AND OUTCOMES

Sea speed and power trial was carried out on the vessel immediately after dry dock, and the measurements were later corrected for wind, waves, current and loading condition using third parties service company approved by the class.

The corrected results were compared with model tests, and performance curves (service + EEDI) were produced to verify contractual and regulatory requirements.

Software used:
STAIMO version 2.6.0, the IMO/ITTC certified tool used to perform all calculations and corrections.

Speed improvement at EEDI condition 0.28knots.

The result has been used to recalculated the attained EEXI to size the EPL.

3. TECHNICAL PARTICULARS

Length Overall (LOA) 183.31m
Length Between Perpendiculars (LBP) 174.00m
Breadth, Moulded 32.20m
Depth, Moulded 19.10m
Gross Tonnage 29,841
Displacement 62,068
Design Draught 11.0m

CAPACITIES
Design Deadweight 39,990
Lightweight 10,757
Service Speed .... 15.4knots @8,530kW

MAIN ENGINE
Manufacturer .... MAN
Model 6S50ME-C8
Installed Power (kW) 9,480
RPM 127
Propeller diameter (m) 5.80
Low load tuning (yes/no) .... N
Continuous low load operation .... N
NOx Tier II
Scrubber (yes/no) .... N
Fuel Type(s) .... LSFO + MGO

PERFORMANCE MONITORING
Flow meters (yes/no) .... Y
Flow meter type (volumetric/mass) .... Mass
Flow meter installation .... ME and AE separate

OTHER ENVIRONMENTAL EQUIPMENT
Ballast water treatment type .... UV type
Ballast water treatment capacity .... 1,500m^3/h
Ballast water system manufacturer .... PANASIA
Weather routing and voyage optimisation manufacturer/supplier .... WNI
Shore power capable (yes/no) .... N

REGULATORY INDICATORS
Applicable EEDI phase .... Phase 0
Required EEXI 4.89
Attained EEXI 5.26
EEXI Pme(kW) 7,110
EEXI Vref (knots): 14.81
EEXI compliance method .... Power limitation, PBCF, Econozzle
EEXI compliance method manufacturer .... Overridable Power limitation
Attained CII (2025) 5.711
CII rating (2025) .... B

OCEANBEAUTY

1. VESSEL PARTICULARS

Builder	Cosco (Zhoushan) Shipyard Co. Ltd
Designer (if different from builder)	SDARI
IMO number	9641338
Vessel's name	*OCEANBEAUTY*
Owner/operator	Waves Maritime Company Limited
Flag State	Liberia
Classification Society	RINA
Delivery Date	January 2013
Total number of sister ships (including those completed for other owners if possible)	*OCEANLADY* - 9641364 *OCEANLOVE* - 9641352 *OCEANMASTER* - 9641340

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Scenario 1: Software / Financial Settlement Module	ShipFORCE (Ship-Reality Inc.)	**Voyage Simulator & Financial Settlement Module**. Digital Twin calibrated to specific vessel data to validate charterer reported consumption against physics-based baselines.
	ShipFORCE (Ship-Reality Inc.)	**Decarbonisation Path Module**. A "Virtual Assessment Workshop" to simulate the cumulative impact of Energy Saving Technologies (ESTs) and fuel transition strategies over the vessel's lifecycle.

2.1 SELECTION OF EFFICIENCY MEASURE(S) (CONTINUED)

Scenario 1: To navigate "Split Incentive" risks under FuelEU Maritime and EU ETS, we implemented the ShipFORCE Voyage Simulator and Financial Settlement Module. Acting as a "Commercial Firewall" for our Time Charter fleet, this system ensures accurate calculation of financial exposure and operational impact.

The solution utilises extensive Noon Report validations to eliminate errors at the source, creating precise MRV Voyage Port Stay breakdowns for settlements. Furthermore, the Voyage Simulator forecasts financial exposure and CII ratings before voyages occur. This pre-voyage insight empowers us to challenge discrepancies; we have successfully denied excess settlement requests by identifying errors on the charterer's side. ShipFORCE provides a trusted, data-driven picture of the status quo, reducing reliance on charterer reporting and ensuring financial accountability.

Scenario 2: With an aging fleet (~13 years) facing the existential threat of CII trade bans – where non-compliance risks seizing operations through Administrative detention or Commercial "Trade Stop" (Charter & BIMCO Clauses, Financing) – we faced critical "hard measure" dilemmas beyond just financial exposure (EU ETS/FuelEU). We selected the ShipFORCE Decarbonisation Path to serve as a "Virtual Assessment Workshop".

Rather than relying on isolated marketing claims, this physics-based framework models the cumulative impact and diminishing returns of stacked Energy Saving Technologies (ESTs). It allows us to simulate the vessel's performance years in advance, testing retrofit strategies against a "Business As Usual" baseline. This pre-validation transforms the risk of stranded assets into a data-driven roadmap, ensuring we identify the specific technical interventions required to maintain trade eligibility before committing to CAPEX.

2.2 IMPLEMENTATION PROCESS

Scenario 1: The implementation involved integrating the ShipFORCE Voyage Simulator and Financial Settlement Module directly into our commercial and technical workflows, transitioning our operations from reactive reporting to proactive validation. The process followed a structured, four-phase approach:

1. *Data Foundation & Error Prevention*: The first and most critical step was establishing the Noon Report Record-keeping module as the single source of truth. We enforced strict usage of the platform for all daily reporting, capitalising on its extensive automated validations and sanity checks. This measure was implemented to arrest errors at the source, preventing data inaccuracies from propagating into downstream financial calculations.

2. *Digital Twinning & Vessel Modelling*: We established a high-fidelity "Digital Twin" for the specific vessel class to serve as the baseline for all simulations. This model was constructed using the vessel's Sea Trial data, General Particulars, and hydrodynamic characteristics. By grounding the simulator in the vessel's foundational design parameters rather than relying solely on variable operational history, we ensured a consistent and objective benchmark for performance analysis.

3. *Pre-Voyage Scenario Testing*: For upcoming EU-related voyages, we implemented a mandatory pre-voyage simulation step. We utilised the Voyage Simulator to run parallel scenarios: one utilising the Charterer's proposed profile and another testing various compliance strategies (e.g., Biofuel grades). This allowed us to forecast the exact financial exposure (EU ETS, FuelEU) and the resulting CII Rating before the voyage commenced, ensuring we understood the cost implications of the Charterer's operational decisions in advance.

4. *Settlement Validation & Commercial Firewall*: Post-voyage, the implementation shifted to financial defense. We utilised the platform's analyser engines to generate the MRV Voyage Port Stay breakdown, which serves as the concrete basis for all FuelEU and EU ETS settlements. Instead of relying on Charterer-submitted reports, we re-simulated completed voyages using our validated actuals to verify penalty and allowance usage.

Scenario 2: We implemented a comprehensive "Digital Twin" simulation workflow to validate our long-term compliance roadmap, utilising the ShipFORCE Decarbonisation Path Planner. This process moved beyond simple additive calculations to a physics-aware simulation that modelled complex interactions.

1. ***Baseline Creation (BAU)***: We first established a "Business As Usual" forecast as a credible benchmark. This projected the vessel's historical operating profile into the future, incorporating a dynamic fouling model that simulated the daily accumulation of hull roughness and its subsequent reset during automatically scheduled default dry docks.

2. ***The "With Measures" Simulation***: We created a parallel digital twin to test decarbonisation strategies, applying measures in a strict, physics-based sequence to ensure realism:
   - ***Fuel Change***: Applied first as the foundation, altering the baseline energy density.
   - ***Hydrodynamic Measures***: Modelled hull friction reductions and fouling resets.
   - ***Consumption Reduction***: Targeted specific machinery efficiency (ME/AE/Boiler).

3. ***Physics-Aware Application Logic***: Crucially, the implementation utilises a robust simulation engine to validate every operational scenario. The system checks the eligibility of each technology against specific physical limits (e.g., wind speed for rotors) and models the realistic degradation of performance over the asset's lifecycle. Furthermore, it addresses the complexity of interactivity, applying advanced logic to determine the net effect of stacked technologies. This prevents the over-estimation of savings by accounting for the diminishing returns inherent in combining multiple efficiency measures.

4. ***Net Power & Energy Balance***: Instead of a simple arithmetic summation of theoretical savings, the system derives a dynamic "Net Power" requirement. This holistic calculation integrates the vessel's evolving baseline condition (including fouling) with the cumulative efficiency gains. It also rigorously accounts for "counter-impacts" – deducting the energy costs required to operate the new systems (e.g., increased auxiliary load) – to ensure the final projection reflects the true operational reality.

2.3 VERIFICATION AND OUTCOMES

Scenario 1: The primary outcome was strategic financial control. The Voyage Simulator proved that for 2025, a "Business As Usual" (BAU) strategy – running on conventional fuels and settling the penalty – was often the most commercially robust path compared to aggressive Biofuel strategies, often resulting in "Compliance Surpluses" that exposed the Owner to complex compensation claims without providing a commensurate financial benefit.
- *Financial Recovery*: By quantifying this risk, we established clear clauses with Charterers and utilised the automated "Voyage Statement" to secure 100% recovery of ETS costs, preventing over-payment.
- *Regulatory Precision*: The system automated the generation of MRV and EU ETS statements, significantly reducing administrative workload.

Scenario 2: The primary outcome was the creation of a scientifically validated Decarbonisation Roadmap that eliminated financial "blind spots".
- *Blind Spot Detection*: The simulation revealed hidden "Counter-Impacts," such as the increased Auxiliary Engine load required for certain pneumatic or wind-assist systems, which significantly altered the net ROI.
- *Compliance Assurance*: We successfully mapped the vessel's CII rating, EU ETS and FuelEU Maritime exposure through the vessel's projected lifetime, identifying exactly when "hard" technical interventions would be required versus operational adjustments.
- *Verification*: The results were verified by the system's "Physics-Aware Stacking Model," which ensured that the cumulative savings of combined technologies were calculated based on modified power demand rather than simple additive percentages, preventing the common error of over-estimating fuel savings.

2.4 LESSONS LEARNED AND REPLICABILITY

Scenario 1: The centralised control of settlements has been highly successful and is being rolled out to the sister vessels as well as our newly acquired vessels (*OCEANHOPE* & *OCEANHARMONY*). However, relying on Noon Reports has limitations in precision. The key lesson is that "Data is Cash".

Scenario 2: This "Digital Workshop" approach has proven that technologies cannot be viewed in isolation; they interact, and often compete. The process has successfully transitioned us from a reactive "compliance" stance to a proactive "strategy" stance. We are now replicating this simulation workflow across the fleet to determine the optimal timing for fuel transitions and retrofits for each specific vessel class. ***Future Integration***: Moving forward, we aim to close the loop between prediction and reality. As we proceed with the selected retrofits, we plan to utilise ShipHULL to validate the actual performance gains against our pre-installation simulations. This will allow us to refine our "Digital Twins" continuously, ensuring our long-term decarbonisation roadmap remains grounded in measured reality, not just theoretical models.

3. TECHNICAL PARTICULARS

Length Overall (LOA) 189.99m
Length Between Perpendiculars (LBP) 185.00m
Breadth, Moulded 32.26m
Depth, Moulded 18.00m
Gross Tonnage 330,49.00
Displacement (Design) 58,897.8t
Design Draught 11.30m
Scantling Draught 12.80m

CAPACITIES

Design Deadweight 48,020.60
Lightweight 10,877.20
Scantling Deadweight 56,803.90
Capacity .... 719,94.10m^3
Service Speed (at 75% MCR, pre EPL) 14.39knots
Range (nautical miles) 23,000

MAIN ENGINE

Manufacturer .... Hudong Heavy Machinery Co., Ltd
Model .... MAN-B&W 6S50MC-C
Installed Power (kW) 8,500
RPM 115
Propeller diameter (m) 6
Low load tuning .... Yes (Engine derated at 115rpm)
Continuous low load operation .... No (low load around 50%)
NOx Tier .... Regulation 13.4 (Tier II)
Scrubber (yes/no) .... N
Fuel Type(s) .... VLSFO / LSMGO

PERFORMANCE MONITORING

Flow meters (yes/no) .... Y
Flow meter type (volumetric/mass) .... Volumetric
Flow meter installation .... 1x Common M/E + A/E before FOM and Mixing Tank, 2x A/E (supply+return) 2x Aux. Boiler (supply+return)
Flow meter manufacturer .... VAF with pulse transmitter (reed switch) and temperature transmitter (PT100)
Digital solution .... METIS & LAROS (PrismaEL)

OTHER ENVIRONMENTAL EQUIPMENT

Pre-swirl duct .... Mewis Duct
Propeller Boss Cup Fin .... PBCF
Ballast water treatment type .... Electrolysis
Ballast water treatment capacity .... 1 x 800
Ballast water system manufacturer .... ERMA FIRST FIT
Weather routing and voyage optimisation manufacturer/supplier .... Zero North
Shore power capable (yes/no) .... No (Not yet fitted with Cold Ironing)

REGULATORY INDICATORS

Required EEXI .... 4.15 gCO_2/ton.mile
Attained EEXI .... 4.15 gCO_2/ton.mile
EEXI Pme(kW) 5,375.91
EEXI Vref (knots): 13.84
EEXI compliance method .... Power limitation
EEXI compliance method manufacturer .... ShaPoLi (Datum electronics)
Attained CII (2025) .... 5.621 gCO_2/ton.mile
CII rating (2025) .... D

KUMIAI NAVIGATION (PTE) LTD

PYXIS ALFA

1. VESSEL PARTICULARS

Builder	Kawasaki Heavy Industries - Sakaide
IMO number	9765457
Vessel's name	*Pyxis Alfa*
Owner/operator	Kumiai Navigation (Pte) Ltd
Flag State	Singapore
Classification Society	NKK
Delivery Date	May 2017
Total number of sister ships (including those completed for other owners if possible)	8

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
At new building stage	Kawasaki Heavy Industries	**Bow Enhancement**: SEA-Arrow (Sharp Entrance Angle bow as an Arrow) **Propeller Duct**: SDS-F (Semi-Duct System with contra Fins) **Rudder Bulb**: RBS-F (Rudder Bulb System with Fins)
Retrofit 2025	Alfa Laval	OceanGlide – Air Lubrication System

The decision to retrofit the vessel *Pyxis Alfa* with the OceanGlide air lubrication system was driven by Kumiai Navigation's commitment and ambition to decarbonisation through a continuous enhancement of the efficiency of its fleet. *Pyxis Alfa* sails long haul between Japan and North America with a even split between ballast and laden. To understand the ALS potential, the vessel was only retrofitted with the OceanGlide ALS thus enabling a direct comparison between fuel consumption before and after dry docking. The OceanGlide ALS creates a controllable air layer underneath the hull, reducing friction through a number of air distribution bands, directly lowering main engine power consumption and overall vessel emissions.

Regulatory requirements, including IMO's EEDI/EEXI and CII frameworks, further motivated the choice, as OceanGlide ALS supports compliance with increasingly stringent environmental standards. Alternative makers were evaluated, but OceanGlide was selected due to its ease of installation on existing vessels and worldwide after sales support.

2.2 IMPLEMENTATION PROCESS

The implementation of the OceanGlide Air Lubrication System (ALS) on *Pyxis Alfa* was a straightforward installation as the air distribution bands do not require any structural changes to the vessel's hull or integrity. The onboard compressors are known equipment to the crew, further facilitating OceanGlide's adoption by the crew as a non-intrusive system that increases the efficiency of the vessel. The key stakeholders were a project team from Kumiai Navigation's Ship Management Department, Anglo Eastern fleet management department, the shipyard, Njord Solutions, and Alfa Laval's operations and system performance departments. A tight and smooth collaboration amongst the key stakeholders ensured a successful installation without extending the allocated dry docking period. The main challenge encounter was the calibration on onboard sensors, which was solved within the project team.

2.3 VERIFICATION AND OUTCOMES

The system performance has been verified through a methodology, whereby the operating profile of *Pyxis Alfa* has been entered into the OceanGlide control system during commissioning. Hereafter the vessel entered into normal operating schedule with OceanGlide continuously running and high-frequency data being recorded during the full voyage in ballast and laden. The data was processed according to ISO 19030-2 and a trend line establish that was then compared to three reference curves, given by Kumiai Navigation: handover from shipyard, current speed-power curve due to vessel's age, and pre-dry docking noon reports. The results shows consistent savings across ballast and laden between fuel savings of 4-5tons per sailing day. The system performance monitoring is on-going.

2.4 LESSONS LEARNED AND REPLICABILITY

Alfa Laval has, since this installation, released the second version of its OceanGlide air lubrication system, which reduces the number of air distribution bands compressors, and onboard instrumentation.

3. TECHNICAL PARTICULARS

Length Overall (LOA)....229.90m
Length Between Perpendiculars (LBP)....226.00m
Breadth, Moulded 37.20m
Depth, Moulded 21.00m
Gross Tonnage 46,884
Design Draught....11.23m

CAPACITIES

Capacity.... 82,200m^3
Service Speed ....17.0knots (at 85% MCR)
Range (nautical miles)....22,100

MAIN ENGINE

Manufacturer....Everllence B&W
Model ....7S60ME-C8.2 - 2-stroke 7-cyl
Installed Power (kW).... 13,100
RPM 89
Low load tuning (yes/no).... N
Continuous low load operation .... N
NOx Tier II
Scrubber (yes/no).... N
Fuel Type(s)....VLS IFO

PERFORMANCE MONITORING

Flow meters (yes/no)....Y
Flow meter type (volumetric/mass) ....Volumetric
Flow meter installation....ME and AE separate
Flow meter manufacturer .... Kawasaki Measuring Instruments Co Ltd

OTHER ENVIRONMENTAL EQUIPMENT

Ballast water treatment type .... electrolysis
Ballast water treatment capacity ....1,000m^3/hr
Ballast water system manufacturer....Electro-Cleen
Weather routing and voyage optimisation manufacturer/supplier ....Wärtsilä FOS
Shore power capable (yes/no).... N

REGULATORY INDICATORS

Applicable EEDI phase....0
Required EEDI ....7.78g CO_2 / tonne-mile
Attained EEDI....6.20g CO_2 / tonne-mile
EEDI Pme (kW)....9,825
EEDI Vref (knots) 17.04
Required EEXI ....5.44g CO_2 / tonne-mile
Attained EEXI ....5.04g CO_2 / tonne-mile
EEXI Pme(kW)....7,789kW
EEXI Vref (knots):.... 15.89knots
EEXI compliance method.... Power limitation
EEXI compliance method manufacturer.... Everllence
Attained CII (2025)....6.66
CII rating (2025) 6.44

SYLVIA

1. VESSEL PARTICULARS

Builder	STX Offshore & Shipbuilding Co., Ltd
IMO number	9471264
Vessel's name	*Sylvia*
Owner/operator	Pavimar SA
Flag State	Marshall Islands
Classification Society	DNV
Delivery Date	01 May 2010
Total number of sister ships (including those completed for other owners if possible)	6

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Propeller Boss Cap Fin	Nakashima Propeller Co., Ltd	PBCF Retrofitted at 2016
High-performance coating	CMP	Ultra-Low friction coating applied in 100% of the hull
Voyage optimisation, Performance monitoring	Ship-Watch	Data Acquisition System with high frequency sensors on Flowmeters(ME & DG), Torque meter and ECDIS.

The selected energy efficiency measures combine proven hydrodynamic improvements with data-driven operational optimisation. A Propeller Boss Cap Fin (PBCF) was retrofitted to improve propeller hub vortex losses, targeting immediate fuel savings without impacting reliability. In parallel, an ultra-low friction hull coating was applied across 100% of the underwater hull to reduce resistance and maintain performance between dry dock intervals. To complement the technical measures, a high-frequency data acquisition system was installed to enable accurate performance monitoring and verification through continuous measurement of fuel consumption, shaft power, and navigation data.

The decision-making process considered the vessel's long-haul trading profile, regulatory pressure from EEXI/CII requirements as well as EU Regulations, low technical risk, and favourable payback periods. Alternatives such as major propulsion retrofits were evaluated but rejected due to higher CAPEX and operational disruption.

2.2 IMPLEMENTATION PROCESS

The implementation followed a phased approach combining dry-dock retrofits and onboard system integration.

The high-performance hull coating was applied during dry docking following standard surface preparation procedures, including high-pressure washing, spot steel treatment, and controlled application to achieve the specified surface roughness. Application quality control was performed to ensure uniform coverage and optimal coating thickness.

The custom data acquisition system was implemented as an onboard retrofit. Mass flow meters were installed on the main engine and auxiliary engine fuel supply lines, and a torque meter was installed on the propulsion shaft. The system was integrated with the vessel's ECDIS and automation systems to synchronise fuel consumption, power, speed, and navigational data. Commissioning included sensor calibration, signal validation, and redundancy checks.

Crew training was conducted on board, focusing on system operation, data interpretation, and basic troubleshooting. Shore-side technical teams were involved to establish data pipelines, dashboards, and reporting protocols.

Key challenges included sensor installation in confined engine room spaces and ensuring data consistency across different operating modes. These were mitigated through careful planning, phased commissioning, and post-installation data validation. No significant operational disruption occurred, and the system entered full operational use shortly after commissioning.

2.3 VERIFICATION AND OUTCOMES

The implemented measures resulted in measurable improvements in vessel fuel performance and propulsion efficiency, primarily through reduced hull resistance and improved operational transparency. Following the application of the ultra-low friction hull coating, lower main engine power demand was observed at comparable vessel speeds and drafts, contributing to improved fuel efficiency during both ballast and laden voyages.

Verification was carried out through a structured baseline and post-implementation assessment supported by continuous, high-frequency data collection. Historical operational data were used to establish reference relationships between vessel speed, draft, shaft power, and fuel consumption. Post-implementation performance was monitored using mass flow meters installed on the main and auxiliary engines, shaft power measurements, and synchronised navigational data obtained via the Ship-Watch platform.

To ensure robustness, data were filtered to exclude transient conditions such as manoeuvring, adverse weather, and abnormal engine operation. Performance comparisons were conducted within defined operating envelopes, ensuring equivalent draft, speed, and engine load ranges. This approach enabled isolation of the coating's impact from operational and environmental variability.

Long-term monitoring across multiple voyages confirmed that the observed efficiency improvements were stable and repeatable. The verified reduction in fuel consumption translated directly into lower reported CO_2 emissions, contributing to reduced exposure to compliance costs and potential penalties under EU ETS and FuelEU Maritime frameworks, while strengthening the vessel's overall regulatory and commercial positioning.

2.4 LESSONS LEARNED AND REPLICABILITY

The combined application of low-risk technical measures with high-quality performance monitoring proved highly effective. The key lesson learned is that continuous, high-resolution data is essential for credible verification and long-term optimisation. Future implementations would benefit from installing monitoring systems as early as possible to establish stronger baselines. Given the favorable cost–benefit ratio, low operational risk, and verified results, these measures are strong candidates for fleet-wide rollout, particularly for vessels with similar operational profiles and regulatory exposure.

3. TECHNICAL PARTICULARS

Length Overall (LOA) 229m
Length Between Perpendiculars (LBP) 222m
Breadth, Moulded 32.24m
Depth, Moulded 20.1m
Gross Tonnage 43,837
Displacement 93,826.5
Design Draught 12.2m

CAPACITIES

Design Deadweight 80,281.2
Lightweight 13,540.8
Capacity .... 95,171.7m^3
Service Speed (at 75 % MCR) 14.8knots

MAIN ENGINE

Manufacturer .... STX-MAN B&W
Model 7S50MC-C8
Installed Power (kW) 11,069
RPM 127
Propeller diameter (m) 6.2
Low load tuning (yes/no) .... N
Continuous low load operation .... N
NOx Tier I
Scrubber (yes/no) .... N
Fuel Type(s) .... VLSFO, MDO

PERFORMANCE MONITORING

Flow meters (yes/no) .... Y
Flow meter type (volumetric/mass) .... Mass
Flow meter manufacturer .... Yokogawa
Digital solution .... Emission monitoring platform, Ship-Watch

OTHER ENVIRONMENTAL EQUIPMENT

Ballast water treatment type .... Filtration, Electrolysis
Ballast water treatment capacity .... 1,250m^3/h
Ballast water system manufacturer .... ERMA FIRST

REGULATORY INDICATORS

Required EEXI 3.51
Attained EEXI 3.23
EEXI Pme(kW) 5,644
EEXI Vref (knots): 13.10
EEXI compliance method .... ShaPoLi (Shaft Power Limitation)
EEXI compliance method manufacturer .... VAF
Attained CII (2025) 3.49
CII rating (2025) .... 4.02 (C)

VERTOM

1. VESSEL PARTICULARS

Builder	Chowgule Group
Designer	Groot Ship Design
Owner/operator	Vertom
Flag State	The Netherlands
Classification Society	Lloyd's Register
Delivery Date	2027-2028
Total number of sister ships (including those completed for other owners if possible)	4

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Hydrodynamic - rudder bulb	Wärtsilä	Rudder bulb fitted at newbuild 3.8m Nozzle propeller
High-performance nozzle propeller	Wärtsilä	3.8m Nozzle propeller
Fuel Consumption Optimisation (EcoControl)	Wärtsilä	Wärtsilä EcoControl is present to optimize the fuel consumption during transit sailing modes, based on the principle that equal thrust can be achieved at more fuel optimised propeller pitch and engine speeds compared to a static combinator mode. The implementation consists of two modules; an active propeller combinator with smart load controller and a fuel limit function.
SCR System	Wärtsilä	NOx Reducer system is designed to reduce the emissions of nitrogen oxide. The operation of the system is based on nitrogen oxide abatement by Selective Catalytic Reduction (SCR). IMO Tier III EIAPP in accordance with MARPOL Annex VI Regulation 13 / NOx Technical Code 2008 and relevant IMO guidelines.

As far as the hydrodynamic performance is concerned, the optimisation and design of the propulsive components was selected based on CFD simulations at the design and ballast condition. The aim was to achieve the best overall performance.

2.2 IMPLEMENTATION PROCESS

The hydrodynamic rudder bulb and high-performance nozzle propeller design has been optimised using Computational Fluid Dynamics (Wärtsilä's OPTI-Design methodology). Wärtsilä's OPTI Design is a hydrodynamic performance assessment methodology based on advanced (CFD) simulations. This approach enables a comprehensive evaluation and optimisation of propulsion solutions within a virtual environment that accurately represents the full vessel context, including all relevant geometries and operating conditions. This ensures integrated optimisation of both the propulsion system and its surrounding components. Such CFD simulations have been performed to optimise the propeller design, the nozzle position, the rudder-bulb configuration and the headbox design.

2.3 VERIFICATION AND OUTCOMES

Based on the CFD simulations, 3.3% power reduction has been achieved by optimising the aft ship. As the vessel has not been built yet, there are no actual data to confirm performance.

2.4 LESSONS LEARNED AND REPLICABILITY

Comprehensive CFD simulations are extremely useful for enhancing vessel efficiency and minimising fuel usage, and they can be applied to any future vessel to ensure greater efficiency and reduced operating costs.

3. TECHNICAL PARTICULARS

Length Overall (LOA)	135.00m
Length Between Perpendiculars (LBP)	133.00m
Breadth, Moulded	16.60m
Depth, Moulded	10.10m
Gross Tonnage	7,460
Displacement	11,008m^3
Design Draught	5.85m

CAPACITIES

Design Deadweight	7,700t
Capacity	532TEU
Service Speed	13.1knots at 100% MCR 12.0knots at 79% MCR

MAIN ENGINE

Manufacturer	Wärtsilä
Model	Wärtsilä 7L25
Installed Power (kW)	2,415
RPM	900
Propeller diameter (m)	3.8
NOx Tier	Tier III
NOx aftertreatment type	SCR
Fuel Type(s)	MDF (Distillate)

PERFORMANCE MONITORING

Flow meters (yes/no)	Y
Flow meter type (volumetric/mass)	Mass
Flow meter manufacturer	Wärtsilä

VILLE DE BORDEAUX

1. VESSEL PARTICULARS

Builder	China Chang Jiang National Shipping Group Corporation Jinling Shipyard
IMO number	9270842
Vessel's name	*Ville de Bordeaux*
Owner/operator	Louis Dreyfus Armateurs
Flag State	France
Classification Society	Bureau Veritas
Delivery Date	April 2004

2. SHIP ENERGY EFFICIENCY MEASURES

2.1 SELECTION OF EFFICIENCY MEASURE(S)

Measure	Manufacturer	Description
Suction sails	bound4blue	Configuration: x3 units Model 2 – 22 x 4.5m

To meet decarbonisation goals, wind-assisted propulsion systems have become a viable solution for reducing vessel emissions. Bound4Blue (B4B) has developed an autonomous suction sail system that can be integrated into a wide range of vessels as a complementary propulsion technology. By generating additional thrust from wind, the system reduces the main engine power required, leading to lower fuel consumption, operating costs, and pollutant emissions. The decision to adopt this technology and install three eSAILs on the vessel *Ville de Bordeaux* is driven by the operational need to improve efficiency while complying with increasingly strict regulatory requirements. Cost–benefit considerations include compliance with mandatory measures such as CII, EEXI, and FuelEU Maritime, while providing a cost-effective alternative to relying solely on engine efficiency upgrades or switching to alternative fuels.

2.2 IMPLEMENTATION PROCESS

The implementation process began with a preliminary performance and feasibility study to determine the optimum number of eSAIL units and a provisional deck configuration, ensuring proper integration with the vessel's operational profile. Following the final investment decision, design modifications were carried out, including structural reinforcement at installation points and installation of foundations and bolted flanges to support the units.

Electrical and control integration included sensors capable of measuring wind speed and direction, temperature, and atmospheric pressure, combined with GPS and inertial sensors providing navigation and vessel attitude data. The main control cabinet, located inside each eSAIL unit, houses key equipment such as the PLC and motor controllers. It receives power from the vessel and distributes it to all system components through a redundant closed-loop Ethernet network. A touchscreen interface installed on the bridge enables monitoring and control by the crew.

Installation was completed during a scheduled shipyard stop in Vigo, including foundation installation, mounting of the eSAIL units, electrical and control integration, and commissioning tests. The system was integrated with onboard monitoring systems to ensure safe and automated operation.

Crew training covered system operation, safety procedures, and maintenance requirements.

2.3 VERIFICATION AND OUTCOMES

Following close collaboration between LDA, Bound4Blue (B4B), and Bureau Veritas Solutions (BVS), consistent results were obtained showing average daily fuel savings of approximately 1.7tonnes, with peak savings reaching up to 5.4tonnes of fuel per day under favorable wind conditions.

Results were verified using one full year of operational data recorded onboard the vessel. Bureau Veritas Solutions M&O conducted an independent assessment of fuel savings through advanced numerical modelling. The analysis relied on a hydro-aerodynamic vessel database developed using Computational Fluid Dynamics (CFD) and a performance prediction model comparing vessel operation with and without the wind-assisted propulsion system. Additionally, Bound4Blue performed a detailed CFD study to evaluate aerodynamic interference effects between sails and vessel structures, and these findings were incorporated into the performance model developed by BVS, ensuring accurate and reliable validation of achieved savings.

The combination of long-term onboard monitoring, validated numerical modelling, and third-party verification provides a reliable assessment of performance improvements and confirms the effectiveness of the installed wind-assisted propulsion system in reducing fuel consumption and emissions under real operational conditions.

3. TECHNICAL PARTICULARS

Length Overall (LOA)	183.31m
Length Overall (LOA)	154.27m
Length Between Perpendiculars (LBP)	138.01m
Breadth, Moulded	23.99m
Depth, Moulded	21.86m
Displacement	14,582
Design Draught	6.50m

CAPACITIES

Design Deadweight	5,968.69t
Lightweight	8,613.31t
Service Speed	17.42knots

MAIN ENGINE

Manufacturer	Caterpillar - MAK 9M43
Model	MAK 9M43
Installed Power (kW)	8,400kW 5,534kW (with Power limitation)
RPM	514 142 (with Power limitation)
Propeller diameter (m)	3.8
Fuel Type(s)	MDO

REGULATORY INDICATORS

Required EEXI	21.1
Attained EEXI	18.1
EEXI Pme(kW)	7 631.0
EEXI Vref (knots):	17.42

NOTES

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