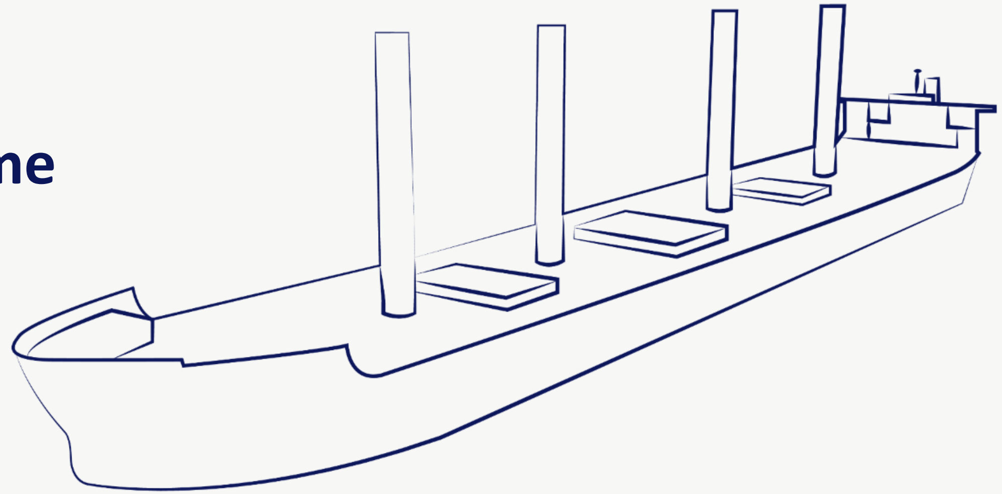
Wind Assisted Ship Propulsion

A win-win-wind solution to decarbonise the maritime sector?



TKI Maritime event 2024

Albert Rijkens - Program Manager
Wind Assisted Ship Propulsion

TU Delft BIJBOEG FONDS


Over 80 % of international trade is carried by sea
GHG emissions are 3% of global total
98.8% of the world fleet sails on fossil fuels
Average ship age: 22.2 years
Source: UNCTAD review of maritime transport 2023

Towards zero emission

- Regulations
  - Generate a level playing field
  - Emission regulations are gradually tightening
  - Stimulus to reduce carbon intensity of ships by 40% by 2030
  - Aim for full decarbonization by 2050

- *What can we do to meet this challenge?*
  - Efficiency gains in operations
  - Slow steaming
  - Alternative fuels
  - Air lubrication systems
  - Wind Assisted Ship Propulsion (WASP)

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This is a scale challenge

- World fleet
  - 56.500 vessels above 1000 GT
  - Tankers, dry bulk and container ships are each responsible for 25% of the global shipping emissions
- Energy consumption shipping sector
  - Fossil fuel energy consumption of ships above 5000 GT is approx. 2500 TWh
  - World renewable electricity generation is about 8500 TWh
  - Assume E-fuel production efficiency of 50%
  - E-Fuel production for shipping would require approximately 60% of today's total world renewable energy production
- Other sectors have similar ambitions to reduce GHG emissions
  - Industry
  - Aviation
  - Road transport

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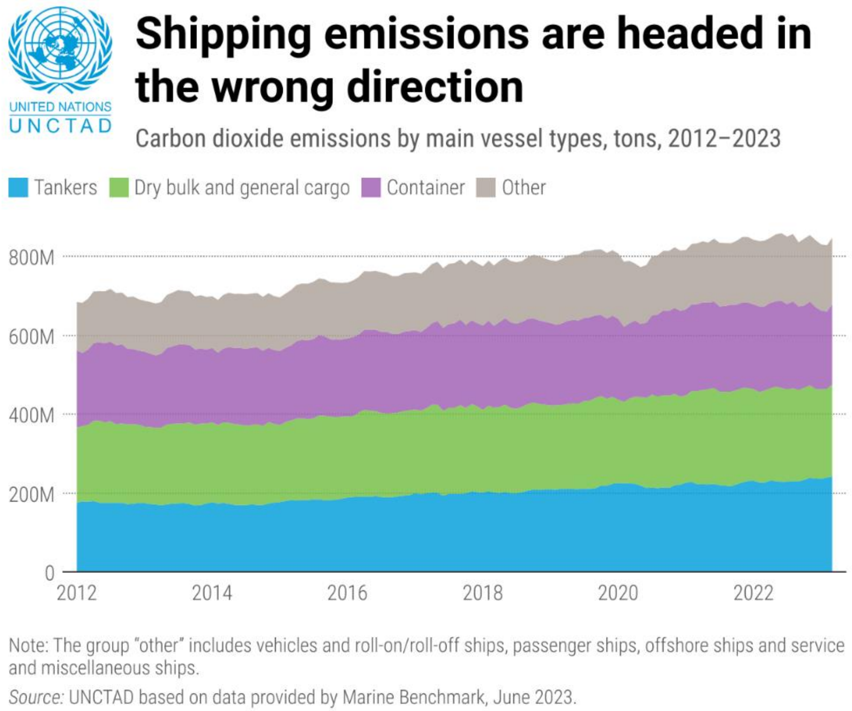

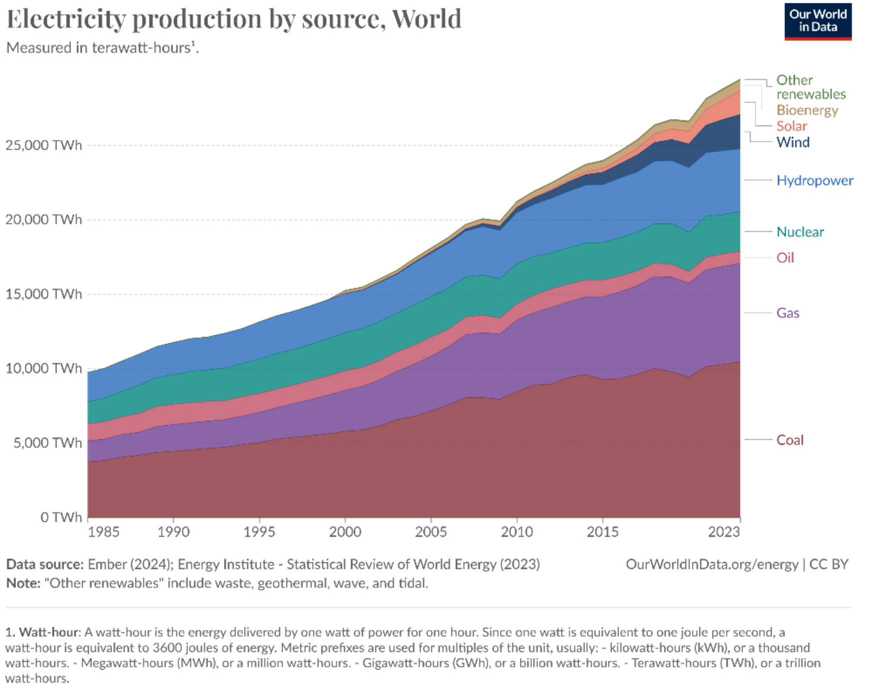


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Short term impact: Retrofitting

- Why retrofit?
  - Global shipyard capacity can produce approx. 1500 newbuild vessel above 1000 GT
  - If we started building only green ships today, it would take 38 years to replace the global fleet
- WASP Fleet
  - Currently about 50 ships with WASP in operation
  - Majority have retrofitted sail systems
  - The number of WASP installations double each year
  - Reported fuel savings range between 5 – 20%
  - There are dozens of different (small) wind propulsion technology providers
- Best suited vessel types
  - Bulk carriers / General cargo vessels
  - Ro-Ro ships
  - Tankers
- Direct reduction of emissions

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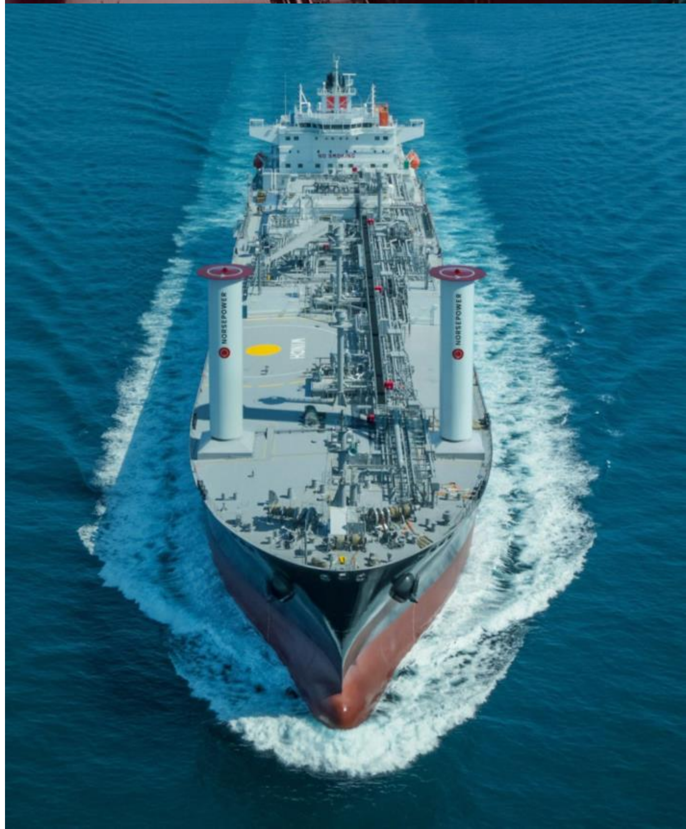

Longer term impact: Newbuild solutions

- More drastic design change
  - Design: Ship and deck configuration
  - Aerodynamics: Sail systems
  - Hydrodynamic: Hull form and appendage design
  - Propulsion system: Propellor and rudder design

- Advantages
  - Potential fuel savings up to 40 – 50%
  - Can be a technology enabler for alternative fuels on ships with large autonomy

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WASP Research Program

TU Delft vision

- We aim to make an *'impact for a better society'*. We take on global challenges that affect everyone personally: the climate, the energy transition, urban growth, digital society, health.

WASP program ambition

- Facilitate the development of high performing wind-assisted ships by increasing knowledge of WASP through research and education

- Program characteristics
  - Interdisciplinary approach
  - Applied oriented research
  - Collaboration with (industry) partners
  - Dedicated program team
  - Facilitates 12 PhD students starting this year

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Program Manager

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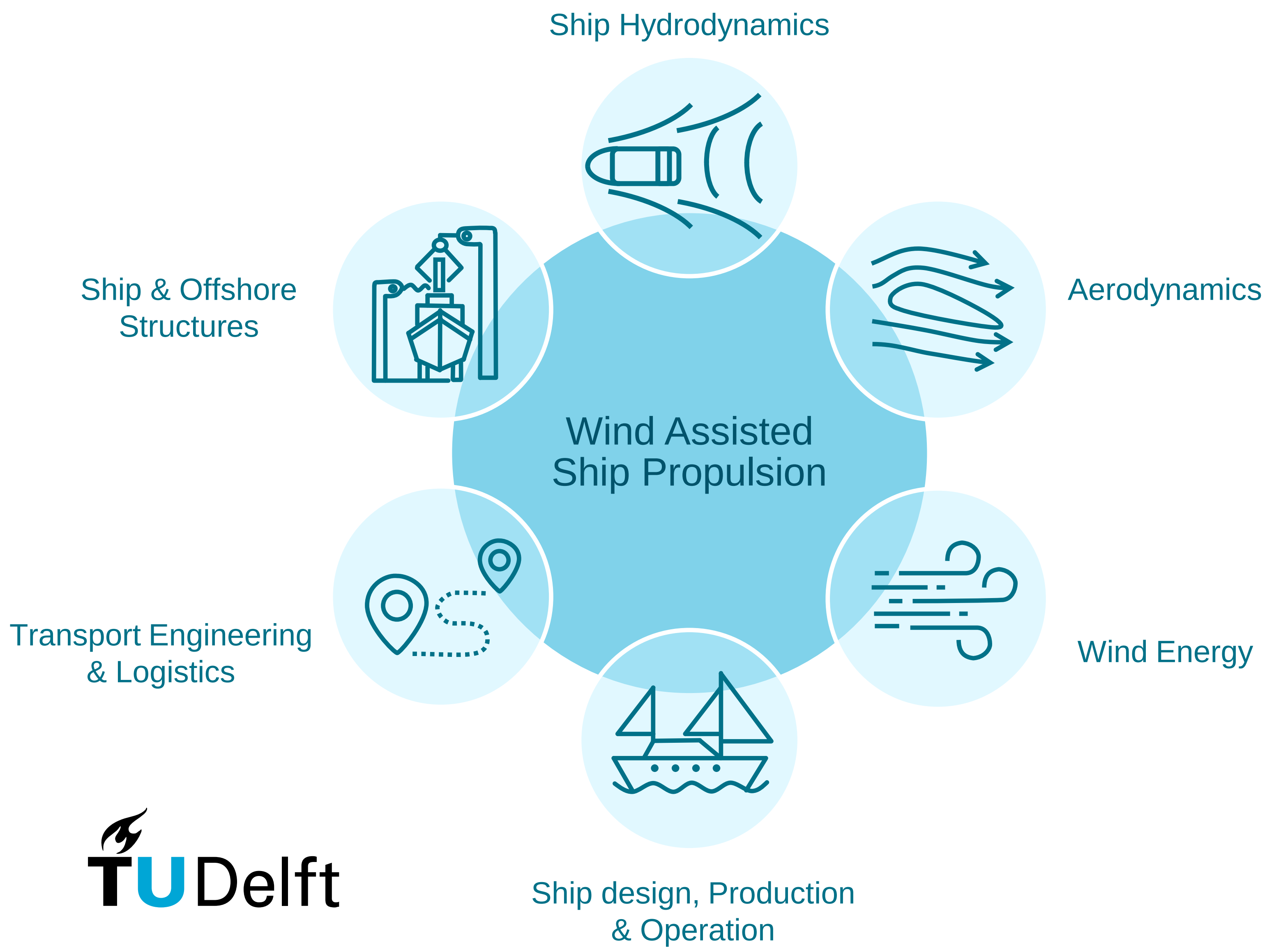
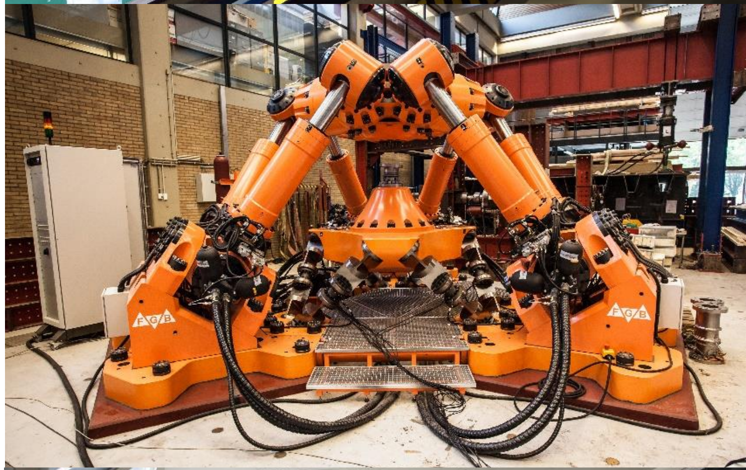
Interdisciplinary research program





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WASP program overview

Fluid dynamics

Aerodynamics

- Fundamental flow physics – Rotor flow under quasi-static and dynamic conditions
- Fundamental flow physics – Experimental research of scaled rotor flow under static conditions
- Modified rotor design and flow control for performance enhancement
- Aerodynamics of multi-rotors in ship configuration

Hydrodynamics

- Scale-resolving simulation of wind-assisted ships and low-fidelity model optimization
- From model to full-scale - Benchmark towing tank tests for wind assisted ships and performance assessment of auxiliary appendages
- Propeller and rudder performance in wind-assisted ship propulsion

Design & operation

Design

- Multi-fidelity modeling for design space exploration for purpose-built wind-assisted ships

Structures

- Multiaxial and variable amplitude fatigue accumulation from WASP

Propulsion systems

- Enhancing Efficiency and Reducing Emissions: Investigating partial load performance of reciprocating IC Engines in WASP applications

Control systems

- Dynamic behaviour and dynamic stability analysis of wind-assisted ship powertrains for enhancing control strategies

Sustainable & social impact

Transport & Logistics

- Optimizing Logistics for Wind-Assisted Shipping

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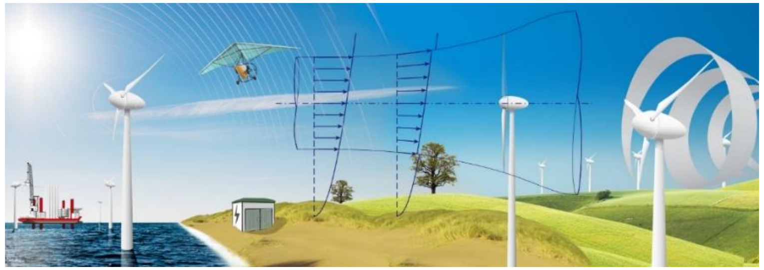
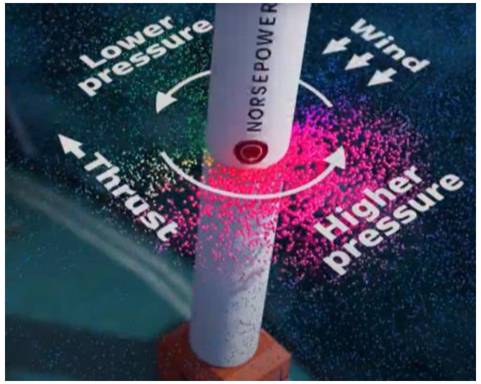
Wind thrust & Loads | Sailing Performance | Propulsion & Control | Sustainable Operation

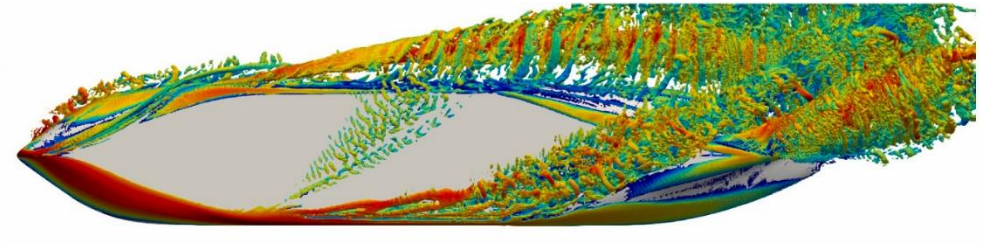
Fluid dynamics - Aerodynamics



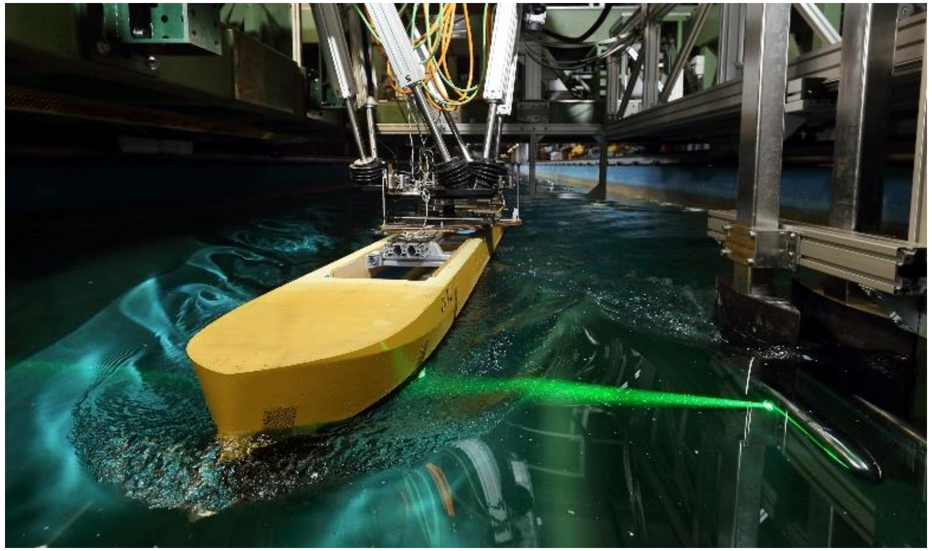
- High fidelity numerical simulations
  - Simulations on large rotor systems in atmospheric surface layer
  - Model dynamic conditions due to ship motions and unsteady inflow
- Wind tunnel & full-scale testing
  - Experimentally simulate full-scale operating conditions
  - Investigate fundamental flow features that determine rotor performance
- Rotor design optimisation
  - Identification of performance improvement areas and metrics
  - Active off-surface & passive surface embedded flow control
- Aerodynamics of multi-rotors in ship configuration
  - Rotor-rotor and ship-rotor interactions
  - Lower fidelity wake model to design multi-rotor configurations on deck



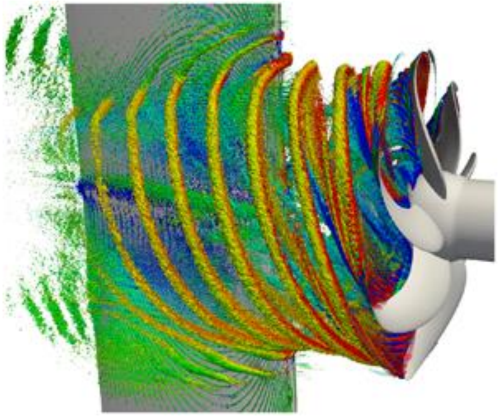
Fluid dynamics - Hydrodynamics

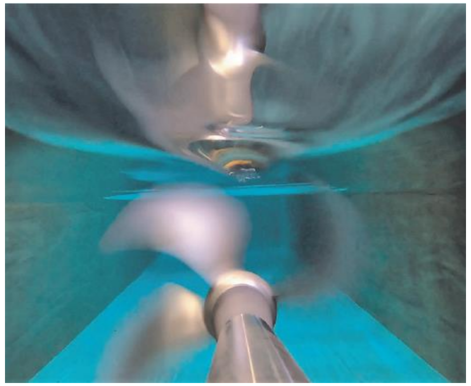


- Wind assisted systematic hull variations
  - Perform high fidelity simulations to capture hull flow structures at drift
  - Develop a low fidelity numerical framework that allows systematic studies on new WASP hull forms



- Appendage design and scaling effects
  - High fidelity measurements of wind assisted ships with appendages
  - Develop a method for scaling similarity for boundary layer appendages
- Propeller & rudder performance in wind-assisted ships propulsion
  - Systematically test the wide range of operating conditions
  - Building a physics-informed performance model





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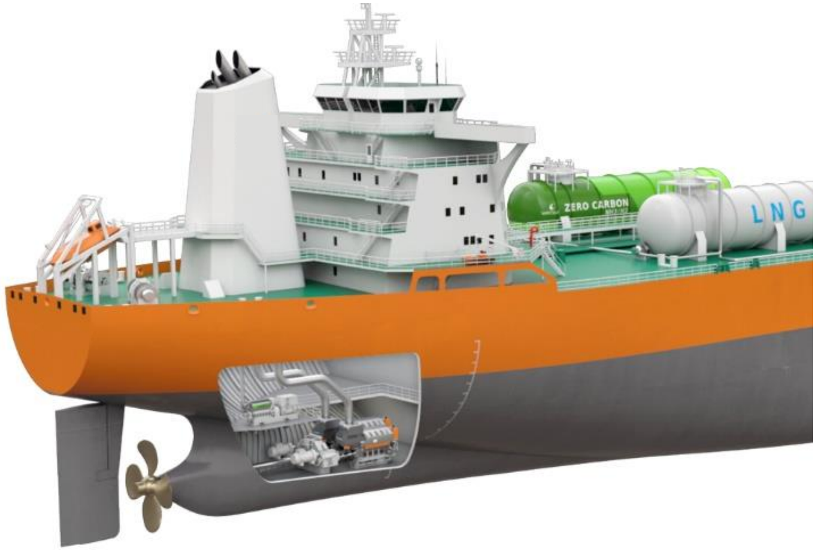
Design & Operation

- Design space exploration of future wind-assisted ships
  - Multi-fidelity modelling framework
  - Multi-objective exploration and optimisation
- Structural fatigue accumulations from WASP systems
  - Full-scale multi-directional loading and response characterisation
  - Fatigue limit state performance calculations
- Reducing GHG emissions of ICE in WASP applications
  - Development of a numerical ICE model that enables emission prediction in part- and low load operation
  - Evaluate different WASP propulsion system configurations
- Enhanced control strategies for wind assisted ships
  - Development of holistic control strategies
  - Real-world validation and application of developed methodologies



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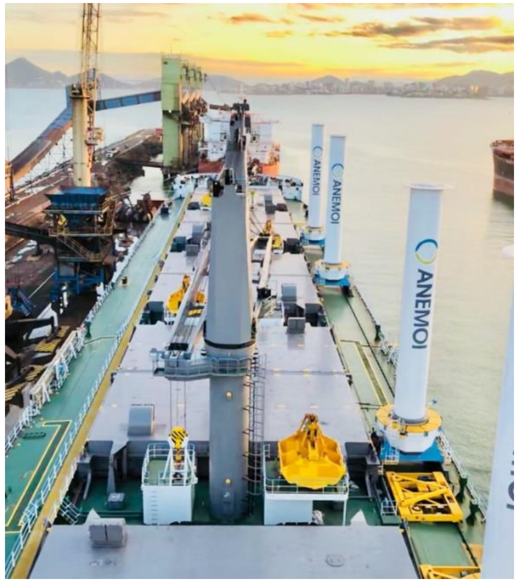
Sustainable and Social impact

- Optimizing Logistics for Wind-Assisted Shipping
  - Logistic planning and decision support
  - Routing simulations and scheduling
  - WASP port calls with physical constraints
  - Cost and market analysis



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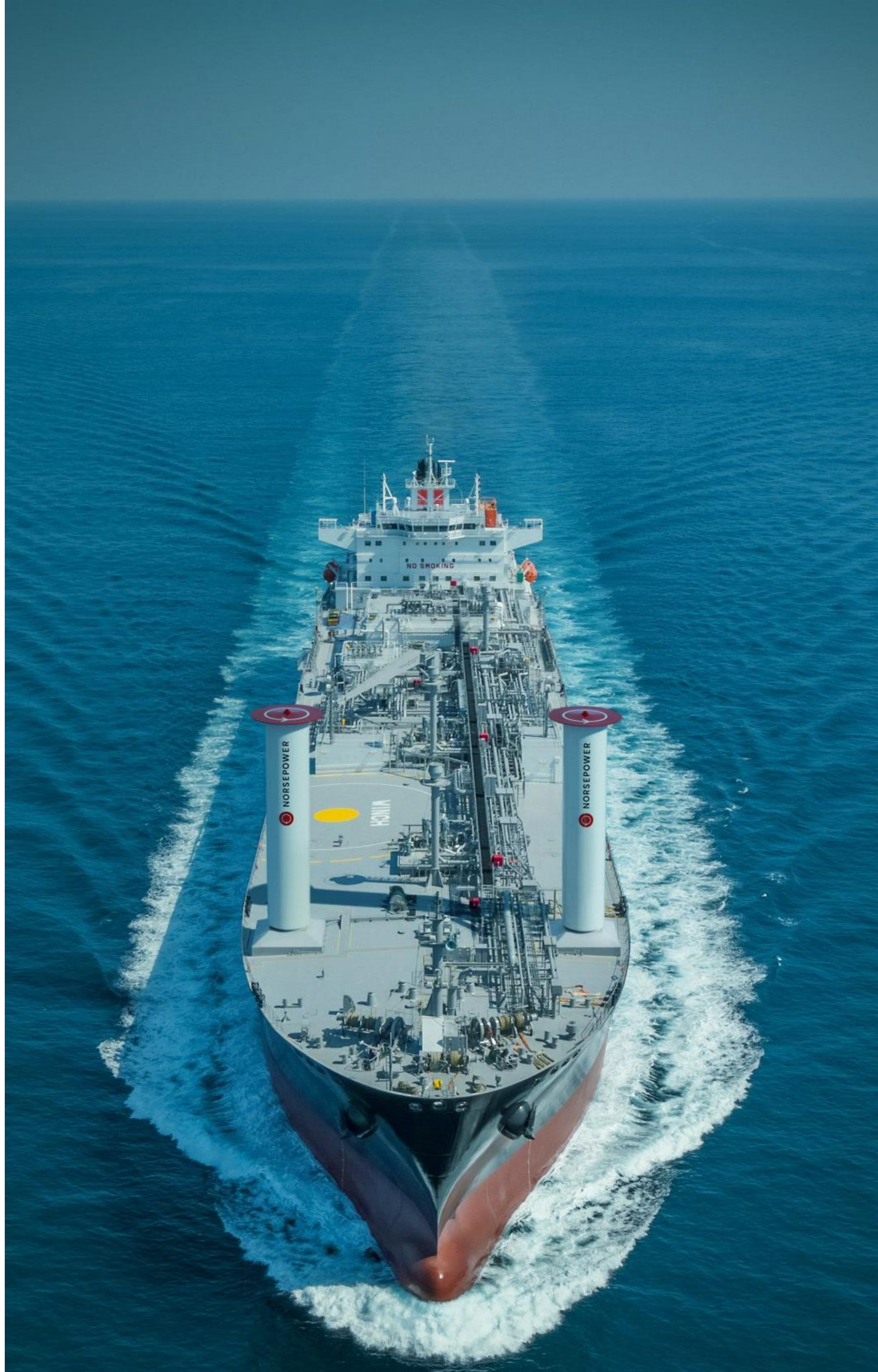
A win-win-wind solution?

- Wind energy
  - Wind is a free, inexhaustible and zero-carbon energy source
  - Wind energy requires no additional infrastructure, distribution network or storage facilities in port
  - No competition with other sectors that depend on scarce renewable energy to make the transition

- WASP technology
  - Short term GHG emission reduction with retrofitted installations
  - Longer term impact with bigger savings on purpose-build WASP ships
  - The technology needs develop to a more mature stage
  - Enabling technology for alternative fuels on ships with large autonomy



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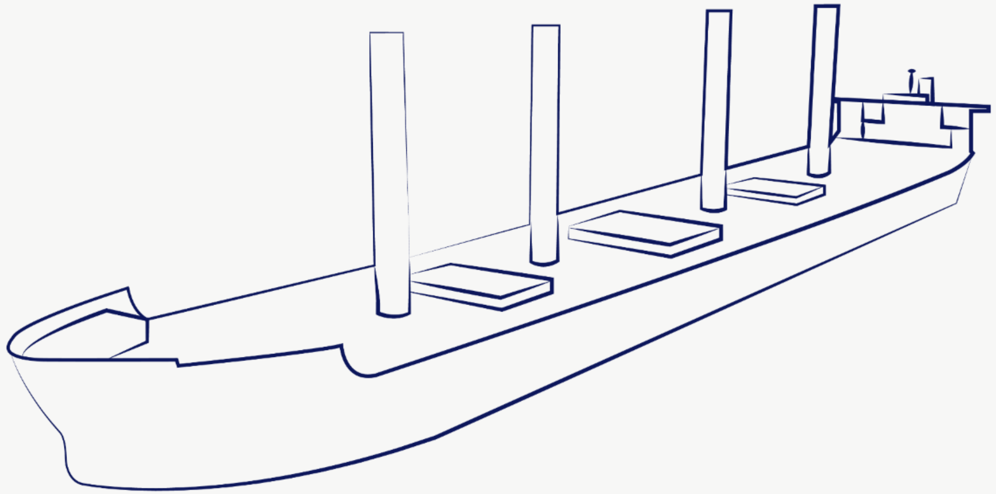
Thank you



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