# *Norsepower Rotor Sail Solution*

## Tuomas Riski, CEO, Norsepower Oy Ltd

03/2019


- Visit https://www.youtube.com/watch?v=G-fuPbhtTFo to see the video

# Modernised wind propulsion

Company

# Background and current status

- Norsepower has brought to market the first proven auxiliary wind propulsion system
- The first Rotor Sail was tested on land during 2014
- The first commercial project with two Rotor Sails was delivered between 2014-2015 to Bore's M/S Estraden
- Viking Line's cruise ferry Viking Grace started Rotor Sail assisted cruises in April, 2018
- Maersk Pelican started Rotor Sail -assisted voyages in August, 2018



Introduction

# Auxiliary Wind Propulsion

- Depending on wind conditions up to 50% of service power is replaced with wind propulsion
  → HYBRID system
  - Average savings depend on configuration and on the wind conditions of the route / route area
- Norsepower's technology is well suited to:
  - Tankers
  - Bulk cargo vessels
  - Ro-Ro, Ropax, Ferries, Short Route Ferries
  - Cruise ships
- Compatible with all other ways to save fuel

DELTAMARIN

Physics:
# Magnus -effect

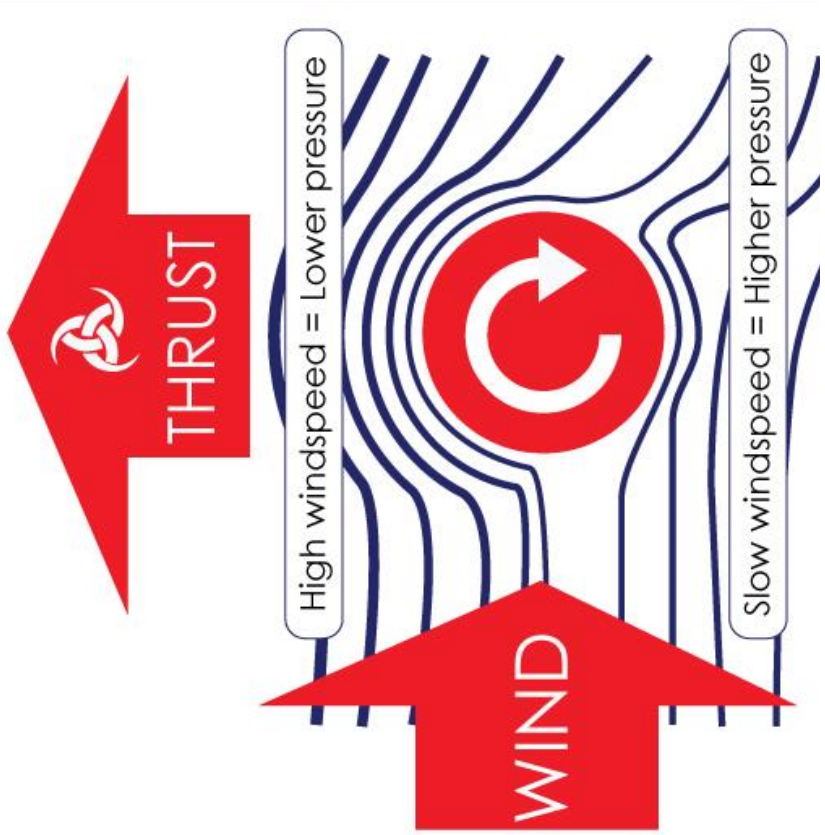
- Visit http://tinyurl.com/nmjyzmo to see the video

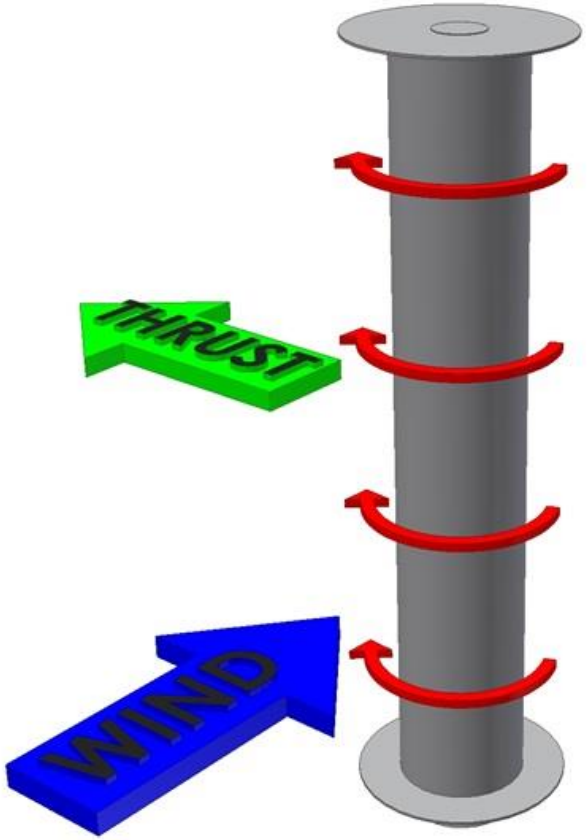
*Source: YouTube*

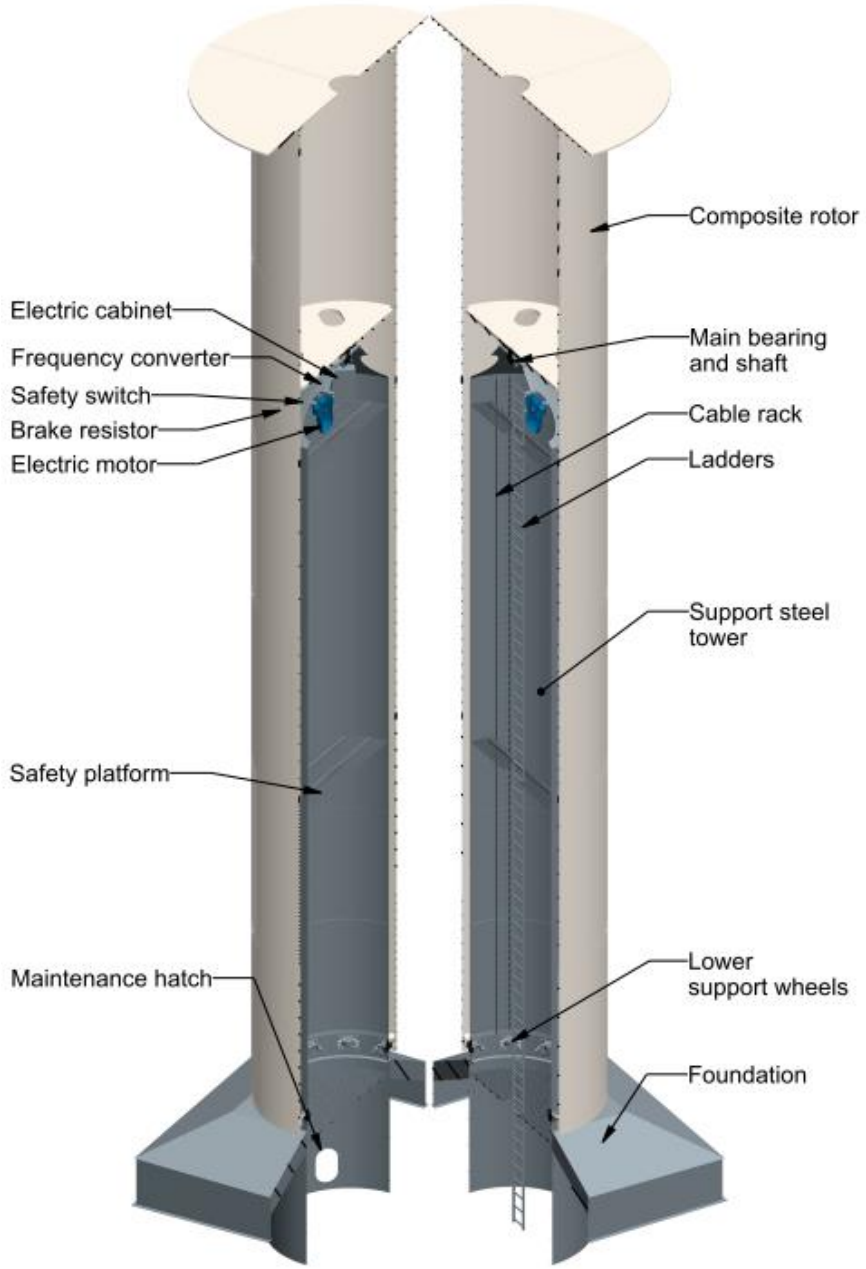
Rotor Sail

# Physics of the Rotor Sail: Magnus Effect explained

- When wind meets a spinning object, it results in a high and low pressure differential, which creates thrust at a 90 degree angle to the wind
- Flettner (DE) and Savonius (FI) discovered the fundamentals of a "Flettner rotor" in 1920s
- Norsepower has modernised the technology entirely by introducing high tech materials and automated operation





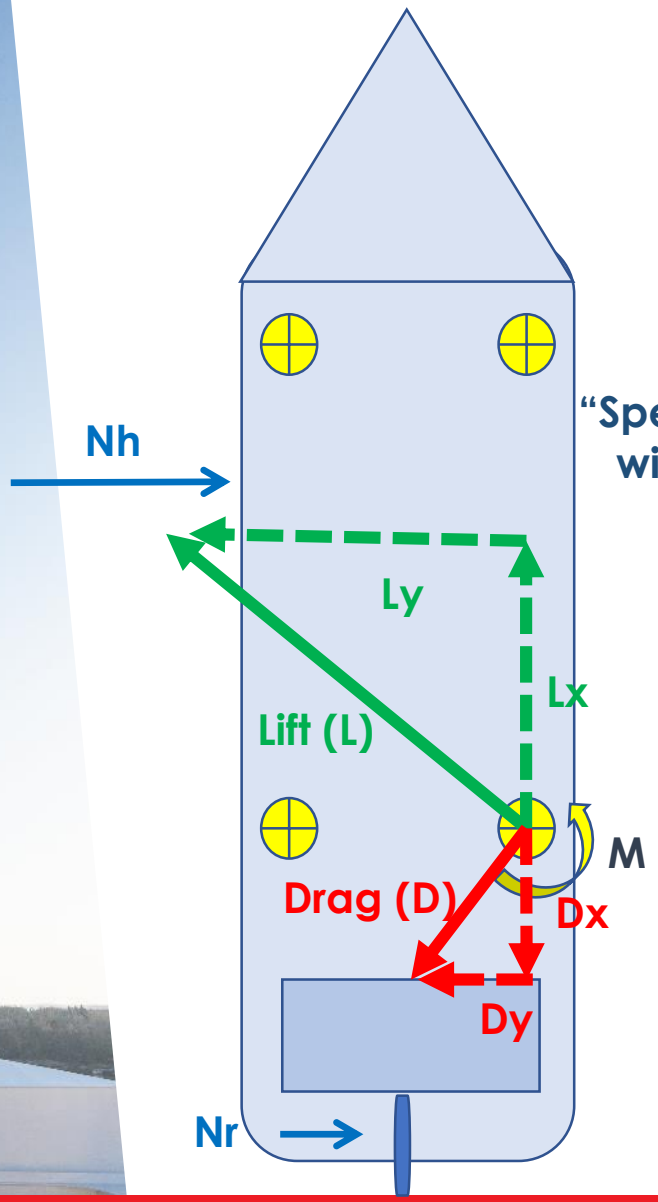

# Norsepower Rotor Sails

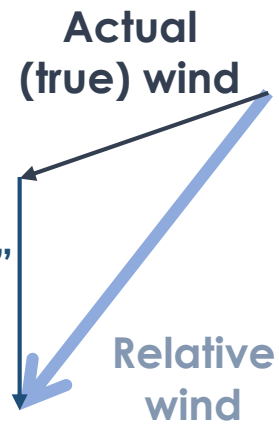
- Main components
  - Composite rotor
  - Internal support steel tower
  - Upper support main bearing
  - Motor and drive for rotation
  - Lower support rollers
  - Foundation on ship's deck
- Properties

| Model | 18 x 3 | 24 x 4 | 30 x 5 |
|---|---|---|---|
| Rotor height x diameter , m | 18 x 3 | 24 x 4 | 30 x 5 |
| Weight without foundation, tons | 20 | 27 | 42 |
| Speed, rpm | 0-250 | 0-225 | 0-180 |
| Electric motor, kW | 55 | 90 | 110 |

#Average el. consumption 15…35kW

# Rotor Sail physics



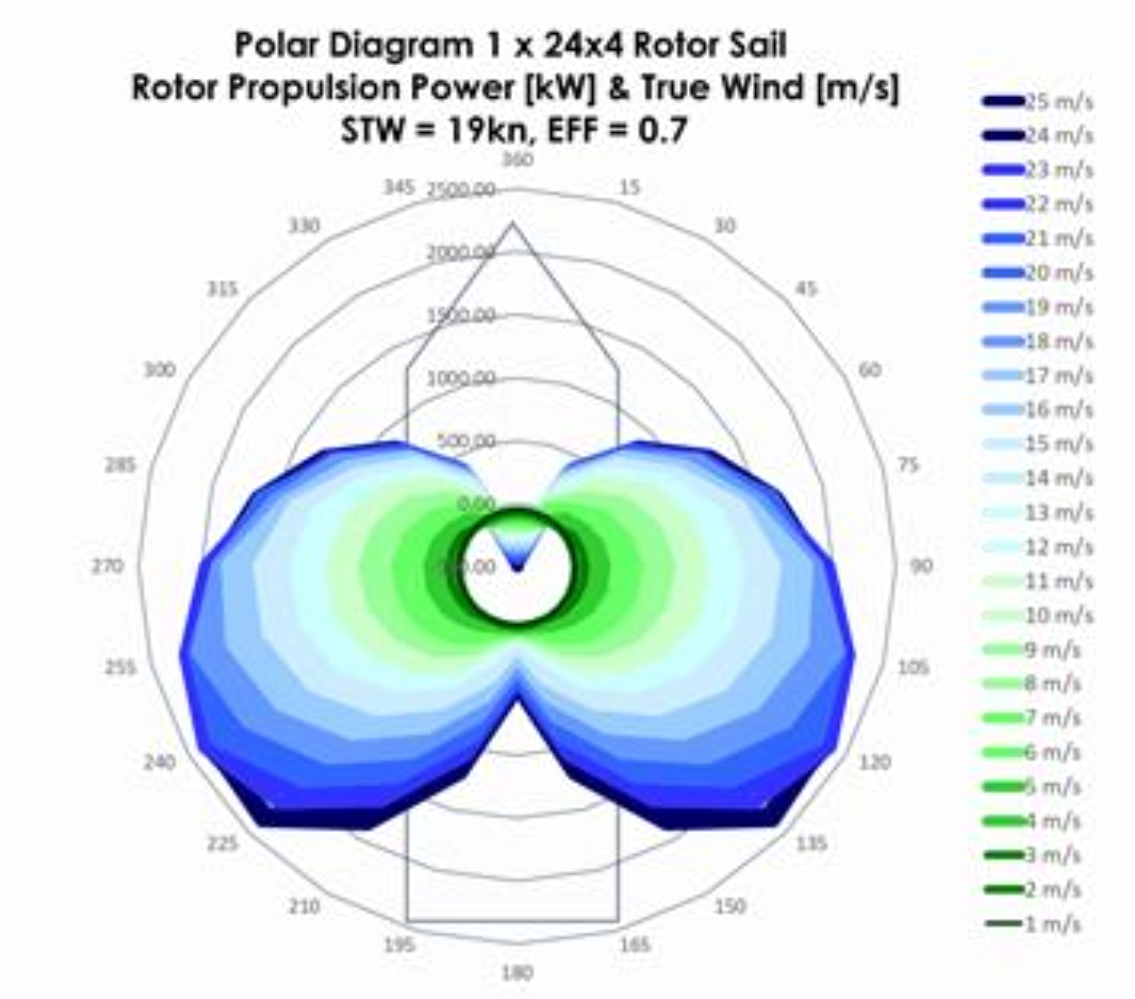




Maximizing thrust:
Max(Lx-Dx)

Balancing sway forces:
Σ(Ly+Dy)=Nh+Nr

## Rotor Sail

# Typical polar diagram




- The main-engine equivalent power produced by one Rotor Sail is represented in the polar diagram for different true wind speeds (the number of each coloured line represents the corresponding true wind speed in m/s). The power produced by the rotor is given in radial direction, the angle from vertical is the true wind angle.
- Parameters:
  - Service speed: 19 knots
  - Assumed total propulsion efficiency: 0.70 (= towing power/brake power)
- As can be seen at the polar diagram, the Rotor Sails start to save fuel already at a 20 degrees true wind angle, when the true wind speed is at least 7 m/s.
- The savings are maximized when the true wind angle is about 120 degrees and when the true wind speed is 20 m/s or more.
- Examples of the maximum thrust of one Rotor Sail expressed as the propulsion power equivalent:
  - 820 kW (10 m/s wind speed)
  - 2360 kW maximum (25 m/s)

Rotor Sail

# Reasoning for using composite rotors

- Mass
- Dynamics
- Loads
- Fatigue resistance
- Cost
- Modifiability
- Dimensional accuracy
- …..

Multiple patents granted

5/9

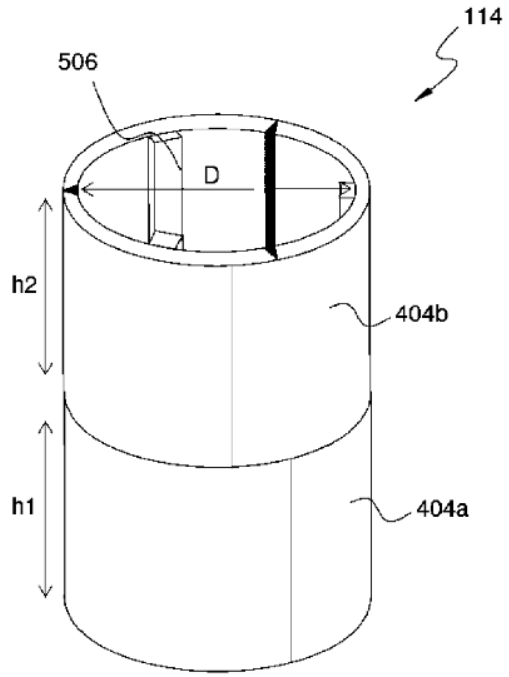
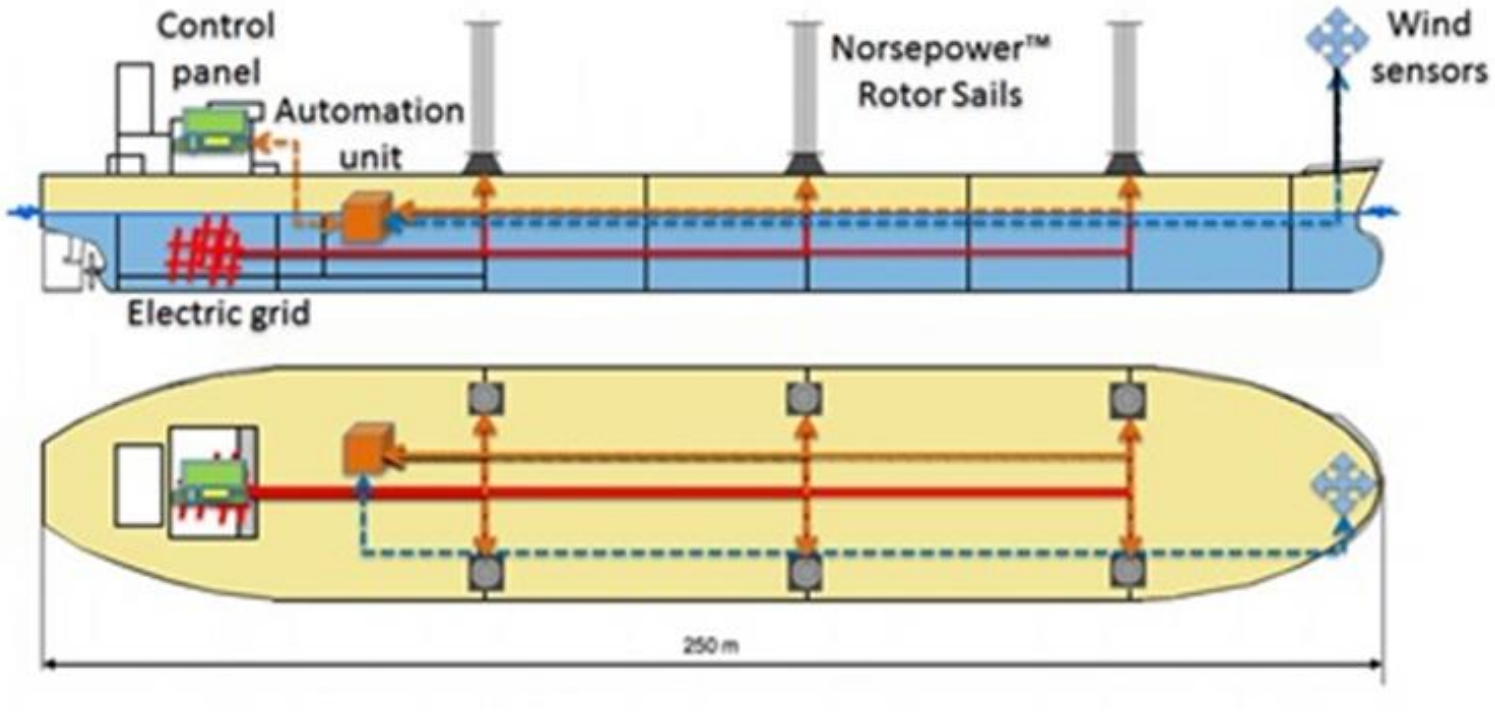



FIG. 5

Rotor Sail

# Architecture

- Control panel on Bridge and optionally in the engine control room
- Electrical power for the Rotor Sail drive system is supplied by ship's power plant
- Wind sensors provide the automation system real-time data of wind speed and direction
- Rotor Sails are installed on foundations which are welded on the ship's deck




**Average yearly net savings:**

- 6,1 % (400 t of fuel ja 1200 t of $CO_2$)

**Payback period (including maintenance):**

- < 4 years (MGO, 500 USD / t)

Experiences from M/S Estraden

# The system works and it is extremely easy to be used

**Technical performance**

- Performs as expected
- More than 99% availability so far

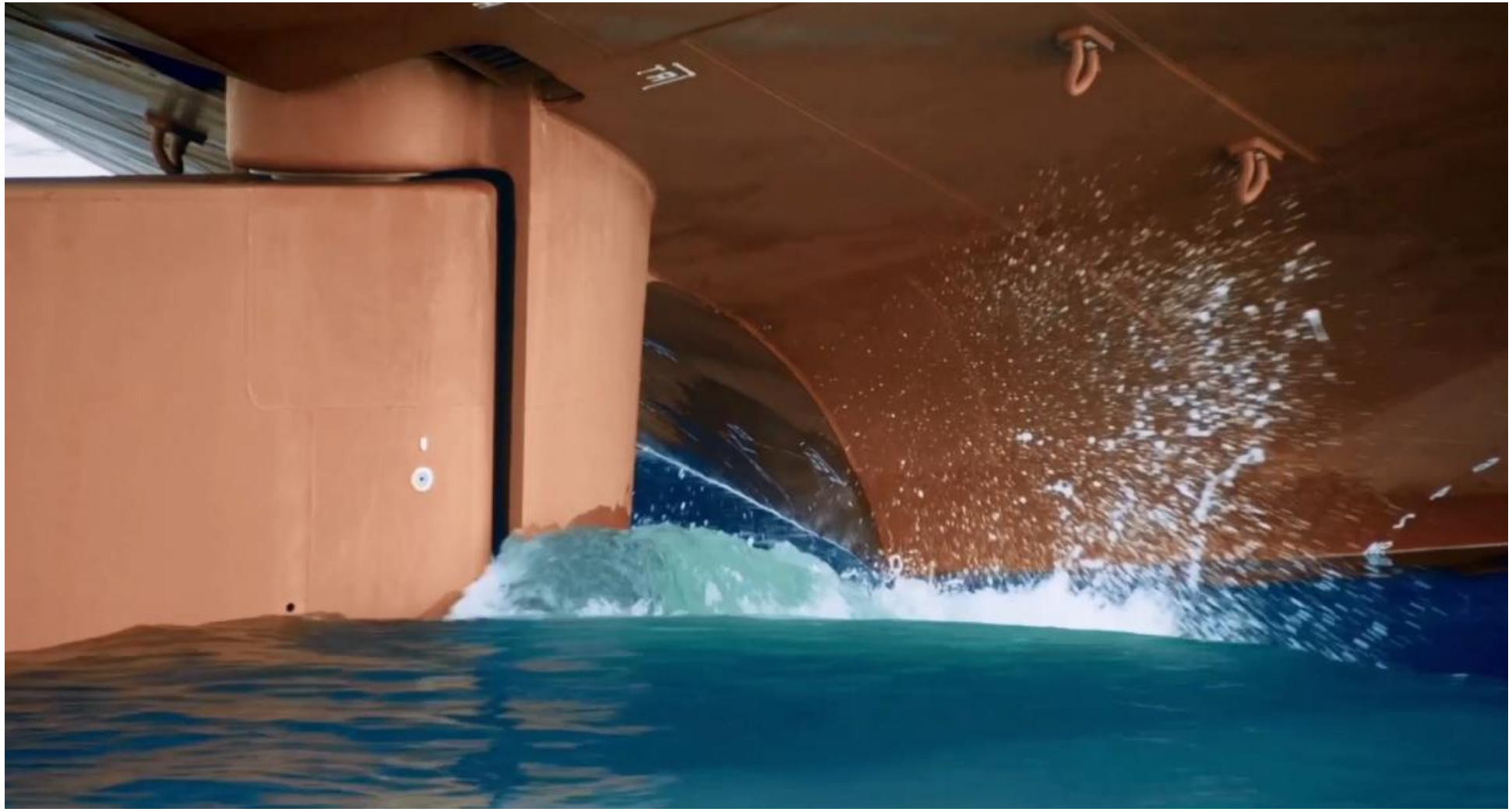
**User experiences**

- No negative remarks.
- Using the system is extremely easy.

**Based on the results, average annual savings of 5-20% can be expected on typical target ships**

# Maersk P-class tanker project

- Two 30x5 Rotor Sails were be installed in August 2018 as a retrofit on a Maersk P-class oil products tanker (109,647 DWT)
- The combined projected average fuel savings on typical global shipping routes are expected to be around 10%.
- Norsepower estimates that up to 20% average fuel savings are possible on routes with favourable wind conditions



- Visit https://www.youtube.com/watch?v=7fjS-l-LVoA to see the video

# Viking Grace project: phases

- One 24x4 Rotor Sail was installed as a retrofit onboard Viking Line's Viking Grace in April 2018
- The installation of the foundation and cabling work were done during a docking in January 2018
- The performance measurement campaign was started on 10 April 2018

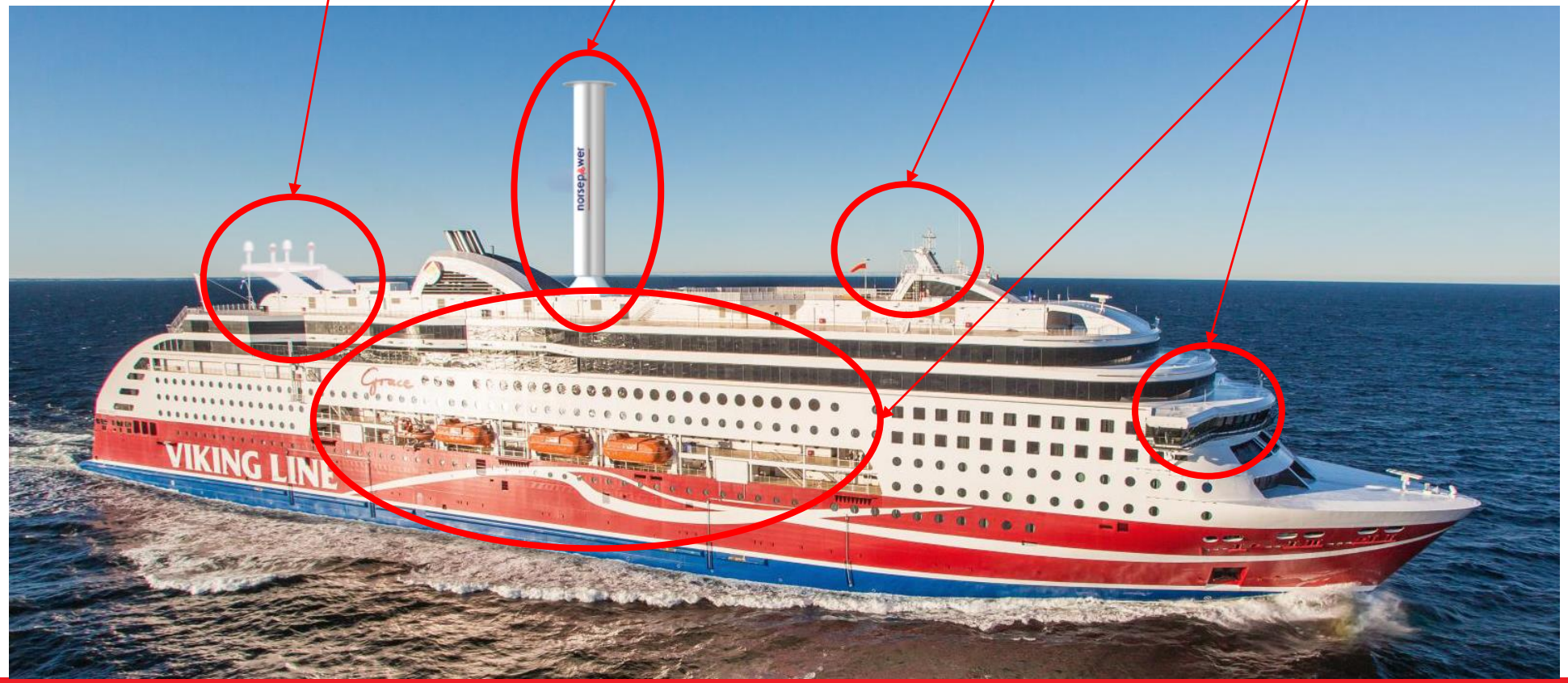
# Viking Grace project: components

Rotor Sail foundation and Rotor Sail

New light mast for masthead lights

New foundation for satellite antennas and relocation of them

Control and automation systems and cabling



# Viking Grace project: bridge controls / automation system


Monitoring display

Control panel

# Viking GRACE: targeted savings potential based on simulations

- LNG savings: 300 t/year
- $CO_2$ emissions reduction: 900 t/year

# Other published projects

- Viking Line has placed an order for one 2800 passenger cruise ferry newbuilding with Xiamen Shipbuilding Industry Co. Ltd.
- Norsepower has an order from Xiamen Shipbuilding Industry for delivery of two 24 m high Rotor Sails
- Operation is planned to start in 2021

# Most promising route areas for Rotor Sails

- The technology performs best when the average wind speed is high and typical winds are coming from the beam
- Examples of routes and areas with a high savings potential:
  - Northern Pacific crossing
  - Northern Atlantic crossing
  - North Sea and Baltic Sea areas

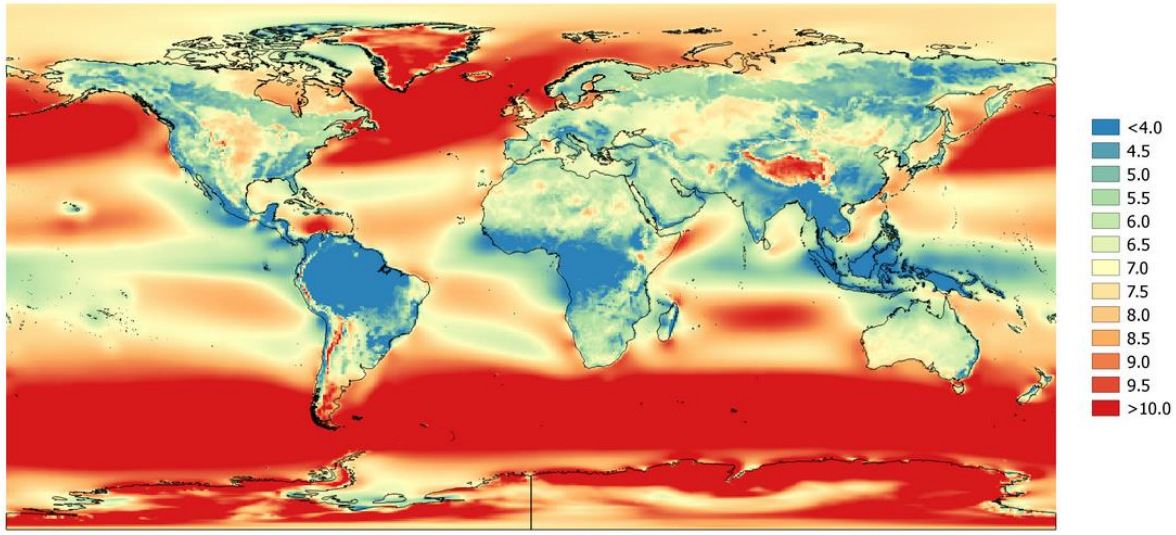



Figure 1
Mean wind speed at 100m from MERRA reanalysis. Period 1979-2013.

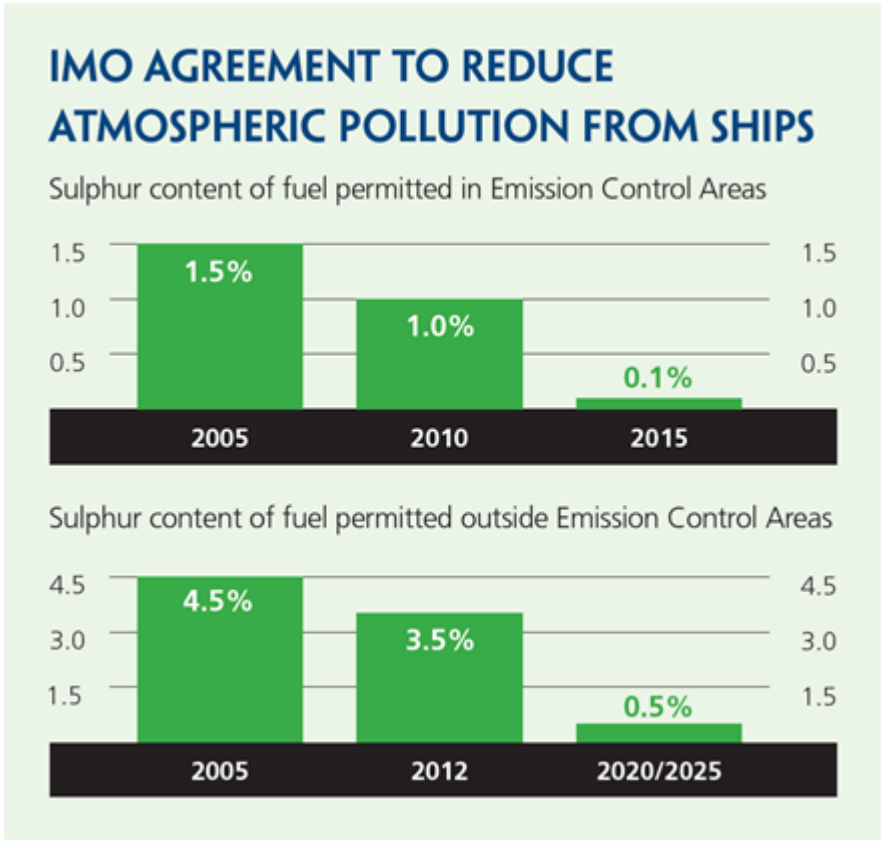
Market

# Environmental regulations increase demand for new solutions

**IMO agreement on technical regulations will reduce ships' $CO_2$**

MARPOL Annex VI, Chapter 4 adopted July 2011 , which entered into force in January 2013

| 2013 | 2015 | 2020 | 2025 | 2030 | 2050 |
|---|---|---|---|---|---|
| Regulations enter into force for over 90% of world fleet<br><br>Ship Energy Efficiency Management Plan (SEEMP): mandatory implementation for all ships | EEDI requires new ships to meet agreed efficiency targets | New ships must improve efficiency 10%<br><br>20% $CO_2$ reduction per tonne/km (industry goal) | New ships must improve efficiency up to 20% | New ships must improve efficiency 30% | 50% $CO_2$ reduction per tonne/km (industry goal) |




Source: International Chamber of Shipping

# Other wind propulsion concepts

Wind Challenger Project HP

Japanese

Home | About WCP | Member | Presentation | Access | FAQ

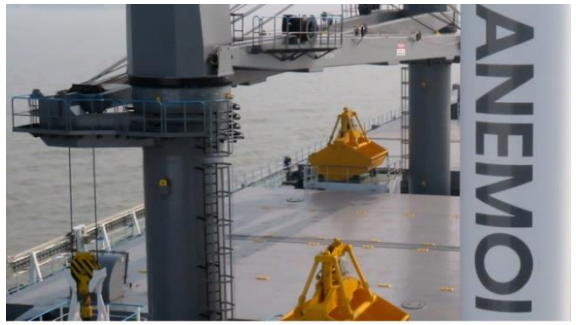
## Wind Challenger Project

**From Fossil Energy to Wind energy**

The Wind Challenger Project which was started by the University of Tokyo and Japanese major shipping companies since 2009 is researching to utilize the maximum ocean wind power for the main propulsion of large cargo vessel.


COMPANY DIVISIONS MEDIA CAREER CONTACT


SKYSAILS - WINDPOWER NEXT LEVEL




Home Page

We are Anemoi – Global Leaders in Wind As

Our mission is to advance Flettner Rotor technology, accelerati and proving it can work for a sustainable future of shipping.

Home / Sector / Tech

DSIC and China Merchants test landmark sail propulsion system on VLCC

OCTOBER 30TH, 2018 JASON JIANG GREATER CHINA, TANKERS, TECH


WINGSAIL TECHNOLOGY

Partners

# Norsepower has vast partner network

**Engineering**

ELOMATIC CONSULTING & ENGINEERING

DELTAMARIN

SKF

**Classification**

Lloyd's Register

DNV·GL

**Manufacturing**

PARAMET

HIGH METAL HAKANIEMEN METALLI OY

**Suppliers**

ABB

SIEMENS

VAISALA

**Research**

NAPA

VTT

**Other**

MAERSK TANKERS

Bore

VIKING LINE

# Future concepts with Rotor Sails

Rolls-Royce, Autonomous bulker (Naples Sept. 2018)

Benefits for wind propulsion:

- Optimized hull form to improve wind flow
- Autonomous operation with 100% system integration
- No superstructures to disturb the wind flow
- No crew on board means no visibility limitations
- Low free board causes less flow disturbance
- Slow steaming

# Future option: design with tiltable Rotor Sails

## MISSION

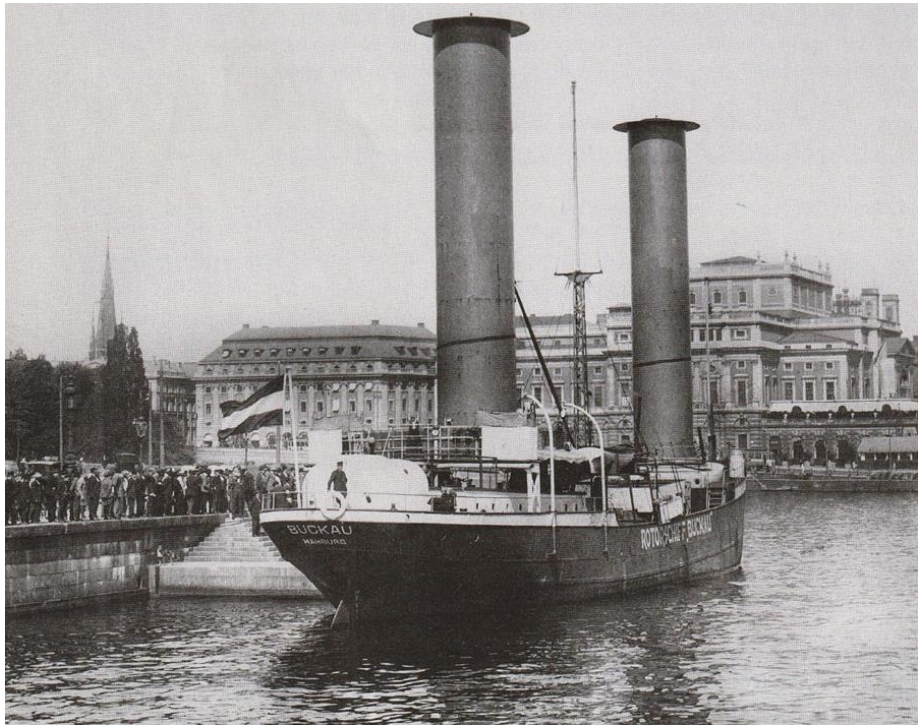
To reduce the environmental impact of shipping by providing efficient, easy to use and reliable auxiliary wind propulsion for ships.

## VISION

To maintain the market leader position in a growing market for auxiliary wind propulsion systems for large ships.

# Flashback: Stockholm in 1926 and 2018

- Anton Flettner's Rotor ship "Buckau" visited Stockholm in 1926





- The next Rotor ship in Stockholm was Viking Grace on 13 April 2018

norsepower™

Tuomas Riski

CEO, Partner, Norsepower Oy Ltd

tuomas.riski@norsepower.com

+358 50 330 5732