RETROFIT55

RETROFIT SOLUTIONS TO ACHIEVE 55% **GHG REDUCTION BY 2030**

CAESES User Conference 2024, Potsdam September 11th

Horizon Europe programme, grant agreement No. 101096068

RETROFIT55: Decarbonization solutions to achieve 55% GHG reduction in maritime industry

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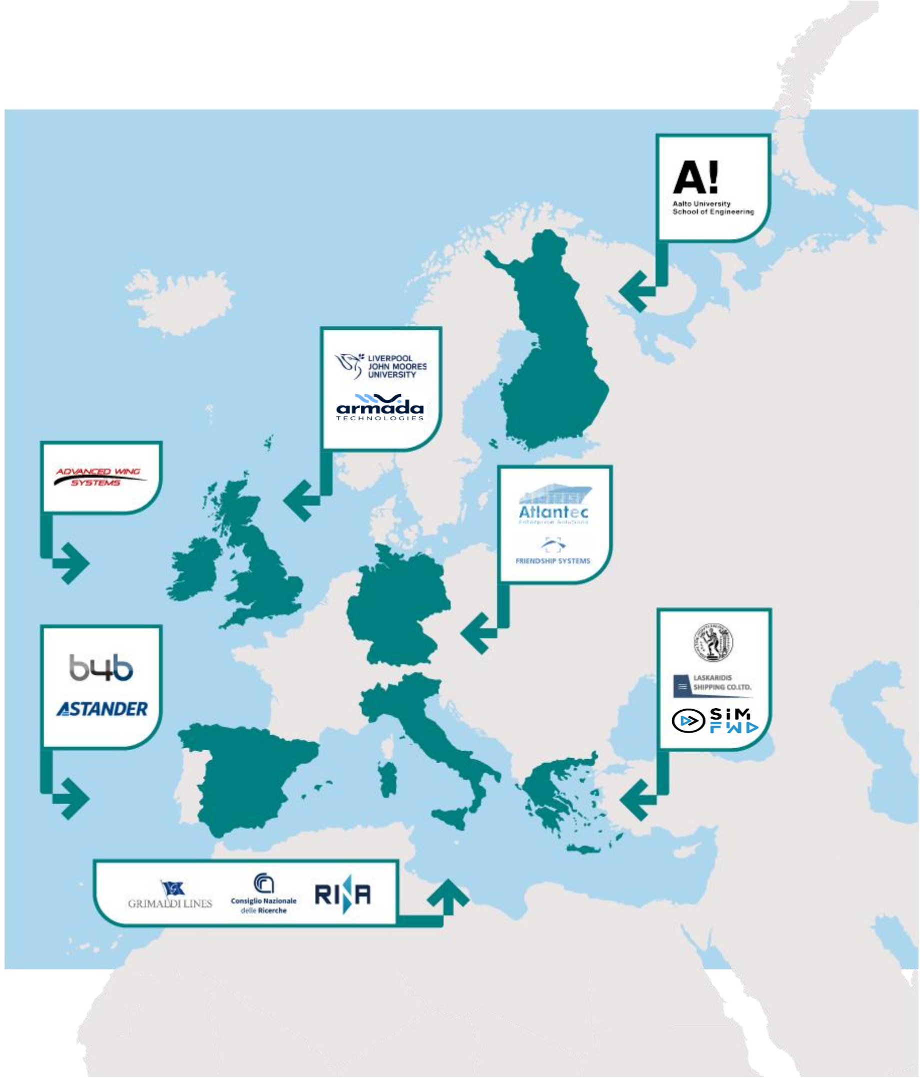
- ✓ EU founded Project
- ✓ *Kick-off*: January 2023
- ✓ *Concludes*: December 2025
- ✓ 14 partners
- ✓ 7 countries

- EU target to reduce 55% GHG by 2030 (Fit for 55)
- Propose decarbonization solutions to upgrade the existing fleet



Decision Support System (DSS)

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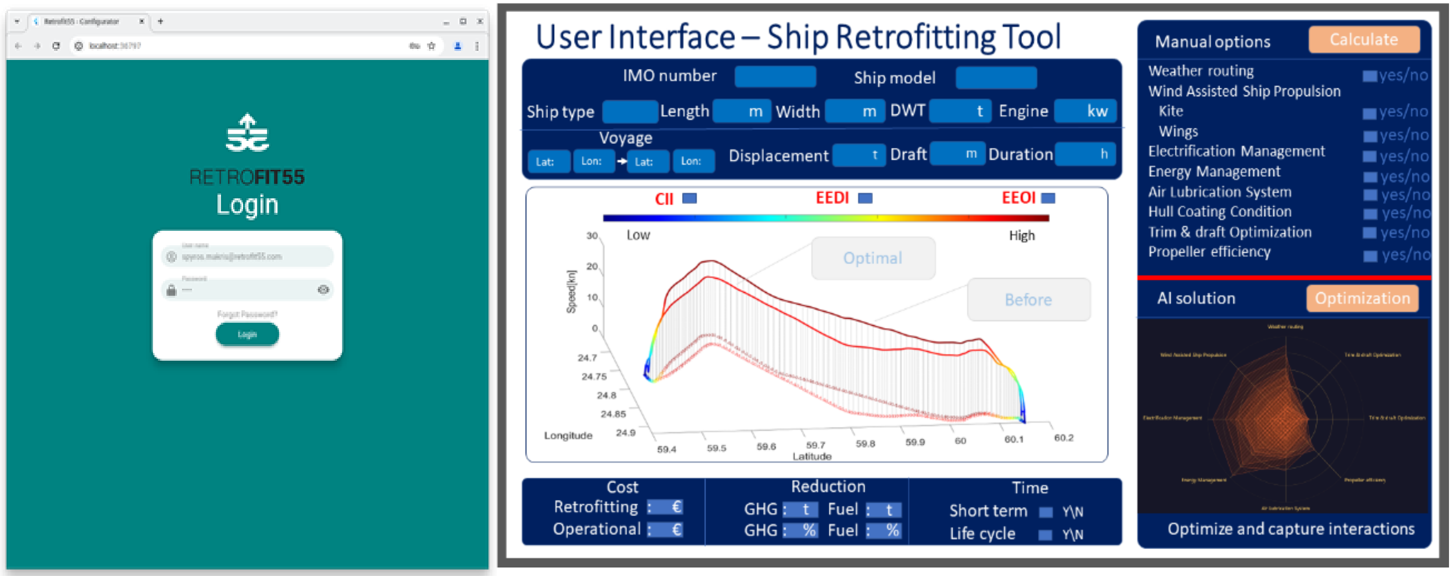
Atlantec Enterprise Solutions

- Interactive web-based tool
- Focuses on safe sustainable ship retrofitting
- It serves as a guide:
  - ✓ Energy Efficient Technologies
  - ✓ Regulatory Approvals
  - ✓ Best Practices

- Users will be able to
  - ✓ Customize retrofitting strategies
  - ✓ Measuring ship performance (EEXI)
  - ✓ Investment criteria (CAPEX and OPEX)



The designed user interface of ship retrofitting tool.

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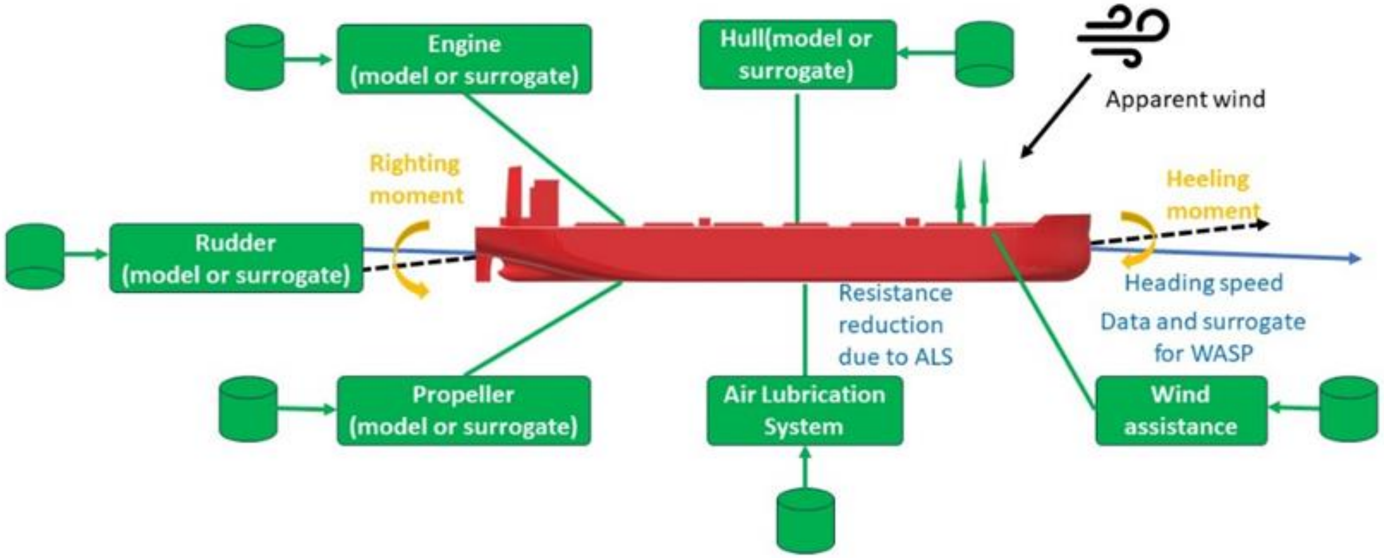
- We examine 5 different solutions:
  - ✓ Operational Synthesis and Optimization
  - ✓ Hydrodynamic Design Optimization
  - ✓ Wind Assisted Ship Propulsion
  - ✓ Air Lubrication System
  - ✓ Electrification and Energy Management System

- Integration into a Decision Support System
  - ✓ Based on a synthesis tool
  - ✓ Digital ship model
  - ✓ Surrogate models, regression formulas, etc



The diagram of the holistic digital ship model for retrofitting.

1. Hull and propeller condition monitoring tool

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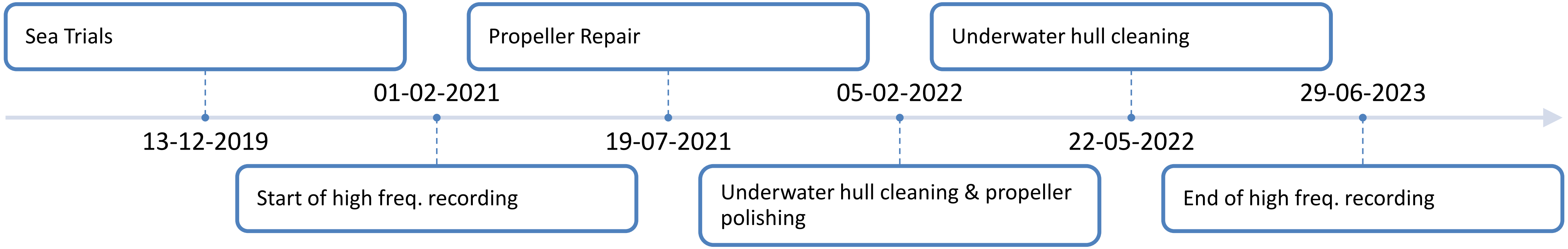
SiM FWD

- Development of a Machine Learning (ML) tool for estimating biofouling penalty
- Processing of two-and-a-half years of operational data from **automated logging** and **noon reports** are leveraged for analysis and simulation.



- A feature engineering process is implemented to identify the key input variables for a Machine Learning (ML) model that predicts SHP.

1. Hull and propeller condition monitoring tool

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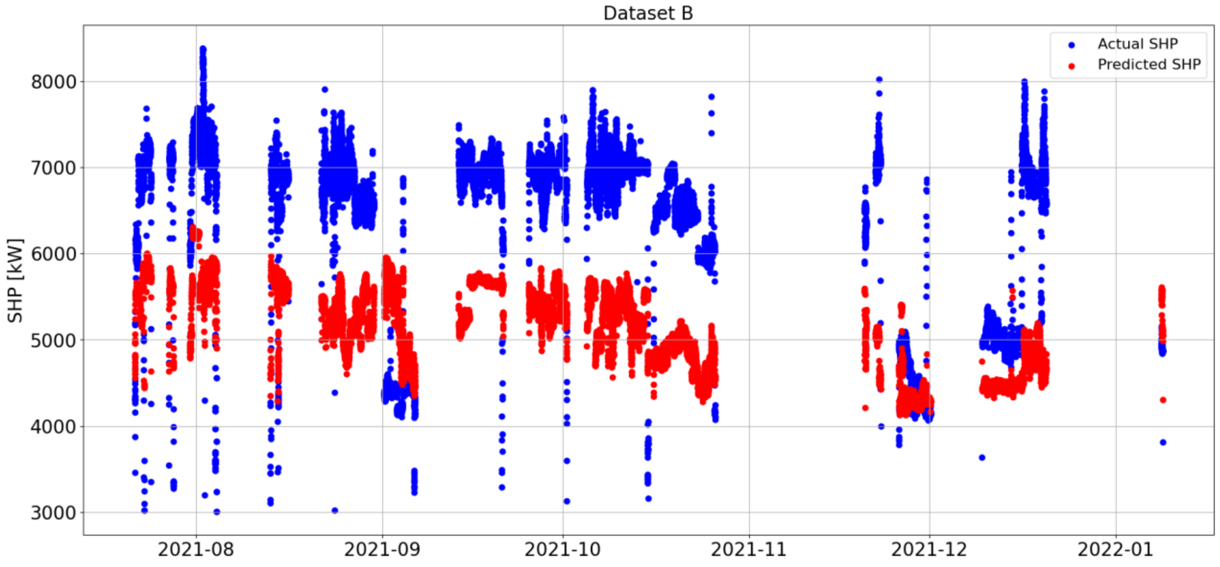
Step-1:

- Training based on data after maintenance (clean condition)
- Aim: Maintenance Optimization
- Result: Mean Increase 21.7%



Step-2

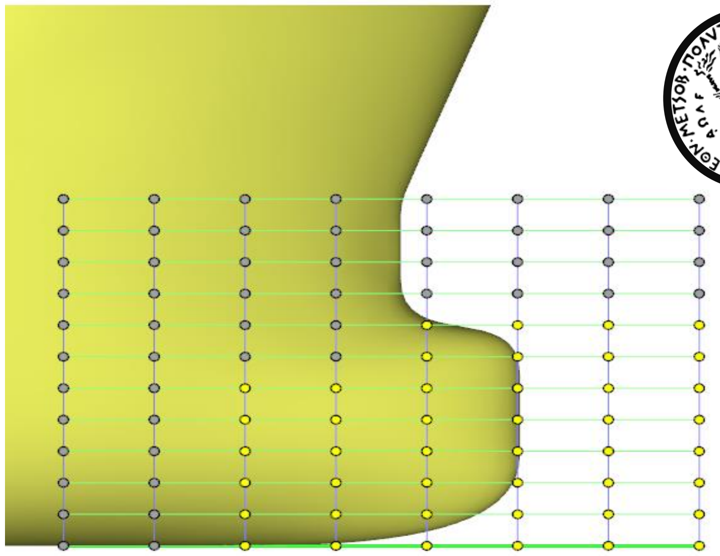
- Training based on data that incorporate also a temporal feature
- Aim: Estimation of added fuel cost
- Result: on Day 400 $2,743 $/day added fuel cost is predicted.

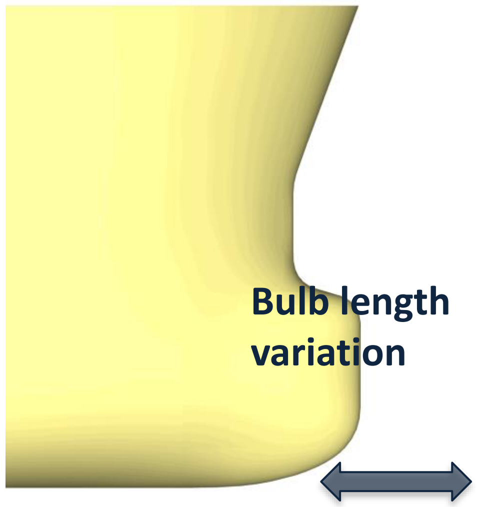
Days after maintenance	Mean predicted SHP (kW)	Mean power increase
51	5,006	-
120	5,283	5.5%
347	6,022	21.1%

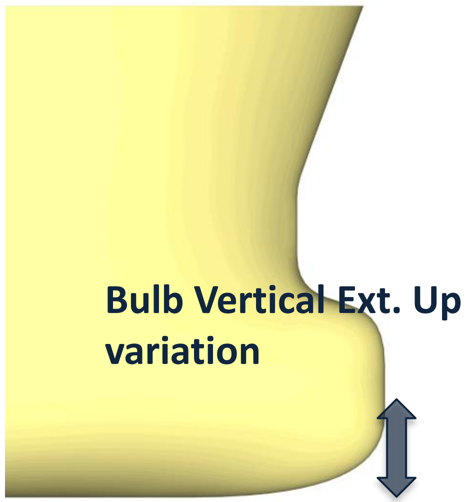
2. Hydrodynamic Optimization

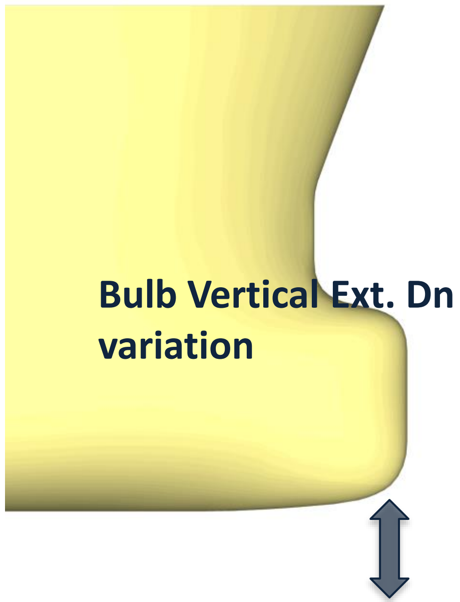
No. 101096068

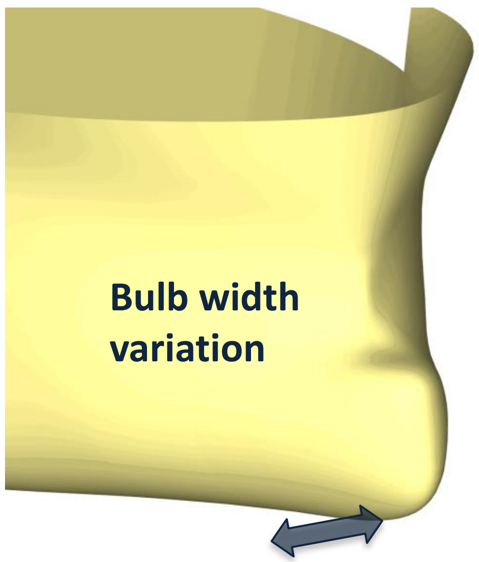
- New hullform with bulbous bow using CAESES software
- Bow transformation using Free From Deformation method
- 4 Bulbous bow design variables
- Small Effect on the ship resistance











2. Hydrodynamic Optimization

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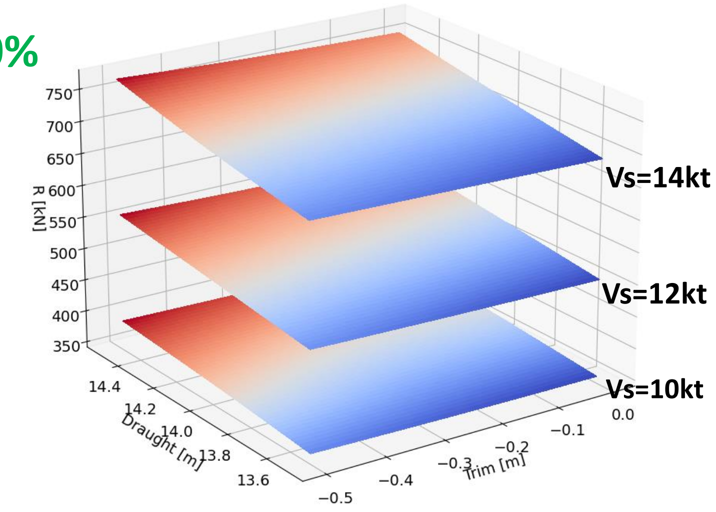
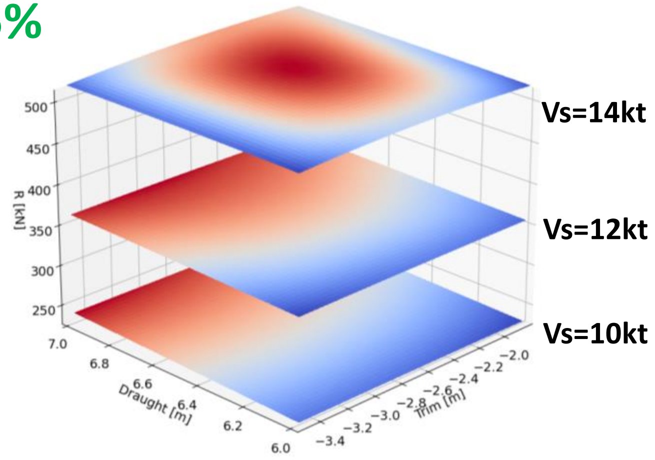
Trim Optimization using CAESES (in progress)

SiM FWD

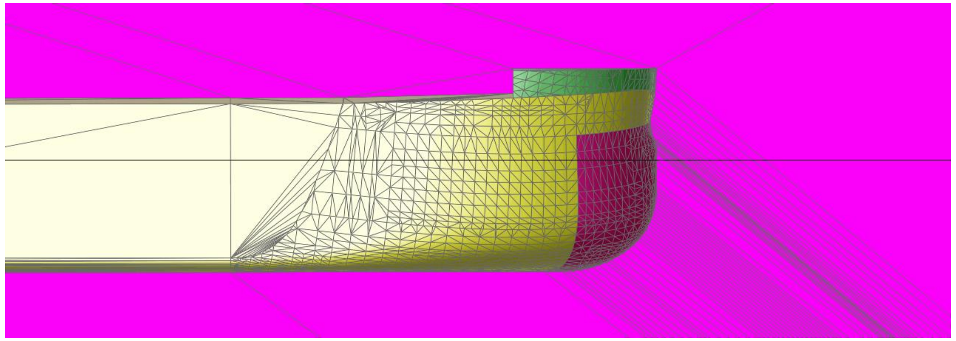
Differences up to 10%



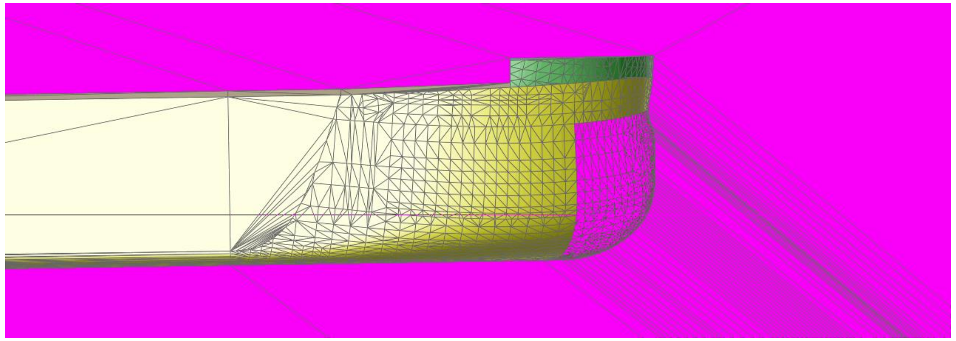
Differences up to 5%



Laden Condition



Ballast Condition



3. WASP – Semi Rigid Wing

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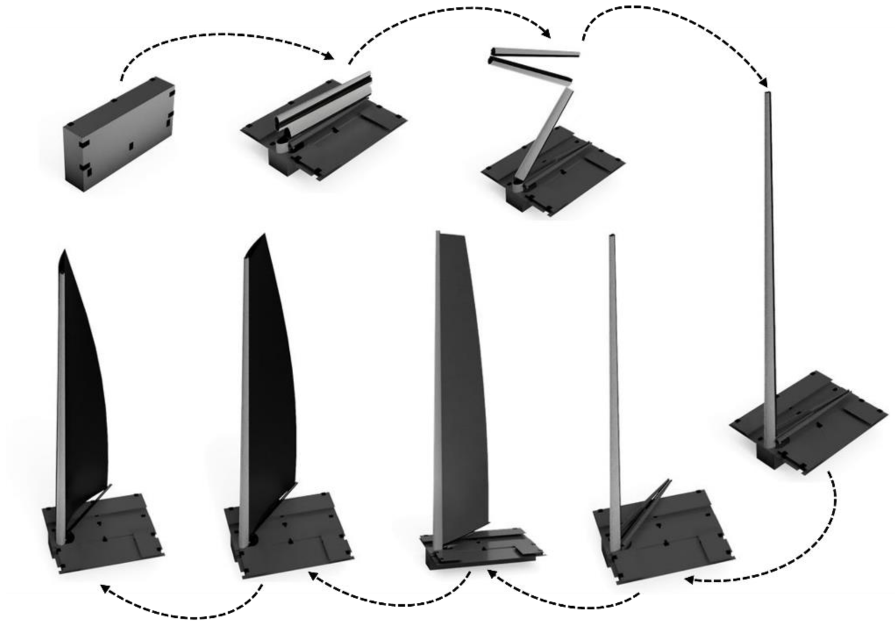
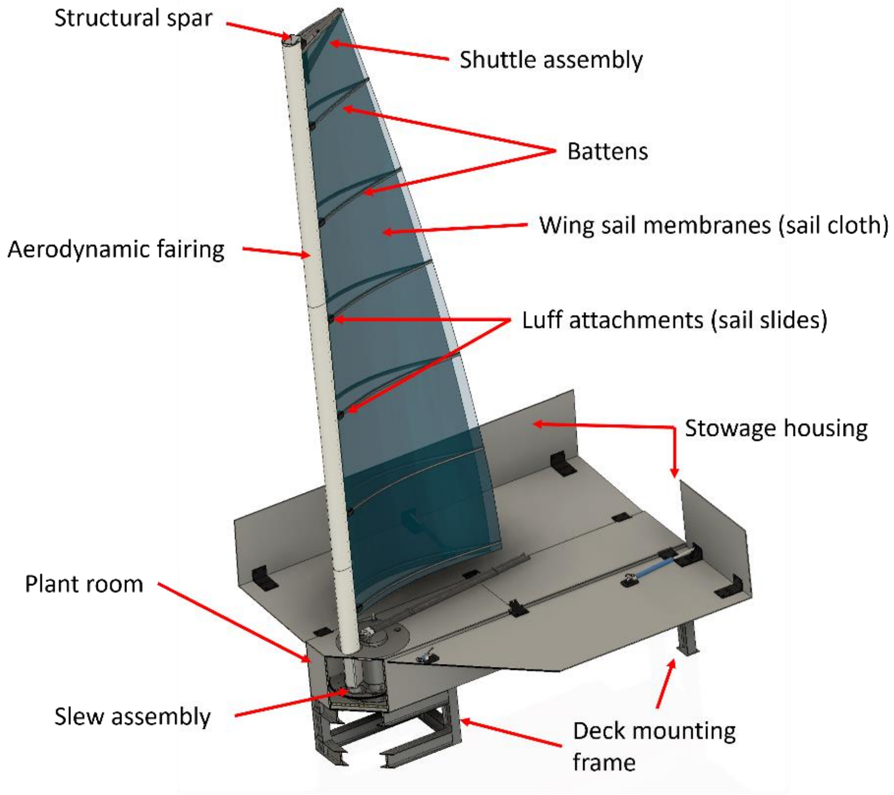
- ✓ Automated, collapsible and foldable. Fits into an ISO container
- ✓ Developed by Advanced Wing Systems
- ✓ The shape of the wind section is controlled through rigid battens



Within RETROFIT55:

- System Design and Layout
- Numerical Modelling



3. WASP – Semi Rigid Wing

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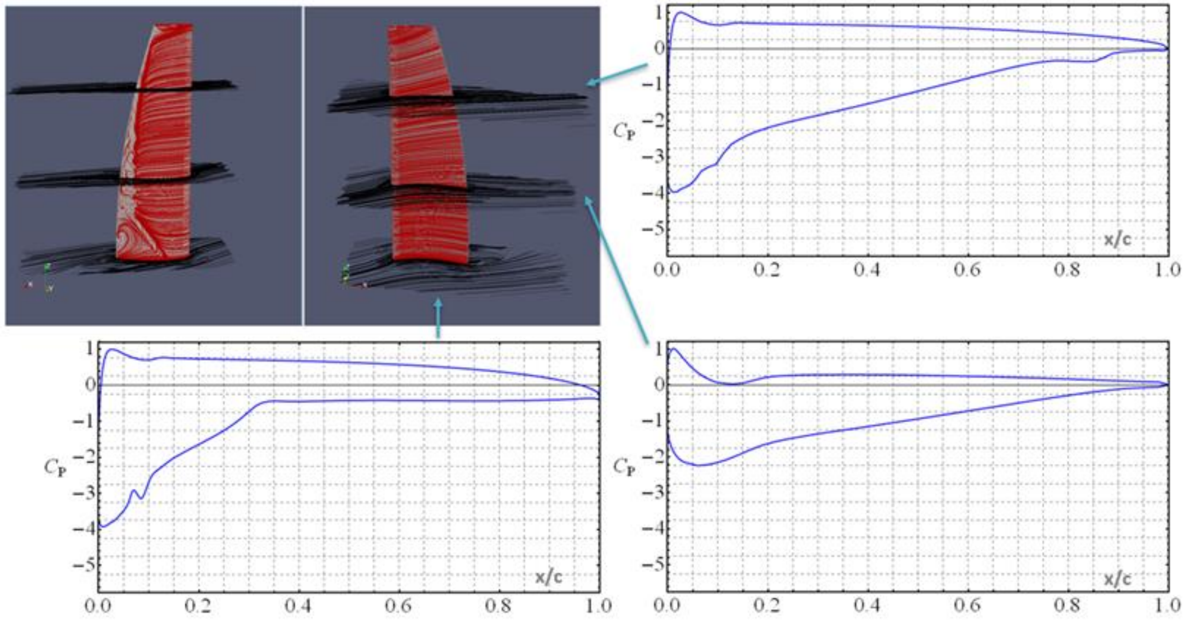
The scope of the task is to obtain:

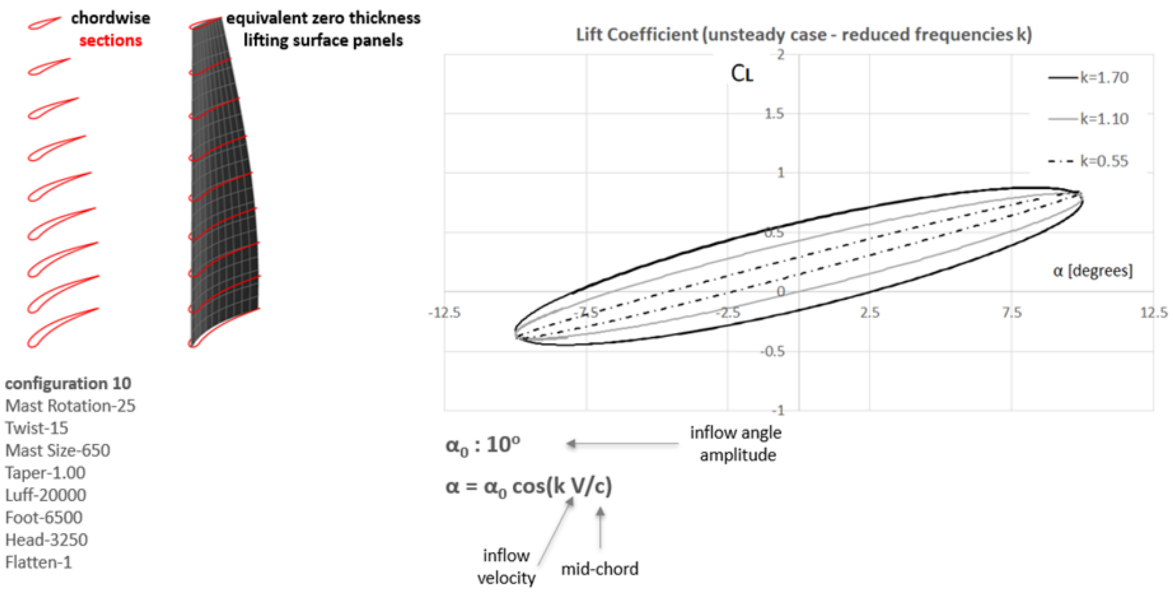
- Pressure loads along the rigid sail design
- Load coefficients to be used to the dynamics ship model

Multi-Fidelity Numerical Modelling

- ✓ Potential for small AoA
- ✓ URANS simulation for large AoA (up to 40°)



URANS results. AoA=20°



Potential Flow Results – Transient LST

3. WASP – Suction Sails

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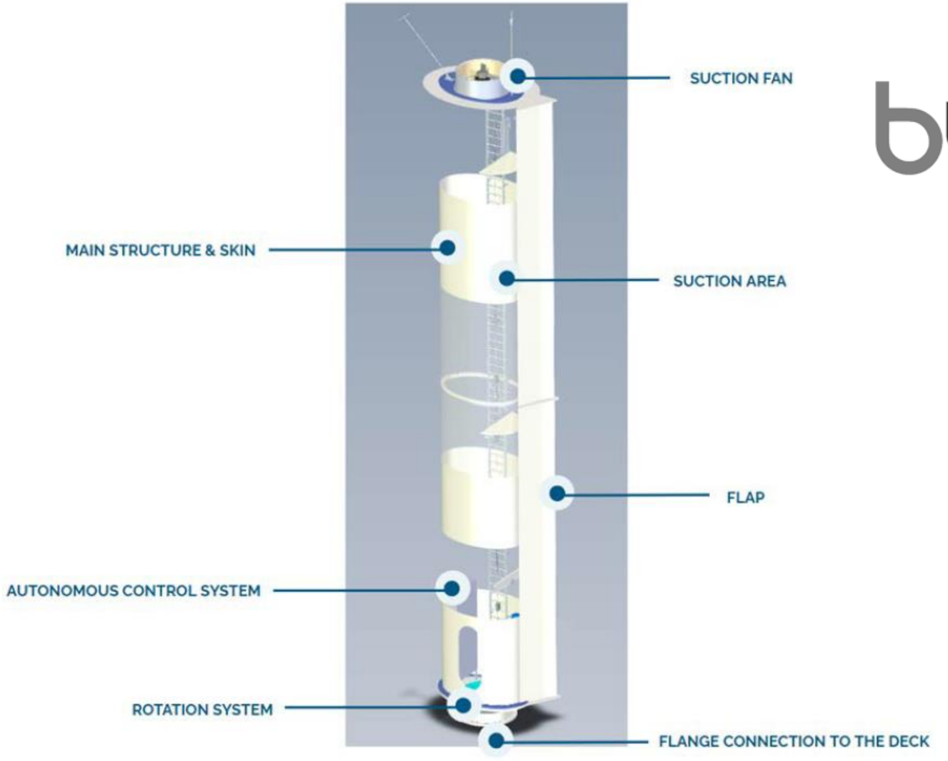
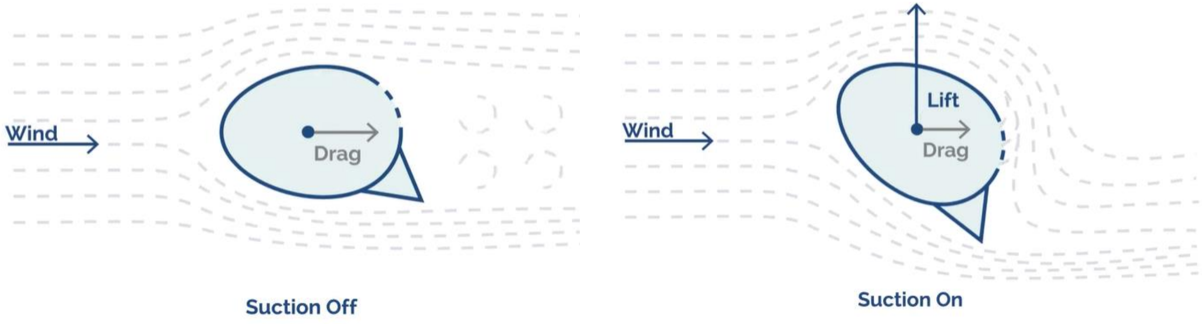
- Rigid wind sail -eSAIL- developed by bound4blue
- Fully automated rigid sail
- Active boundary layer control using suction

Within RETROFIT55:

- Design a standardized family of steel reinforcements
  - ✓ Right force distribution over hull and bow
  - ✓ Lowest weight
  - ✓ Minimum footprint on the vessel working are
- Weather Routing Optimization





3. WASP – Suction Sails

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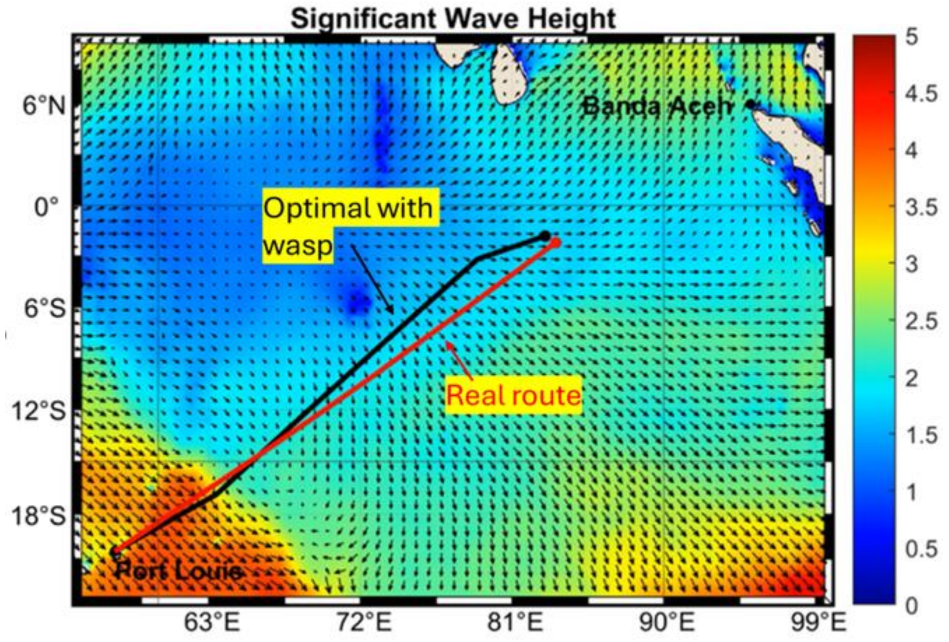
- ✓ Integration of the examined ship in the NTUA's weather routing tool
- ✓ Calculation of shaft power and main engine's fuel oil consumption
- ✓ A real voyage was simulated by the weather routing tool

	Time [days]	% Difference total FOC	% Difference ME FOC	% Difference DG FOC
Real Voyage w/o WASP	10.26	-	-	-
Real Voyage with 4eSAILs	10.26	-10.06%	-14.45%	29.18%
Optimal route with 4eSAILs	10.48	-12.95%	-17.80%	30.56%



Real and optimised route considering the WASP eSAIL

4. Air Lubrication System

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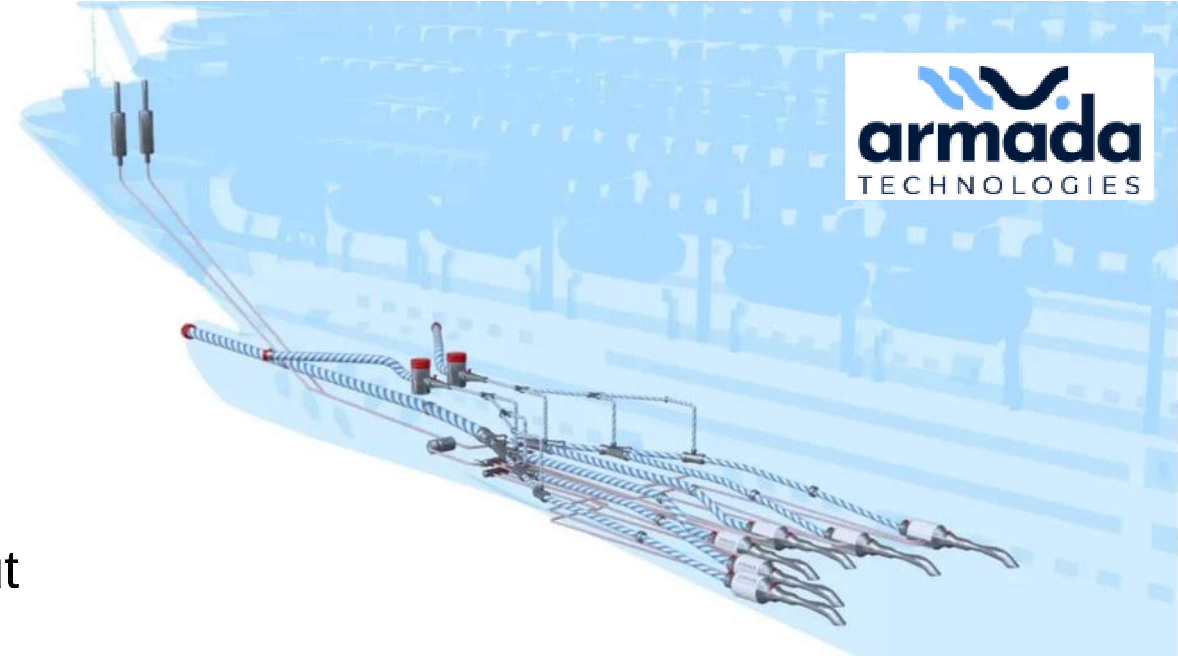
- Passive air lubrication system (PALS)
- Developed by Armada Technologies
- The power consumption is significantly reduced through the application of a Venturi to passively create bubbles



Within RETROFIT55:

- Determine the complete system design and layout
  - ✓ Injection Conditions
  - ✓ Outlet Design
- Hull and Sea Condition effect
- Optimizing the system to deliver fuel savings of 6-8 percent .

5. Electrification and Energy Management System

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- Analyze on board energy systems of M/V Kastor
- Propose New Solutions:
  - Active and reactive load analysis
  - **Shaft Generator systems (PTO/PTI)**
  - Cold ironing
  - Power Converters for supplying large motors
  - **Photovoltaic solar panels**
  - Optimum operation of electric energy system
  - Fuel Cells
  - Batteries

Measure	Design stage	Retrofit feasible	Mature technology	Technology needs further development
Optimal selection of generator sets	Appropriate if not mandatory	Difficult, if not impossible	✓	
Active and reactive load analysis	Appropriate if not mandatory	Difficult, if not impossible	✓	
Shaft Generator systems	Yes	Possible	✓	
Cold ironing	Yes	Yes	✓	
Power Converters for large motors	Yes	Yes	✓	
Photovoltaic solar panels	Yes	Possible	✓	
Optimum operation of electric energy system	Yes	Difficult, BUT not impossible	✓	
Direct Current integration	Yes	Difficult if not impossible	✓	
Waste heat recovery - TEG	Yes	Possible	✓	
Fuel Cells	Yes	Difficult, BUT not impossible		✓
Batteries	Yes	Possible		✓

Summary of applicability of ship performance improving measures.

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Conclusions

- Operational Synthesis and Optimization
  - Optimized maintenance of hull and propeller can prevent the significant power increase (M/V Kastor ~ up to 21%)
- Hydrodynamic Optimization
  - Small gains have been observed from bow retrofitting and trim optimization
- Wind-Assisted Ship Propulsion
  - Gains up to 10% have been observed in FOC
- Air Lubrication System
  - Research is still ongoing however a drag reduction up to 8% is expected
- Electrification and Energy Management System
  - Shaft generator systems (PTO/PTI) is a viable solutions

Future Steps

- Hydrodynamic Optimization
  - Evaluation of Energy Saving Devices
    (Pre-Swirl Fins, Wake Equalizing Duct, Propeller Boss Cap Fin)
- Wind-Assisted Ship Propulsion
  - Prototype construction and land based trials (Semi-Rigid Wing)
- Air Lubrication System
  - Experimental Studies to examine hull and sea condition effects
- Electrification and Energy Management System
  - Integration of a Smart Energy Management System
- Decision Support System
  - System testing and validation

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Thank you

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