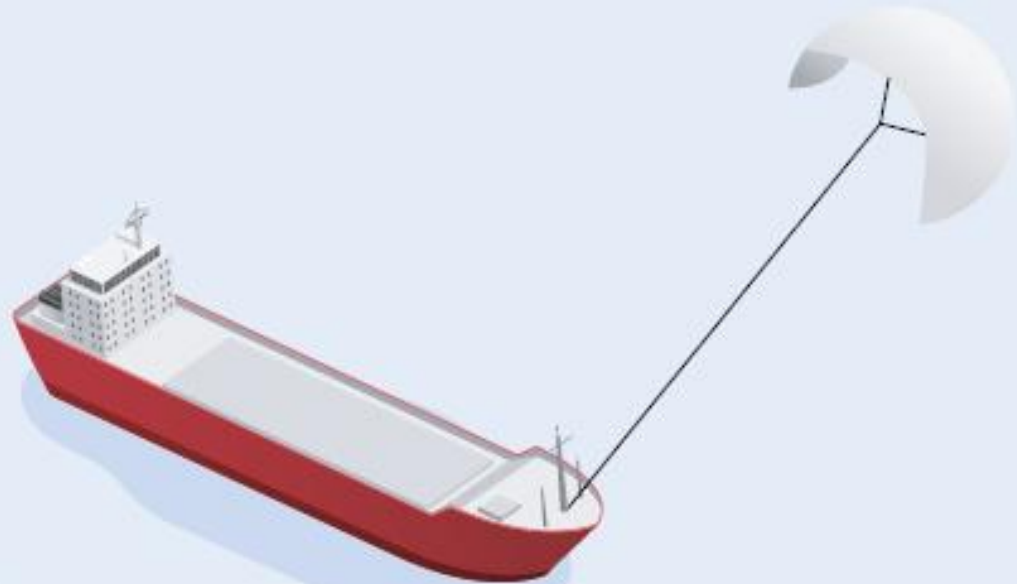


SSPA

Wind-Powered Ships.



Supporting the maritime industry with independent guidance and assessments of wind-powered ships.



OUR KNOWLEDGE BASE

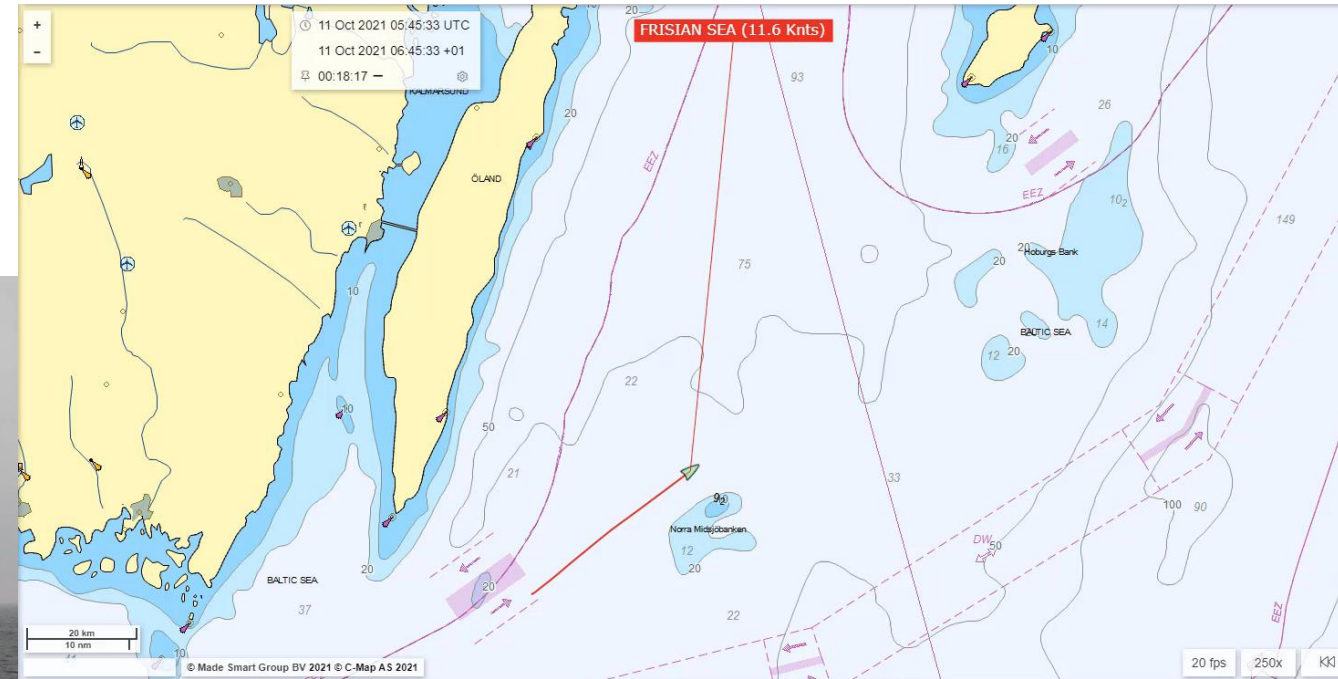


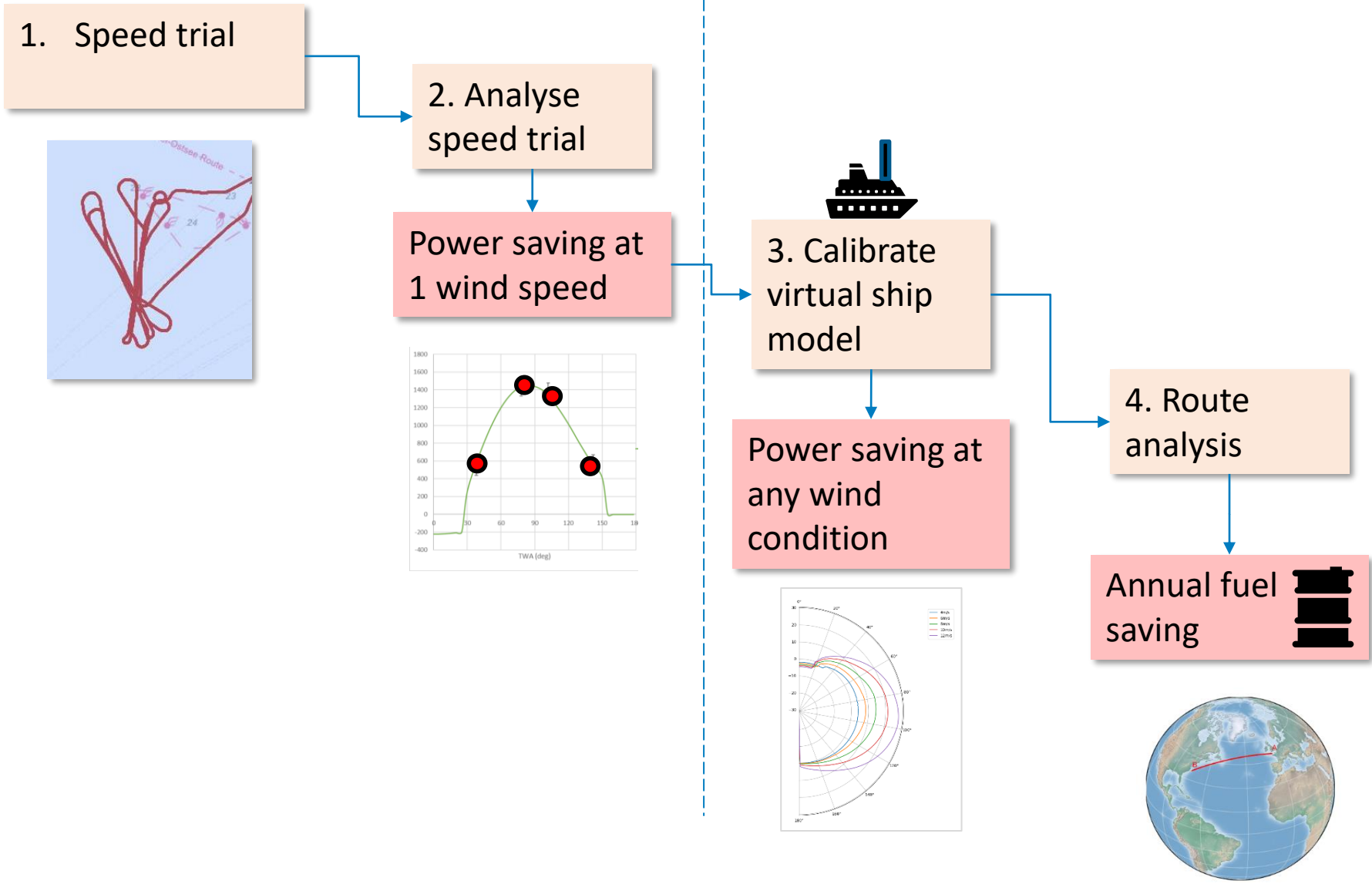
SSPA WASP Sea Trial for Wind Powered Ships




Your Maritime
Solution Partner

Frisian Sea – with Ventifoils from Econowind



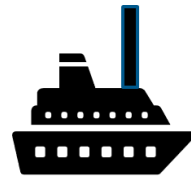


WASP Sea trial methodology

 INTERNATIONAL TOWING TANK CONFERENCE	ITTC – Recommended Procedures and Guidelines	7.5-04 -01-01.1 Page 1 of 77	
	Preparation, Conduct and Analysis of Speed/Power Trials	Effective Date 2021	Revision 06

ITTC Quality System Manual

Recommended Procedures and Guidelines



Procedure

Preparation, Conduct and Analysis of Speed/Power Trials

SEAMAN winds – The Wind Propulsion Showroom

Select ship type

RoRo	KVLCC2	Container	RoRo	KVLCC2	Container	RoRo	KVLCC2	Container	RoRo	KVLCC2	Container
------	---------------	-----------	------	---------------	-----------	------	---------------	-----------	------	---------------	-----------

Ship length: 320m, Beam: 58m, Draught: 20.8m

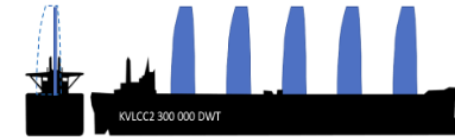
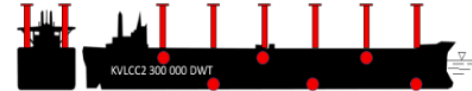
Ship length: 320m, Beam: 58m, Draught: 20.8m

Ship length: 320m, Beam: 58m, Draught: 20.8m

Ship length: 320m, Beam: 58m, Draught: 20.8m

Select wind propulsion system

No WPS	6 Flettner ZigZag	5 Wingsail small	5 Wingsail large
--------	-------------------	------------------	------------------



Select route and operational parameters

yanbu_singapore	yanbu_singapore	yanbu_singapore	yanbu_singapore
-----------------	-----------------	-----------------	-----------------

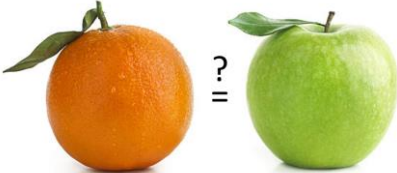


EEDI wind matrix	Route specific weather data	EEDI wind matrix	Route specific weather data	EEDI wind matrix	Route specific weather data	EEDI wind matrix	Route specific weather data
Fixed speed at 15kts	Fixed speed at 12kts	Fixed speed at 15kts	Fixed speed at 12kts	Fixed speed at 15kts	Fixed speed at 12kts	Fixed speed at 15kts	Fixed speed at 12kts
MCR=24MW, 75 rpm	MCR=12MW, 69 rpm	MCR=24MW, 75 rpm	MCR=12MW, 69 rpm	MCR=24MW, 75 rpm	MCR=12MW, 69 rpm	MCR=24MW, 75 rpm	MCR=12MW, 69 rpm
HFO	30% renewable	HFO	30% renewable	HFO	30% renewable	HFO	30% renewable

Select output

Business case support for ship owners

How do you select a WPS?



What is best? A rotor or a wingsail?
How large?

What happens if the wind dies?



- Ship owners
- Ship operators
- Etc..



Payback time?

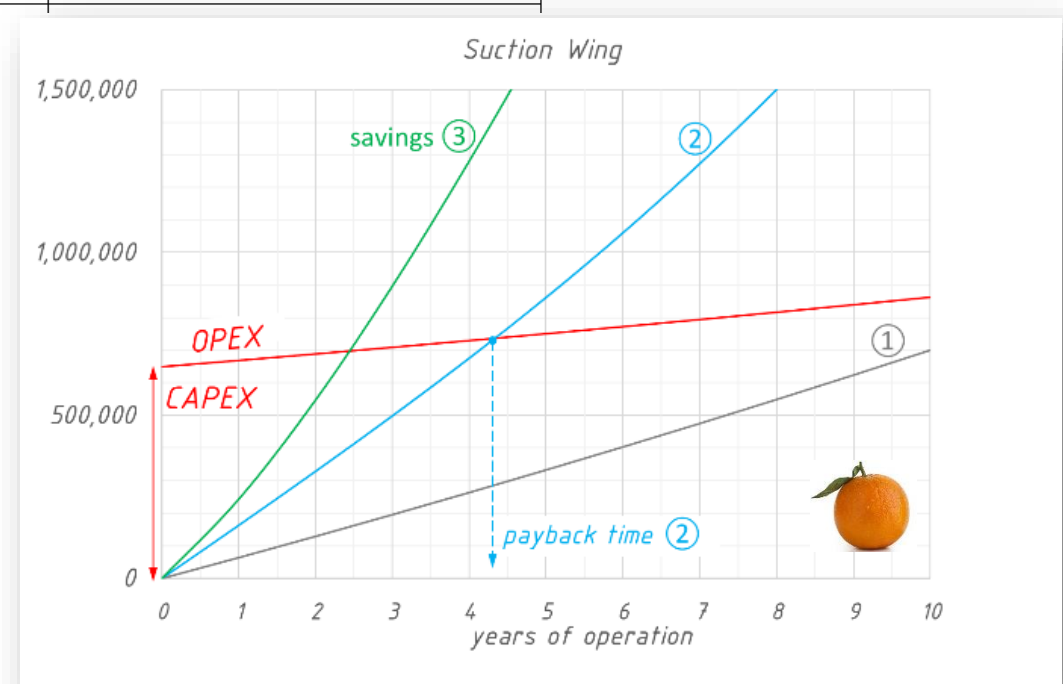
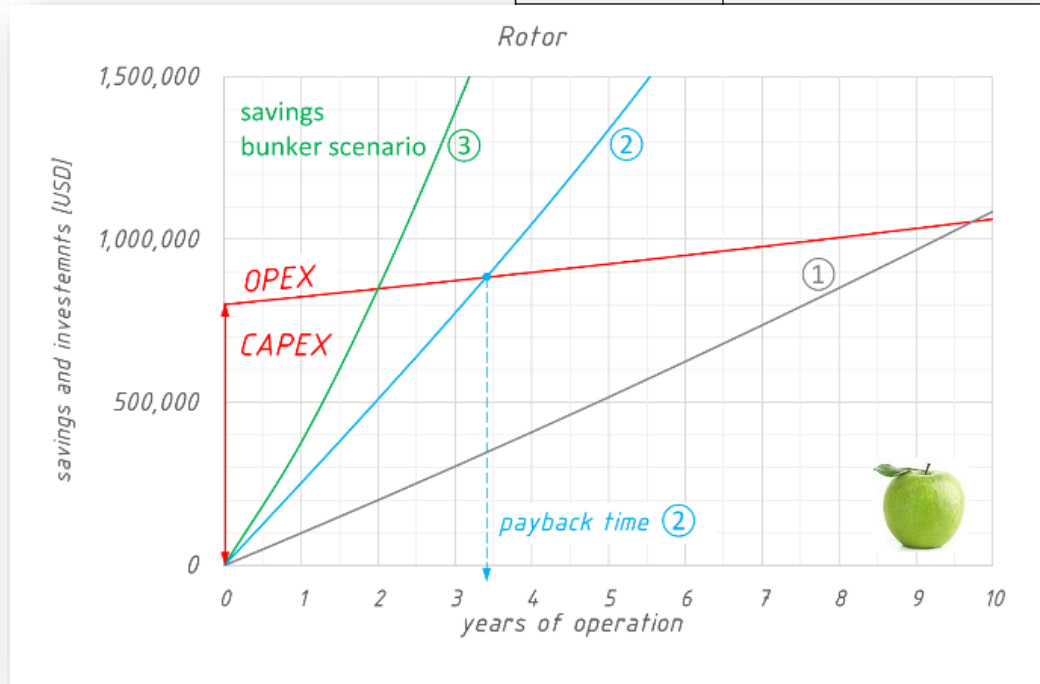
What are the risks?

EEDI, EEXI, CII?

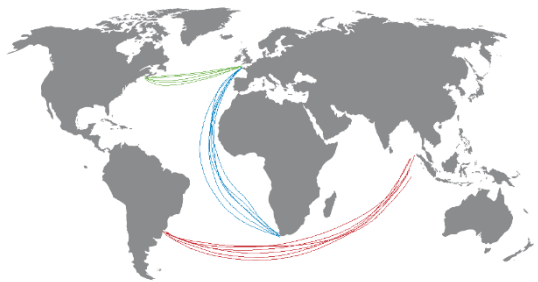
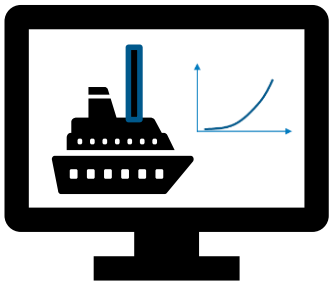
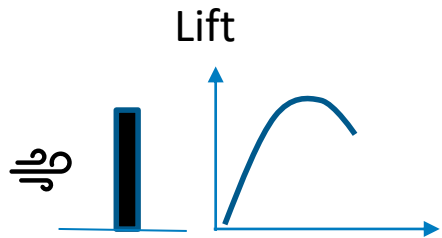
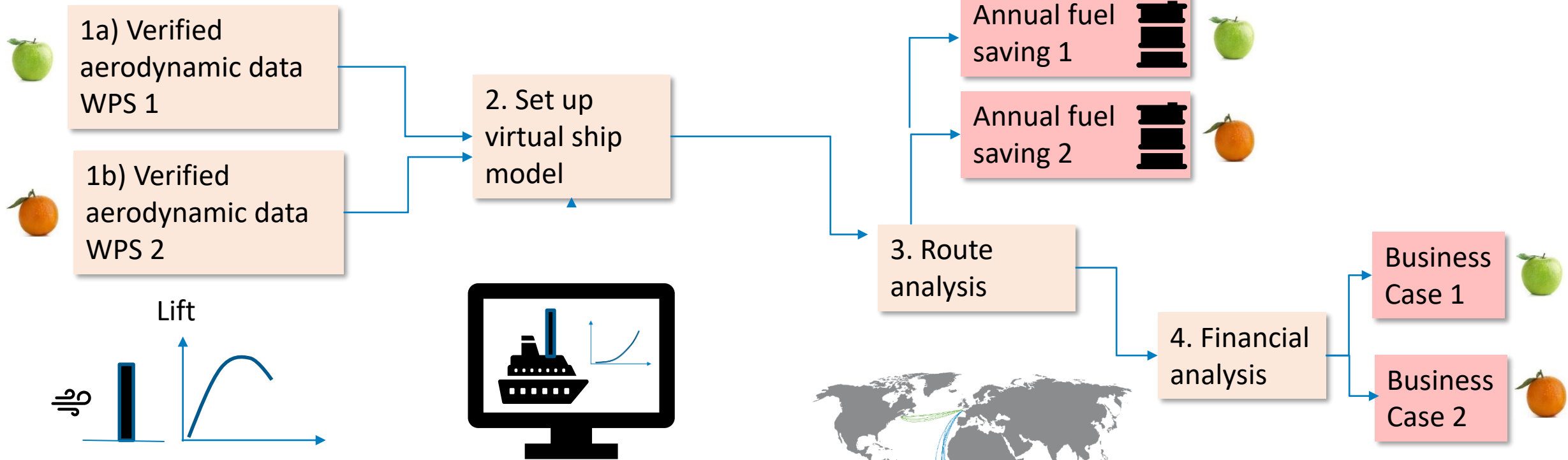
How much fuel will it save?

Results route + case specific!

Case	Actual	Hypothetical
WPS	Rotor (R)	Suction Wing (SW)
Principal of operation	Magnus Effect	High lift wing profile, boundary layer suction to delay stall
		
Dimensions	30 m x 5 m	24.8 m x 6.13 m
Area S	150 m ²	152 m ²



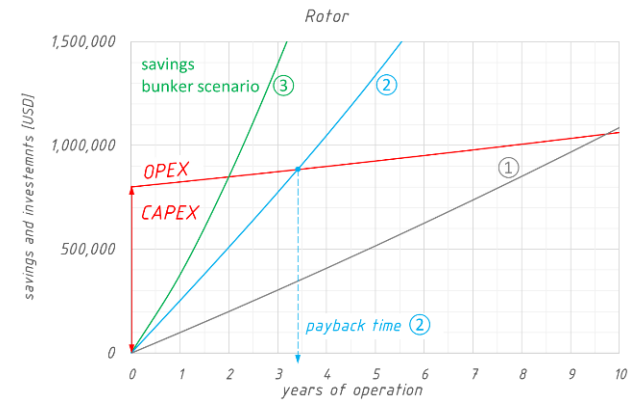
WPS	Rotor (R)	Suction Wing (SW)
Power savings	3.9 % annually	2.5 % annually
Energy saved	1 240 MWh/a	800 MWh/a
Bunker savings	248 t/a	160 t/a
CO ₂ savings	771 t/a	498 t/a
Payback time for bunker scenar. ③/②/①	2/3.5/9.75 years	2.5/4.3/13 years



- Wind tunnel data
- Extensive CFD
- Sea trial results

- Ship specific
- SSPAs database of model test results
- Interaction models (Hull-WPS and WPS-WPS)

- Trading and operational profile



SSPA simulators and wind-powered ships

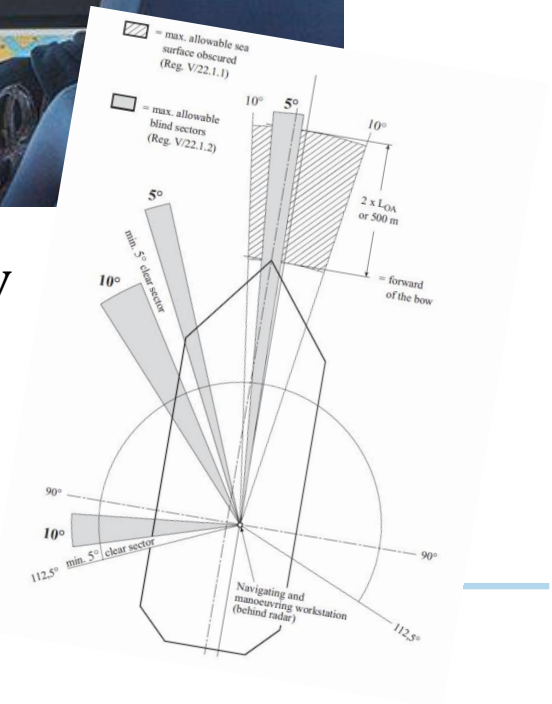
Desktop



Bridge, full mission



Navigation bridge visibility



Manoeuvre simulations and HMI development

Own ship control

Thrusters

Engines

Rudders

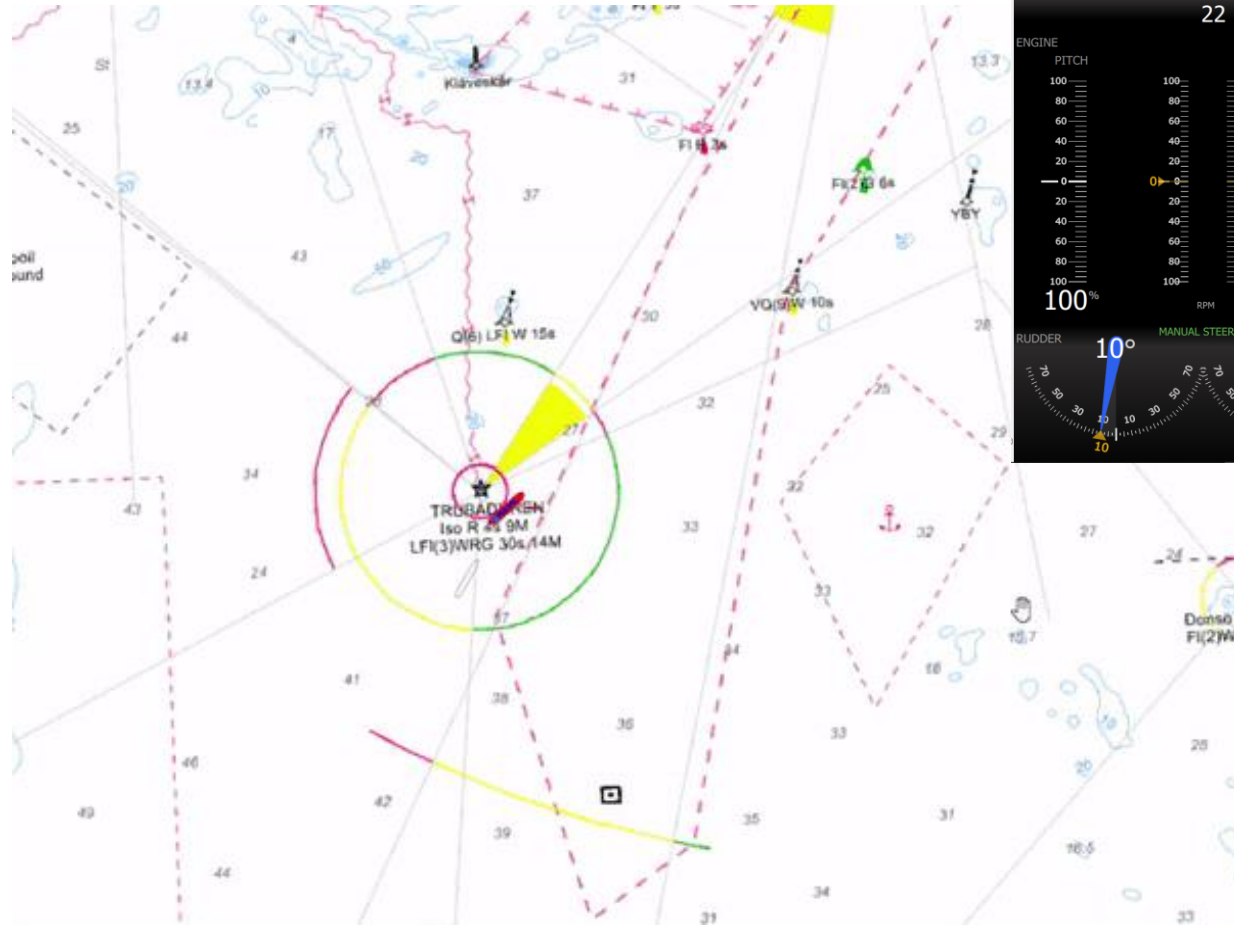
- Hand steering
- Set heading
- Course over ground
- Track keeping

Set heading: 035.00

Sails Max angle: 180

- Manual control - Angle relative to ship
- Automatic control - Angle relative to wind

Reefing



ROW THRUSTER

0% 100 75 50 25 0 25 50 75 100

315 320 325 330 335

29.9° Drift to PORT 294.7° COG

324.6° HEADING

1.5 SOG 1.3 STW

6.1 m/s Relative wind

5.9 m/s True wind

0.85 kn

1.32 kn

0.66 kn

ENGINE PITCH 100% RPM 100%

RUDDER 10° MANUAL STEERING 10°

Ukc FP: 31.5 m

Ukc AP: 31.5 m

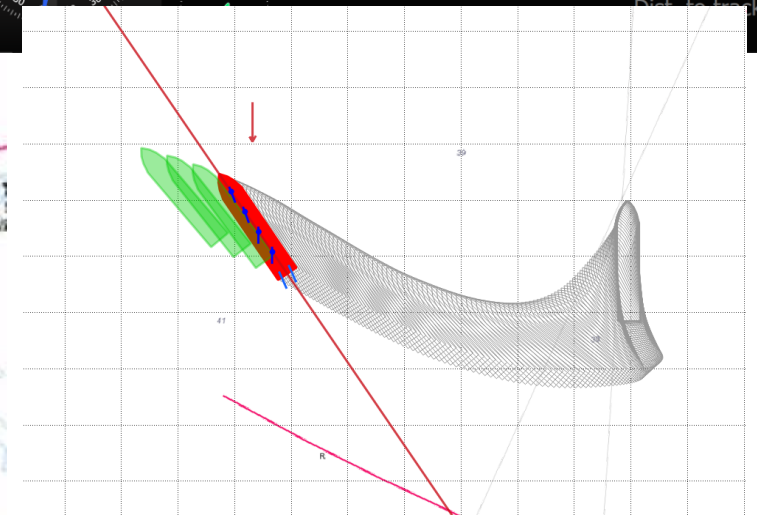
Current FP: 0.0 kn

000°

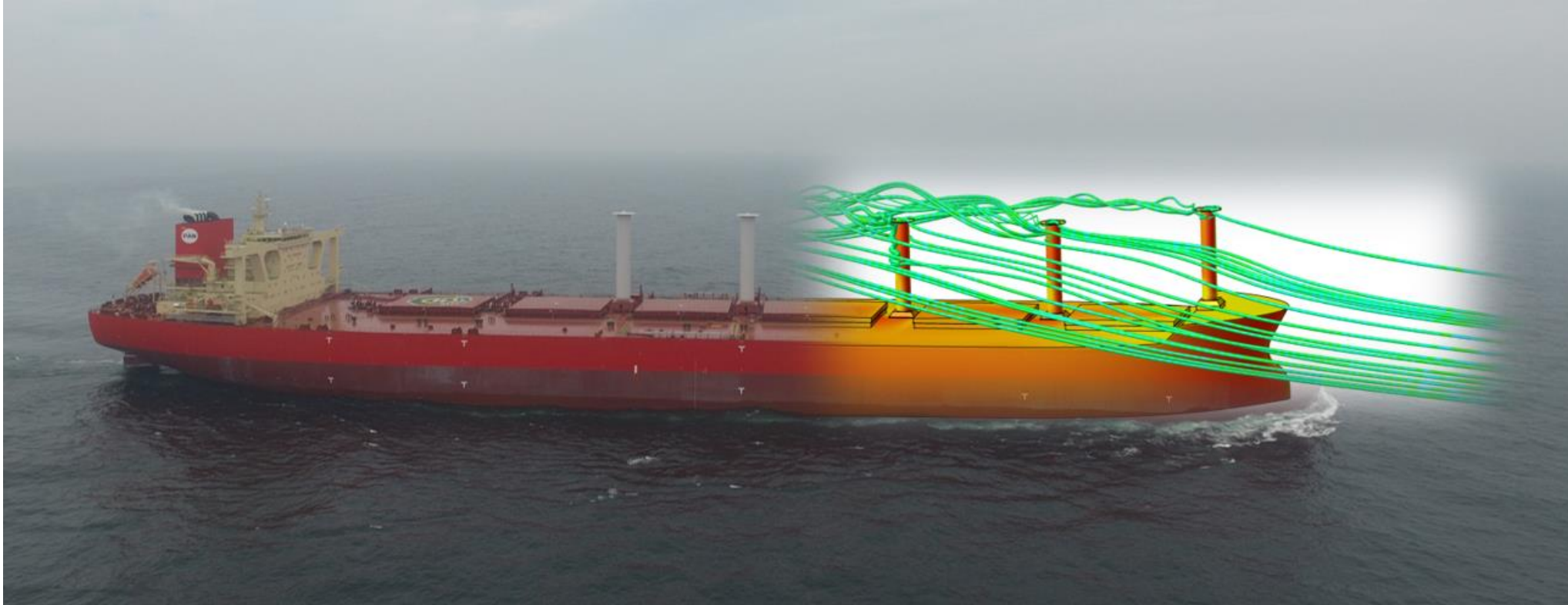
Current AP: 0.0 kn

000°

Dist to track: ?? m



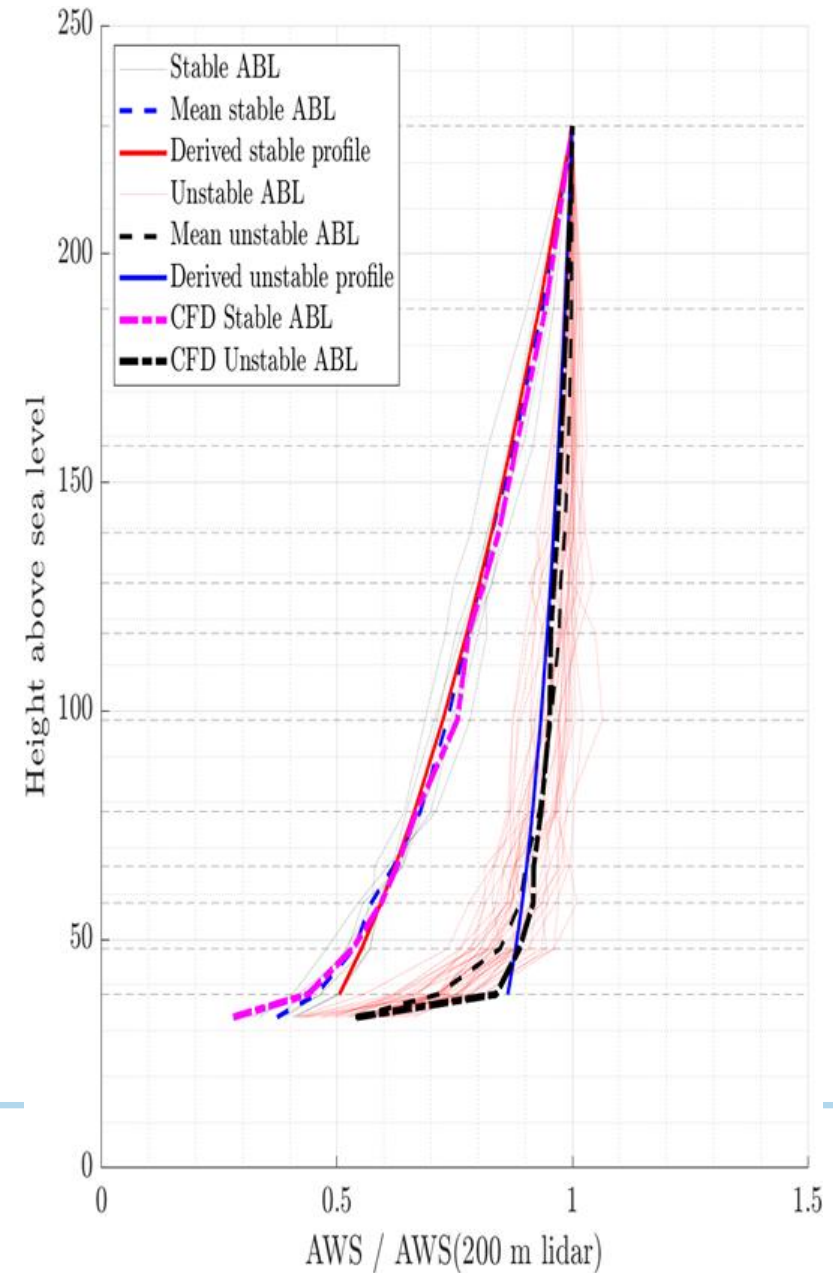
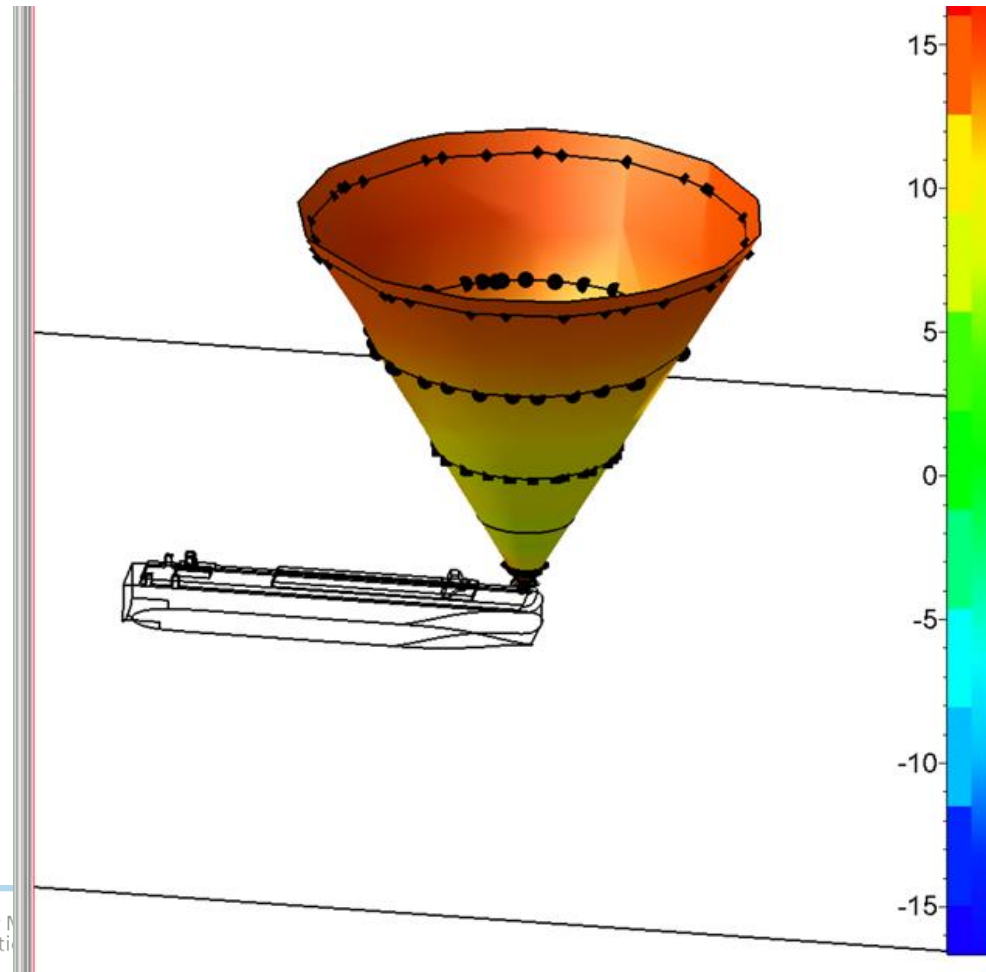
Aerodynamics



Above: The Brazilian company Vale recently had rotor sails installed on *Sea Zhooshan*, one of the largest ships in the world. SSPA was involved from the very start.

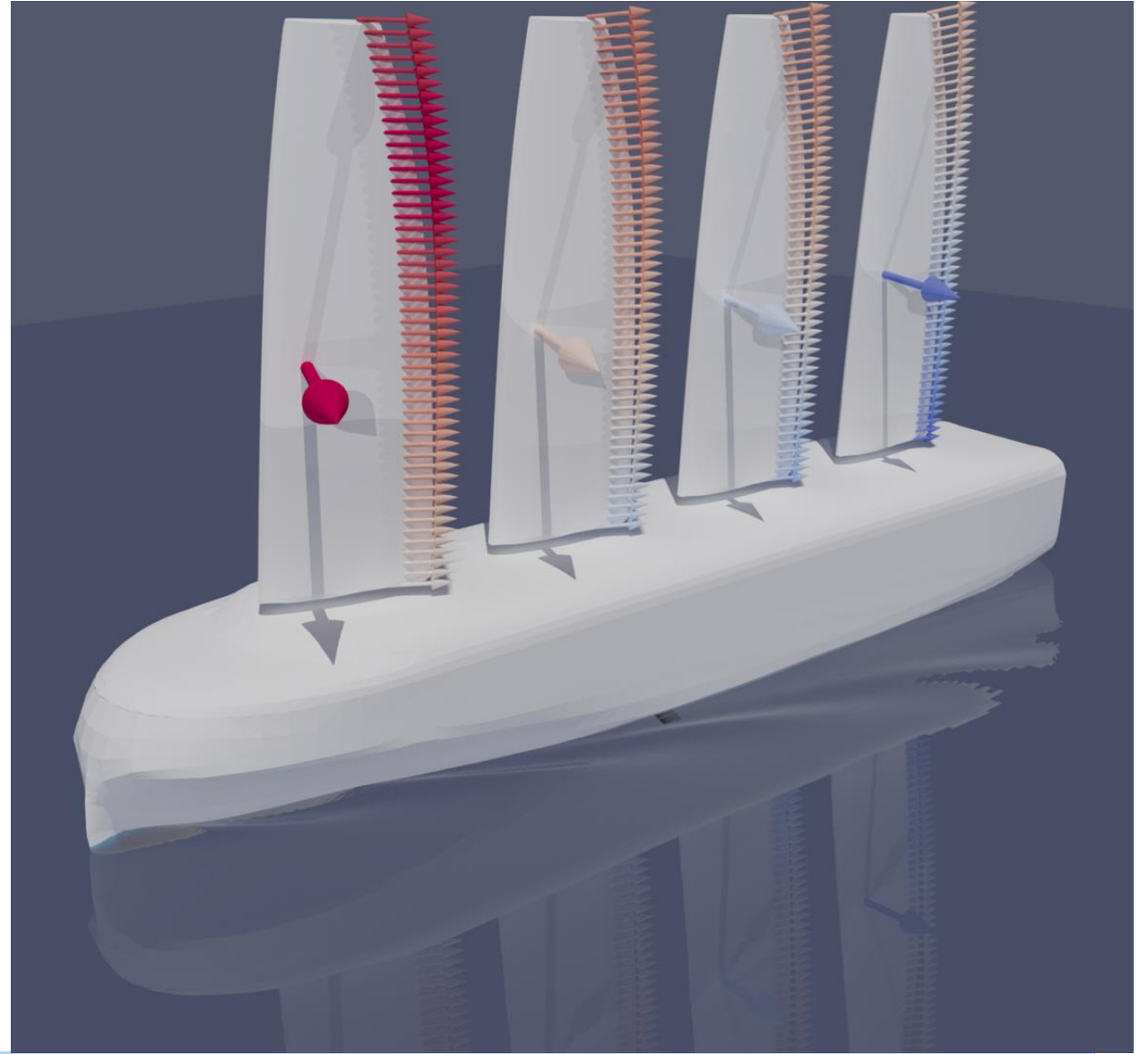
Validation with LIDAR measurement of ABL (in harbour case)

- Collaboration with KTH

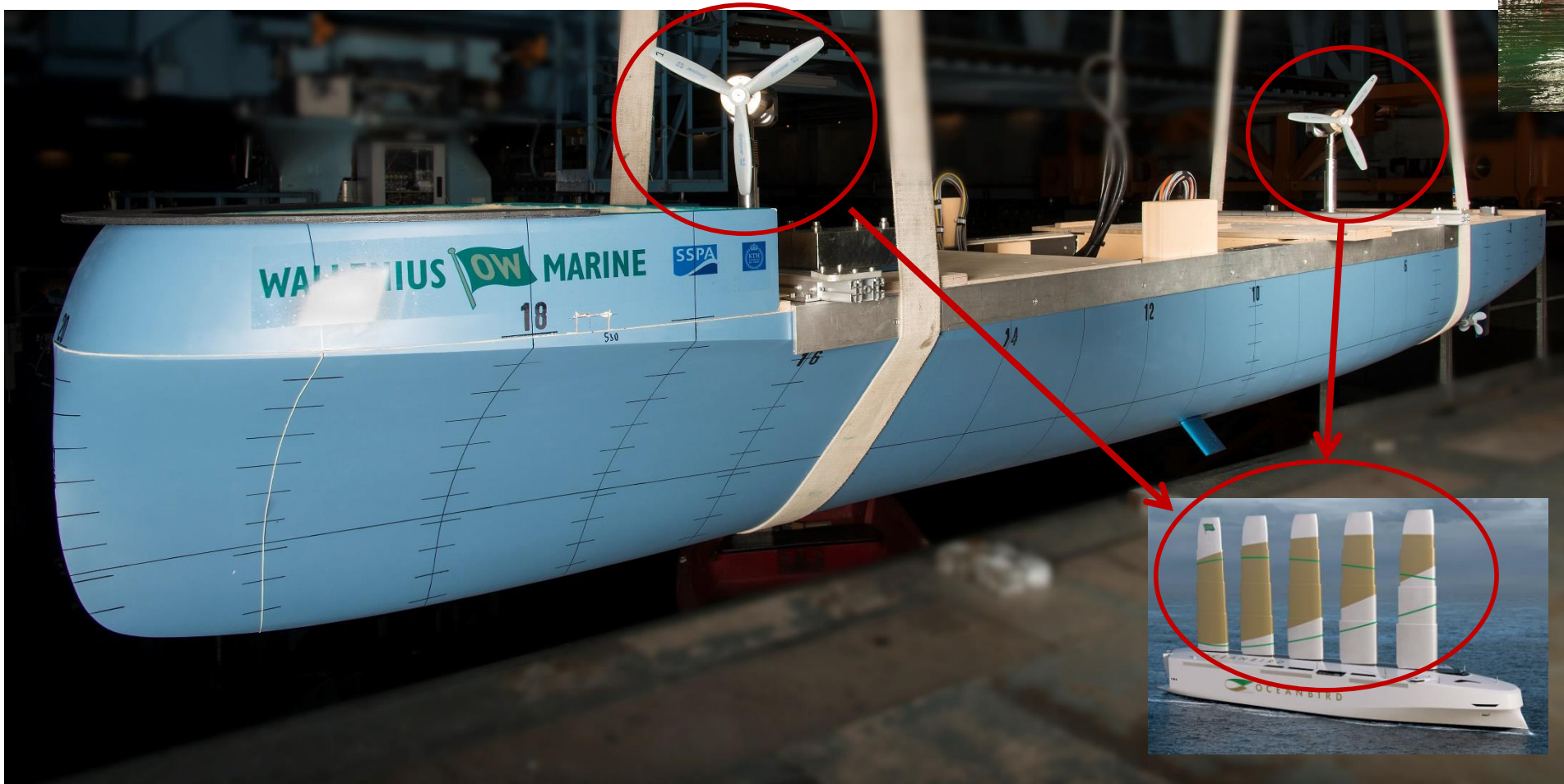
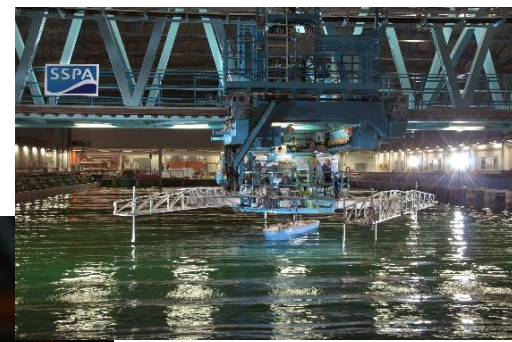


Seakeeping CFD

Assessing dynamic loads of wind powered ship in waves – an important input in the design process and class approval.



Seakeeping and Manoeuvring model test



Wind propulsion units are modelled using pulling fans

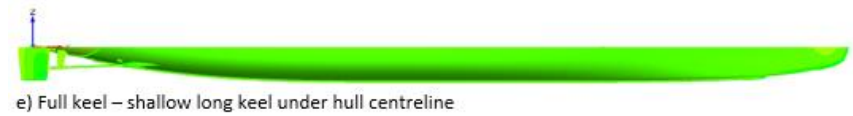
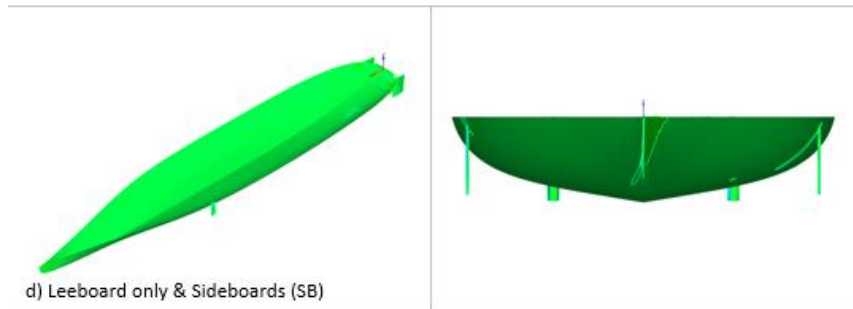
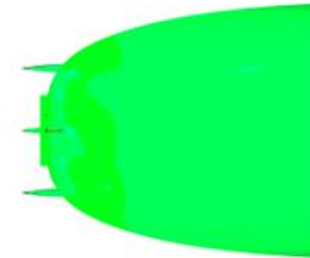
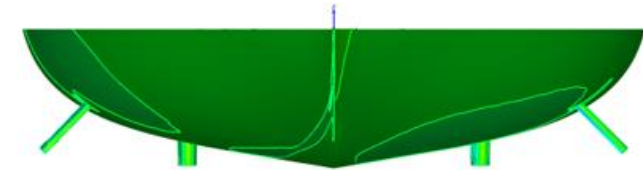
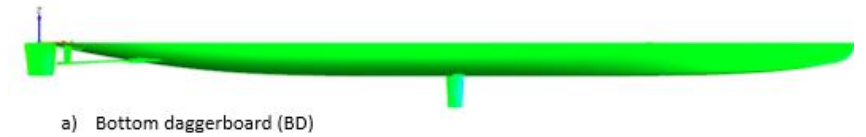
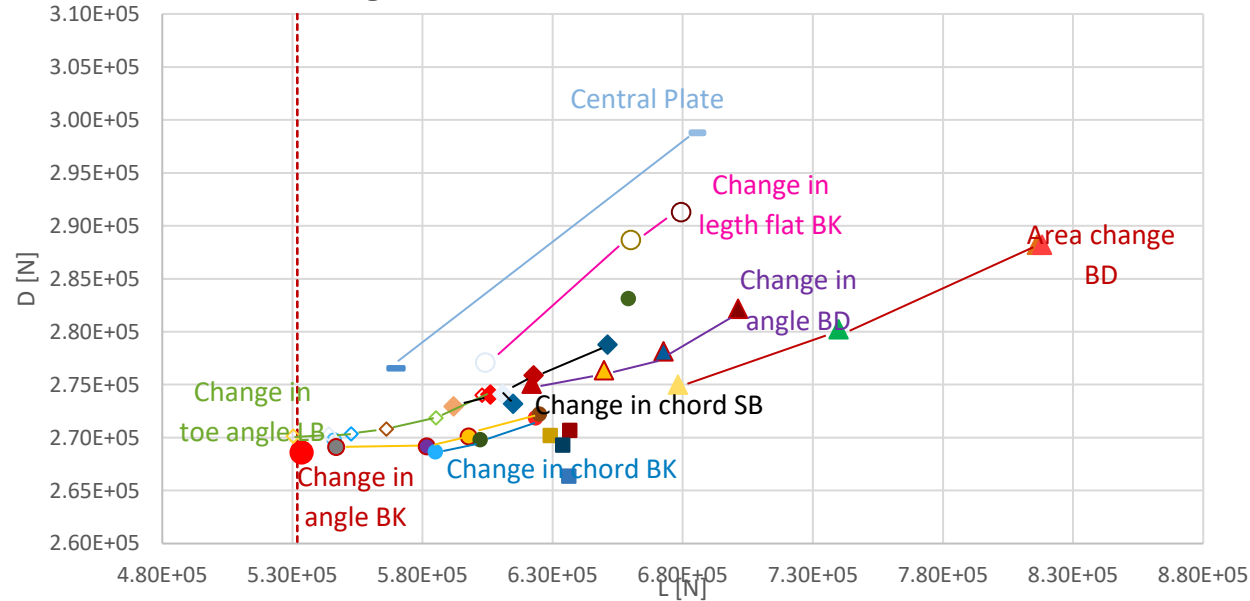


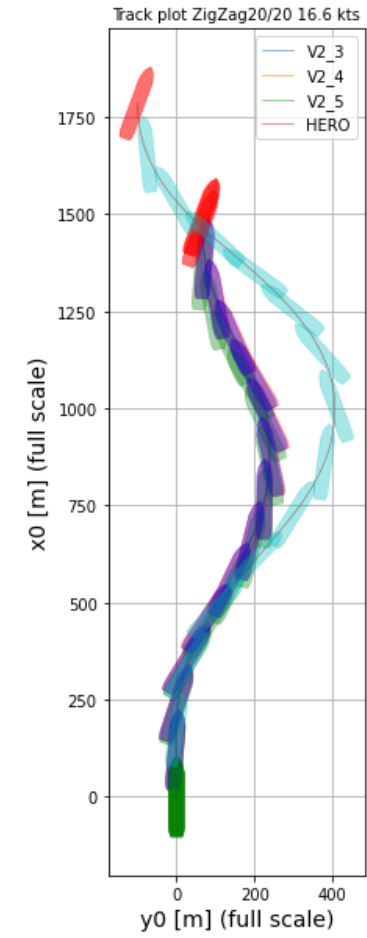
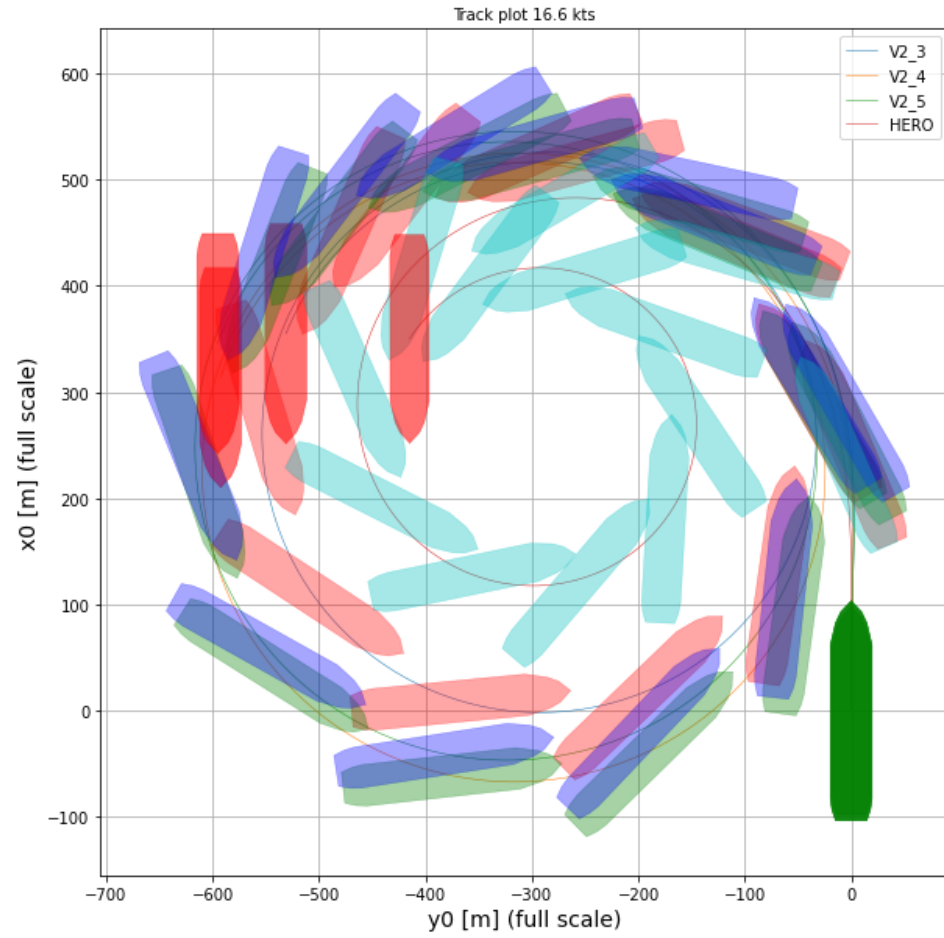
Hydrodynamics - Appendages



Appendge design

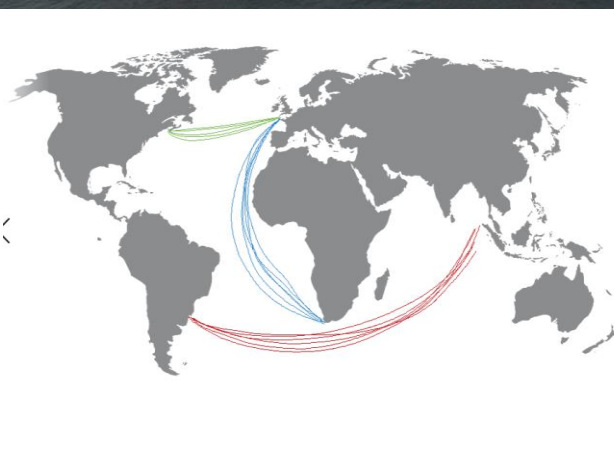
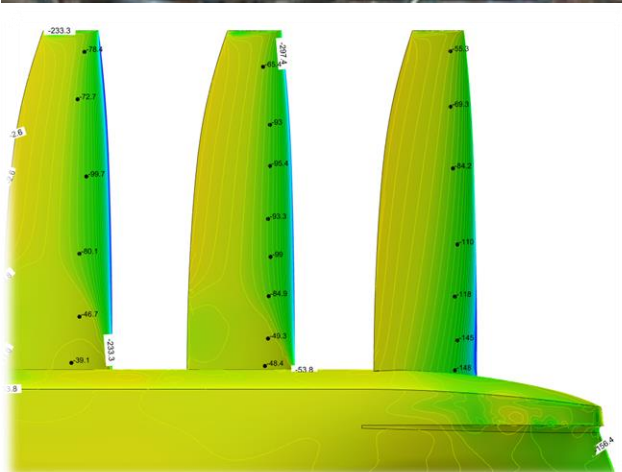
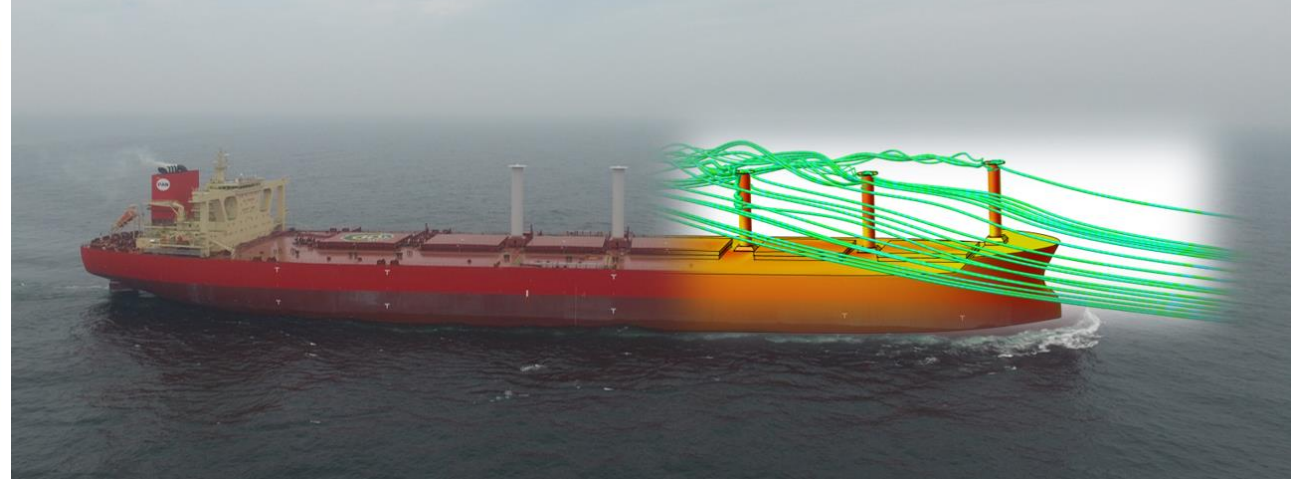
- INITIAL DESIGN
- Central Plate $s=8m$ $c=44m$
- Flat Bilge Keel 0.3LBP
- Flat Bilge Keel 0.4LBP
- Full Keel $s=0.5m$
- ◇ NACA2412 Leeboard toe in 1.5deg
- ◇ NACA2412 Leeboard toe in 4deg
- ◇ NACA0012 Leeboard $A=15.4m^2$
- ◇ NACA0012 SB $c=1.5c1$ $A=2x37m^2$ $AR=2.33$
- ◇ NACA0012 SB $c=2.5c1$ $A=2x59m^2$ $AR=1.4$
- ◇ NACA0012 SB 2 each side $A=2x30m^2 + 2x18m^2$
- NACA0015 3 rudders
- ▲ NACA0015 BD $A=64m^2$ $AR=2$
- ▲ NACA0015 BD $A=122m^2$ $AR=1.06$ Rudd NACA0015
- ▲ BD "off the shelf" angle=-2deg
- ▲ BD "off the shelf" angle=-6deg
- NACA0015 3 rudders shaft @ 30%
- Central Plate $s=5m$ $c=20m$
- Flat Bilge Keel 0.15LBP
- Flat Bilge Keel 0.4LBP
- ◇ NACA2412 Leeboard
- ◇ NACA2412 Leeboard toe in 2.5deg
- ◇ NACA2412 Leeboard toe out 4deg
- ◇ NACA0012 SB $A=2x24m^2$ $AR=3.5$
- ◇ NACA0012 SB $c=2c1$ $A=2x47.4m^2$ $AR=1.75$
- ◇ NACA0012 SB $c=3c1$ $A=2x71m^2$ $AR=1.17$
- NACA0018 3 Rudders
- ▲ NACA0015 BD $A=122m^2$ $AR=1.06$
- ▲ NACA0015 BD $A=41m^2$ $AR=3$
- ▲ NACA0015 BD "off the shelf" $A=36.8m^2$ $AR=1.8$
- ▲ BD "off the shelf" angle=-4deg
- NACA0018 3 rudders shaft @ 30%
- NACA2412 BK One correct xle $A=2x36m^2$ $AR=1.3$







Wind powered ships



Select wind propulsion system

6 Flettner ZigZag

5 retractable wings

Select route and operational parameters

southampton_newyork

