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PERFORMANCE IN SEAWAY

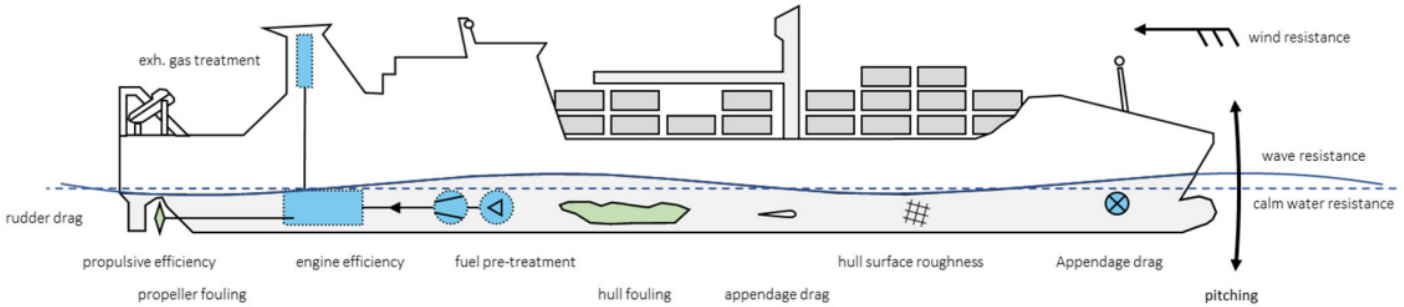
Anders Alterskjær, SINTEF Ocean

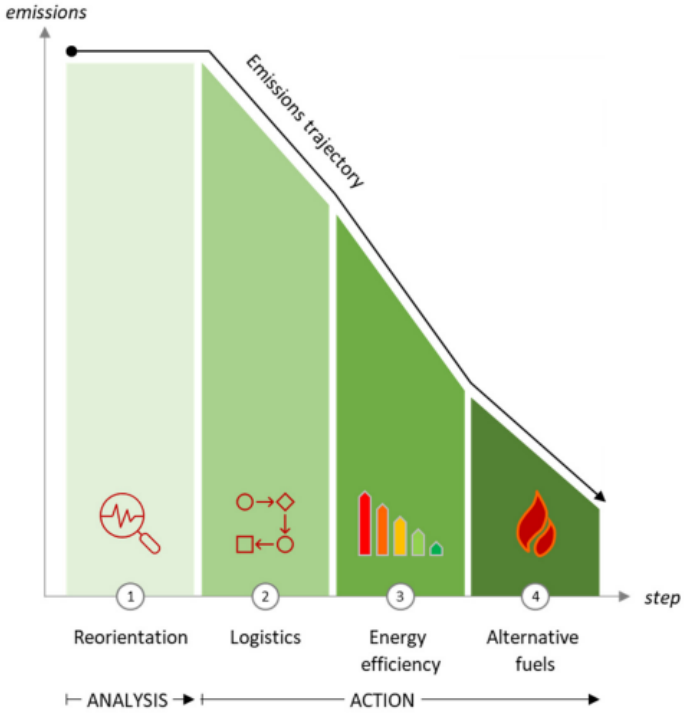
June 20, 2023 - Trondheim

OVERARCHING GOAL

Support transition in ship design processes

- Single, idealized condition => real sea- and operating conditions
  - Waves, wind, current
  - Varying speeds and loading conditions
  - Fouling/marine growth
- By developing knowledge and tools
  - Experimental studies
  - Full scale data processing
  - Model test methods
  - Numerical tools and models





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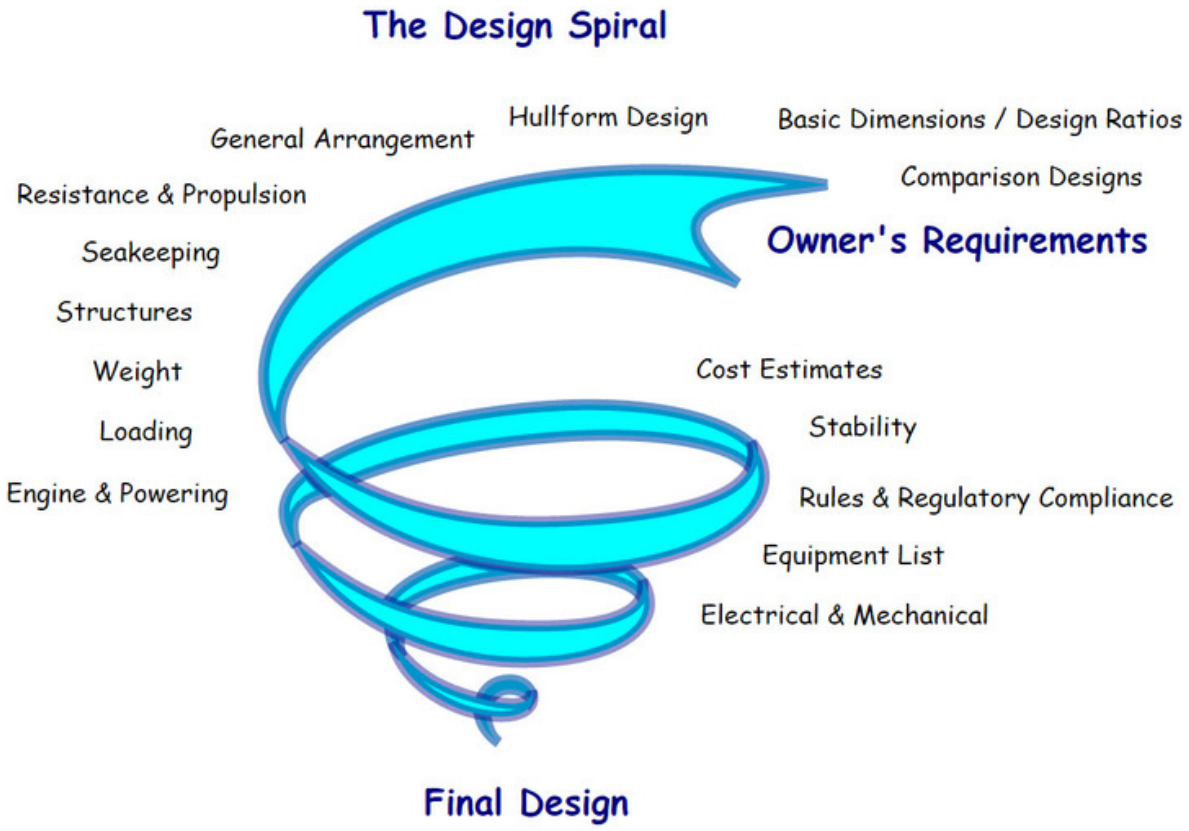
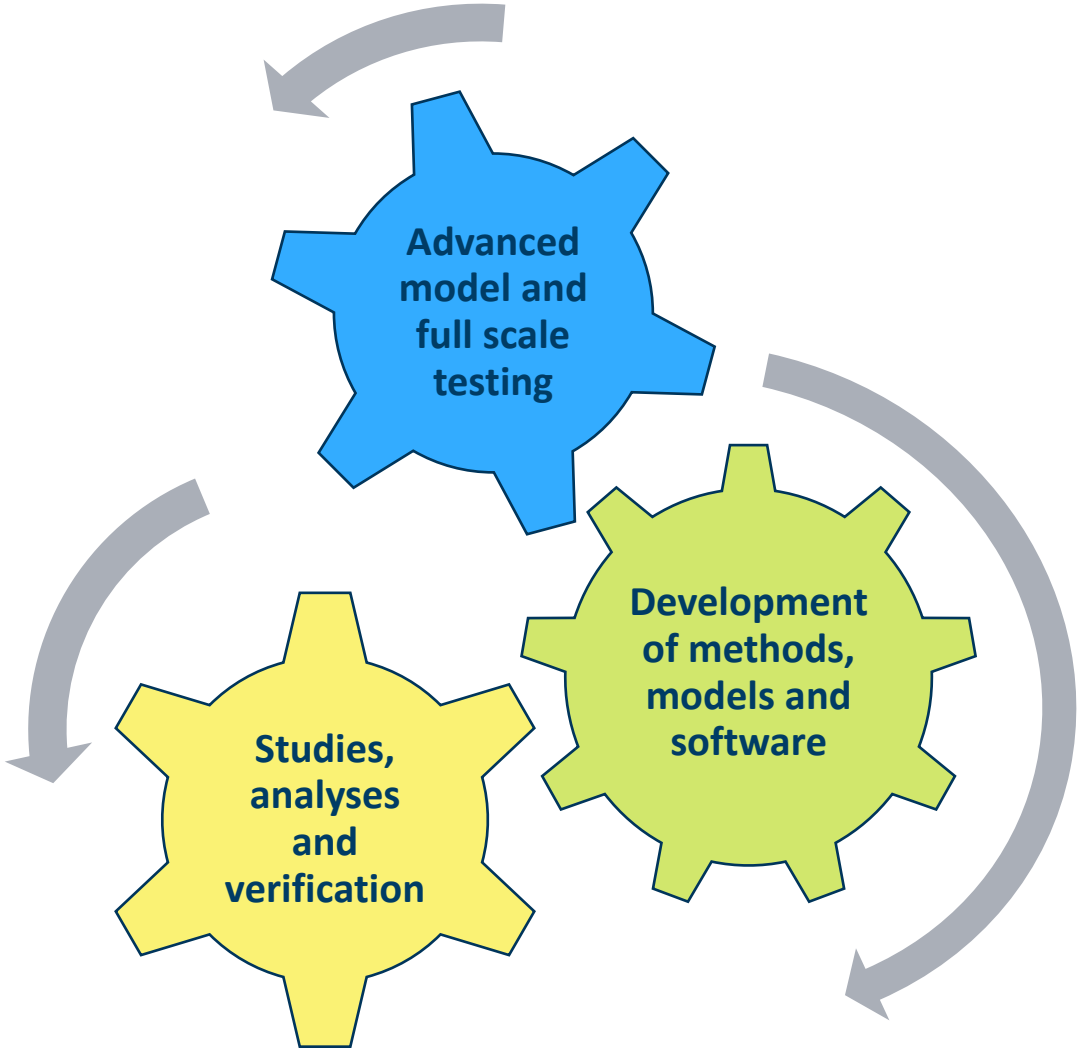
Knowledge and tools in ship design

- Ships are complicated! Interactions between systems, trade-offs between performances etc.
- Some aspects are too complex and computationally demanding to assess early on
- On the other hand, the earlier in the design, the more freedom is there to optimize the vessel
- The utopian dream is an all-encompassing simulator



ShipWright LLC; The design spiral

Tool development



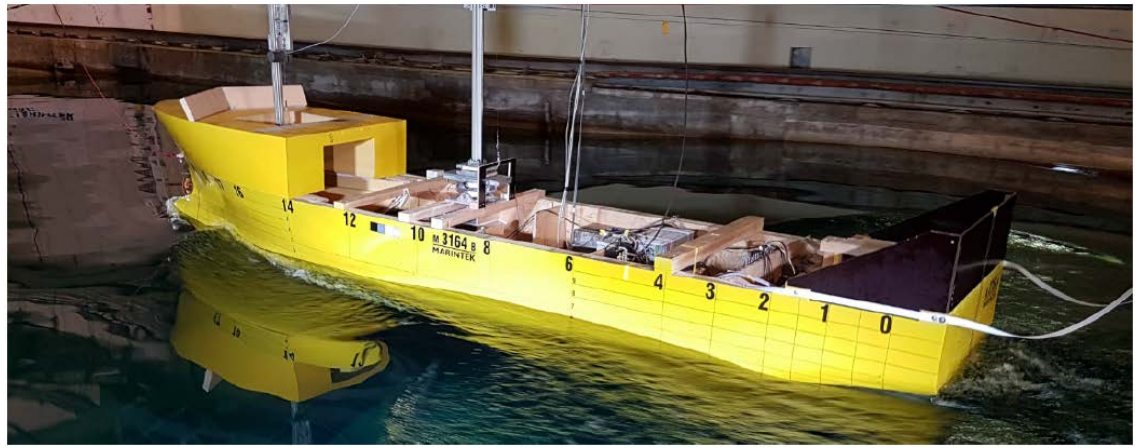
Practical design tools vs scientific forefront

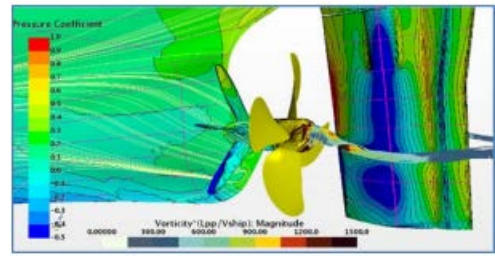
Developing new knowledge

Implementing "old" knowledge

Continous topics; Energy Saving Devices (ESD)

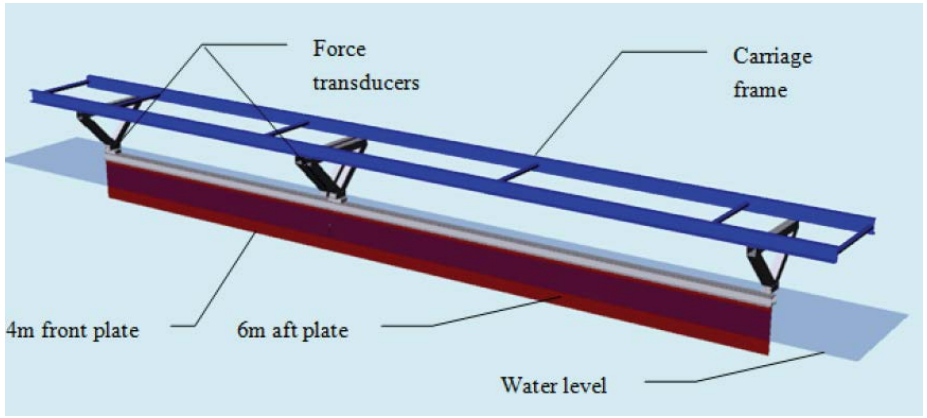
- One of the first activities in the SFI; Model test campaign conducted together with VARD and Kongsberg
- Objective: knowledge into effect of waves on energy saving devices (Here: PROMAS rudder system)
- Conclusion: Efficiency maintained in the tested conditions (head seas)

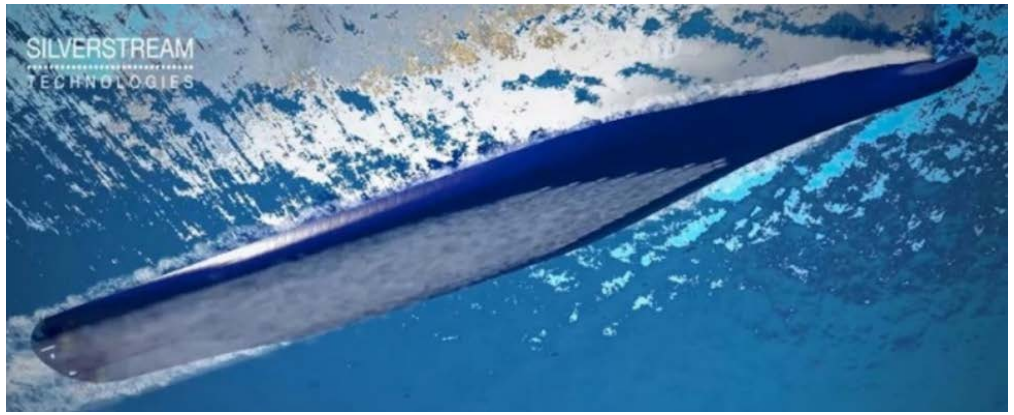


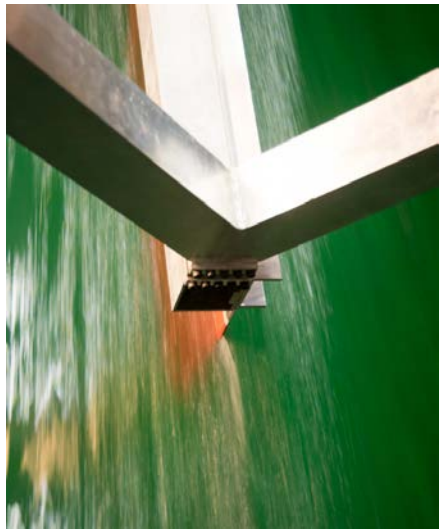


Continous topics; frictional resistance

- Model test Campaign together with JOTUN, frictional resistance and flow characteristics of different surfaces
- Continued efforts in project REDRES, ON-AIR and now most recently AirOcean







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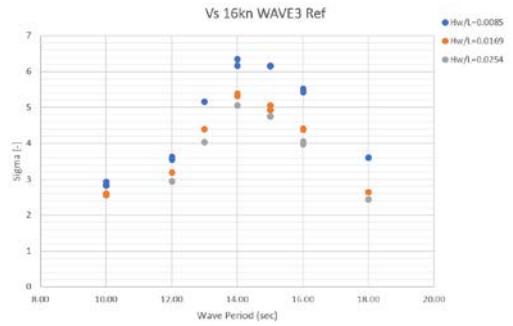
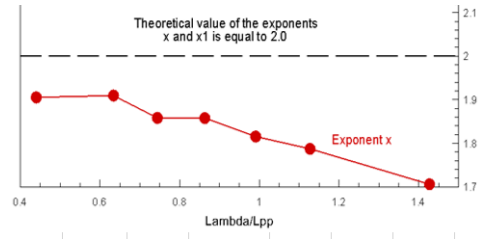
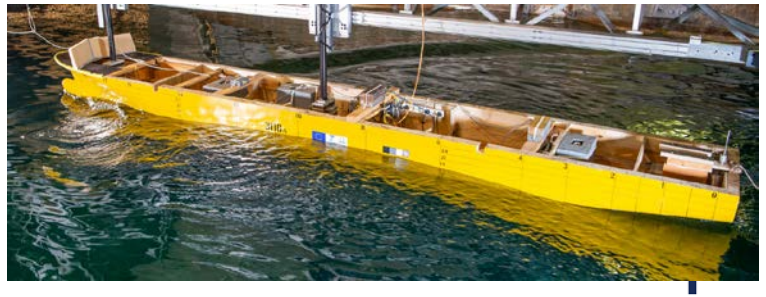
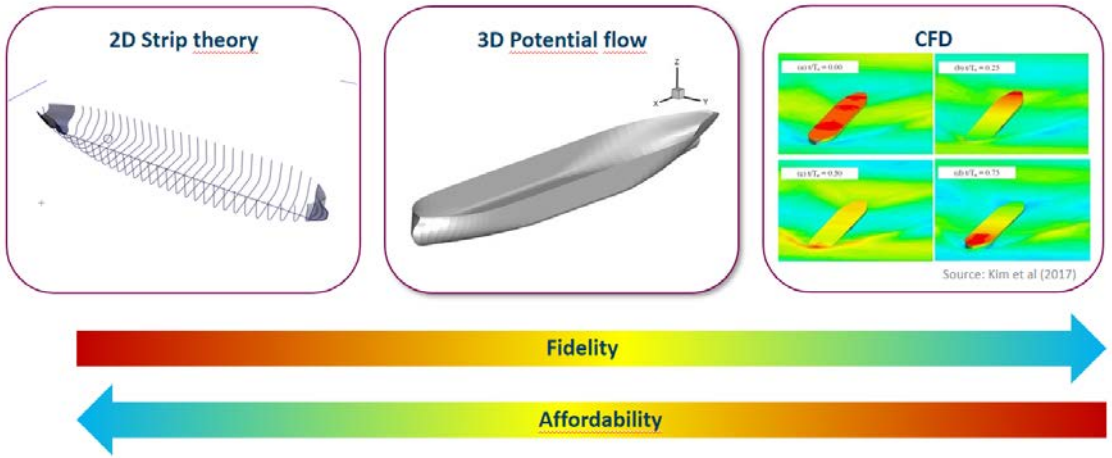
Continous topics;
Added Resistance in Waves

- State-of-the-Art reviews
- Benchmarking of existing methods
- Development of automated (and unmanned) model test technique to run large test matrices cost-effectively
- Initial development of VERES 3D – medium fidelity 3D potential flow seakeeping code
- Continued in KPN IPIRIS (VERES 3D + advanced NWT methods)









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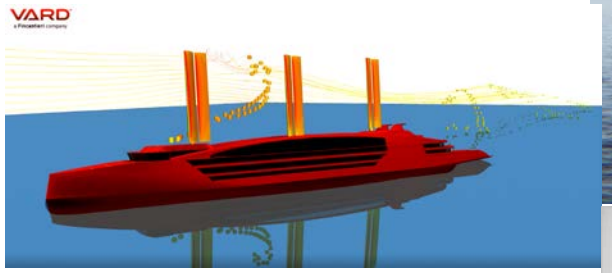
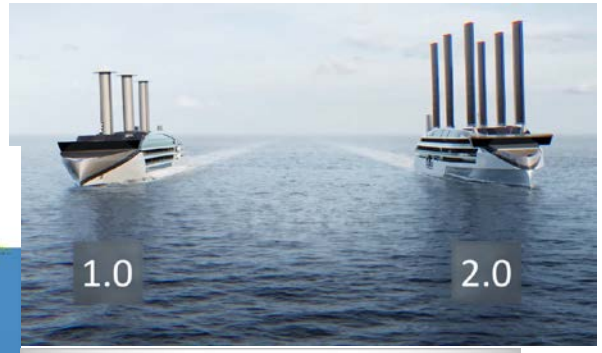
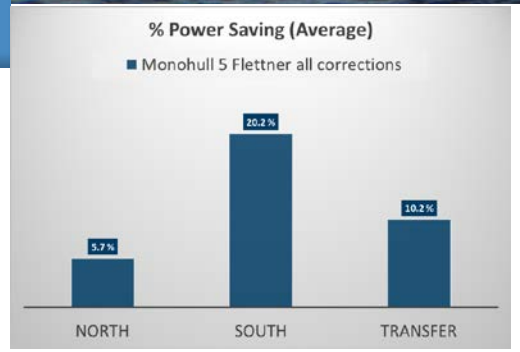
Case Studies

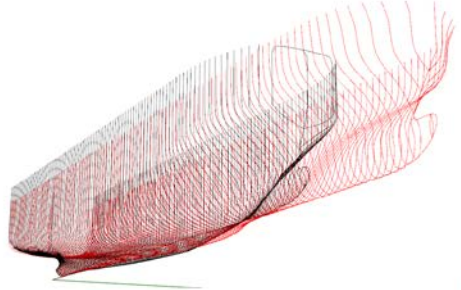
The case studies ran in SFI Smart Maritime has been valuable:

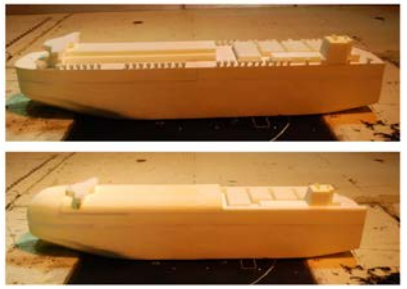
- For our partners for exploring new ideas and concepts
- For putting old and new tools and methods to the test

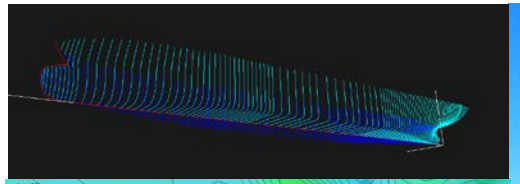


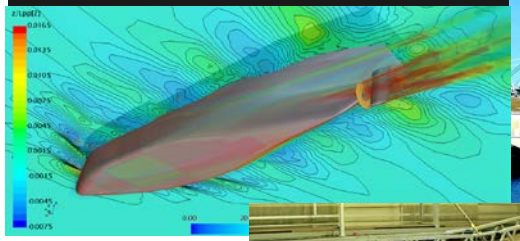












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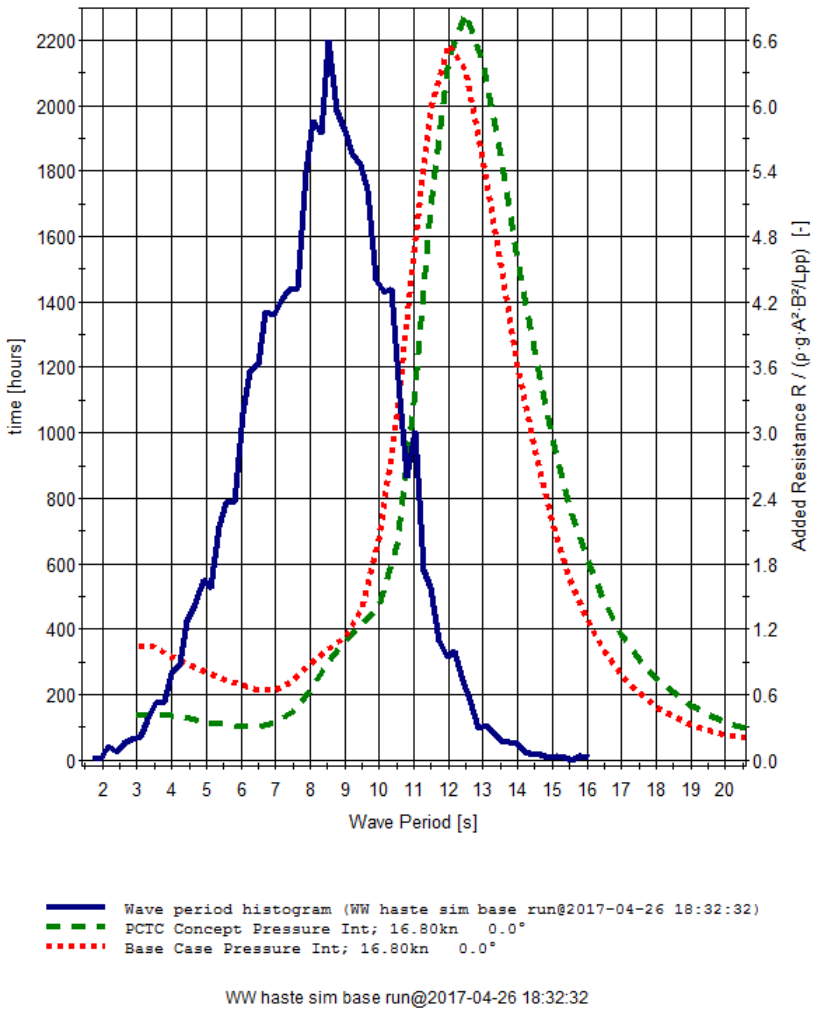
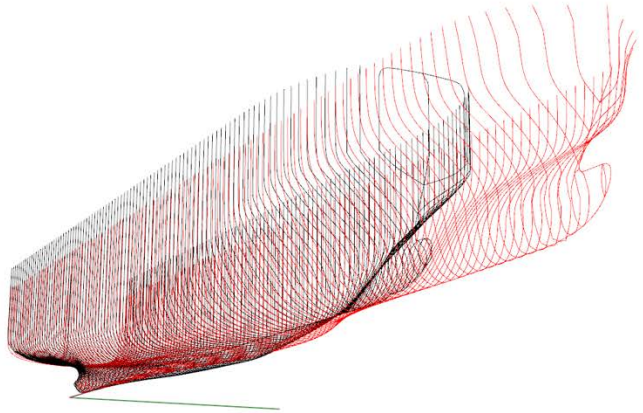
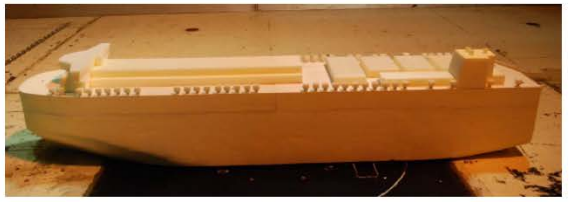
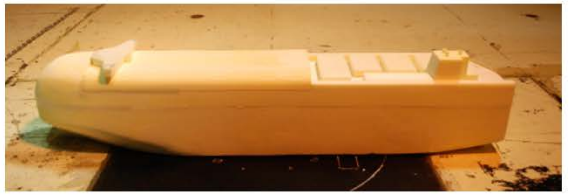
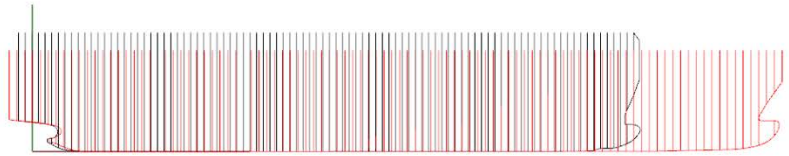
Case Study WW PCTC, for exploration











Economical KPI's

Parameter	Thermopylae	PCTC Concept 1	
Energy consumption (prop.)	524 624 000 kWh	472 928 000 kWh	- 10 %
Distance	781knm (17,89 kn)	784 knm (17,96 kn)	- 0 %
Cargo capacity			Equal
Energy efficiency in transit	**671 kWh/nm**	**603 kWh/nm**	**- 10 %**
Calm water resistance (18 kn)	10438 kW	10021 kW	- 4 %
"Sea Margin" (Resistance increase)	21 % (Waves 17%, wind 4%)	12 % (Waves 10%, wind 2%)	

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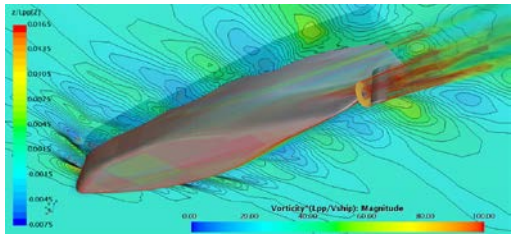
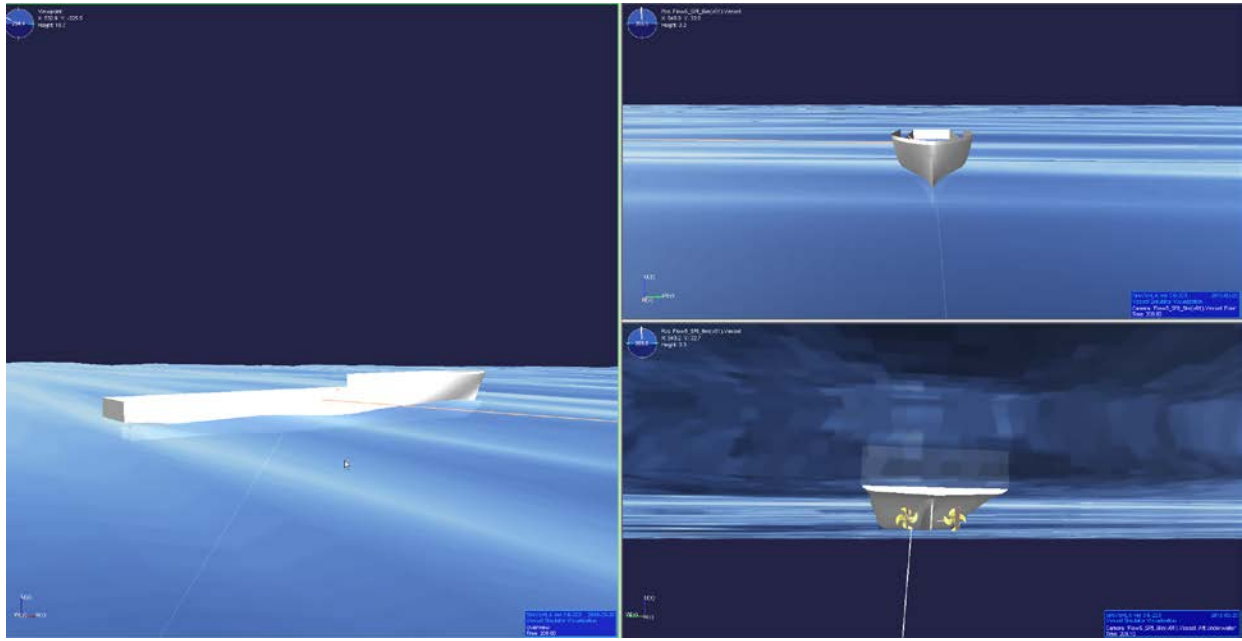
Case studies Grieg, resulting in benchmark vessel

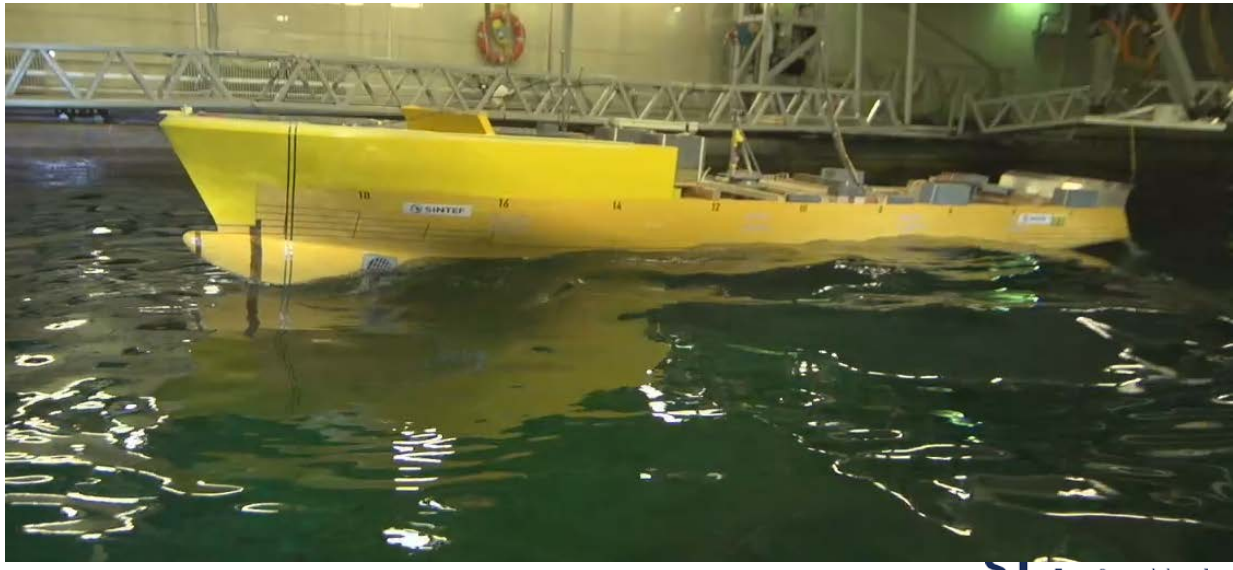
- Resulted in a **new benchmark open geometry for exploration of zero emission technologies, namely SOBC-1**
- The complete vessel geometry including hull, propeller, rudder and superstructure is available, along with benchmark data from model tests at SINTEF Ocean.
- Has been subject to several studies allready since it "was born" in 2020, and will be used also for the newly started KSP's WIND and SeaWorthy



Case study: Safe Return to Port and Minimum Power Requirements

- What about safe operations in the drive towards energy efficiency and lower installed engine power?
- Comprehensive study Together with DNV and Vard on the assessment of power requirements in adverse weather conditions
- The results indicated a significant difference between results obtained by the different methods
- Need for better prediction of the performance in heavy weather conditions in the design stage





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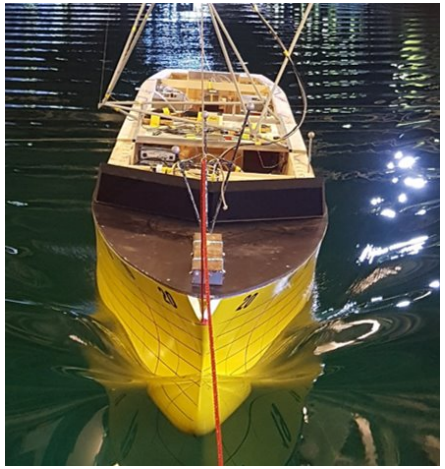
Spinoff KSP Project SEAWORTHY

- Build on existing methods and software tools
- Improve functionality and accuracy to cover the needs identified by the industry (partners)
- Let the industry partners test the tools and give feedback during the project
- Improved methods will be validated through comparison with CFD, model tests and full-scale measurements.

Participants

Norges Rederiforbund
Norwegian Shipowners' Association
Kystrederiene
polarkonsult
naval architects & marine engineers
Eidsvaag
FOSEN DESIGN & SOLUTIONS
CFD marine
DNV
ULSTEIN
SINTEF
NTNU
KONGSBERG
møre maritime
BRUNVOLL
HAV design
LMG MARIN
DSME
SINTEF



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Zero Emission Cruise Case and its spinoff Cruizero

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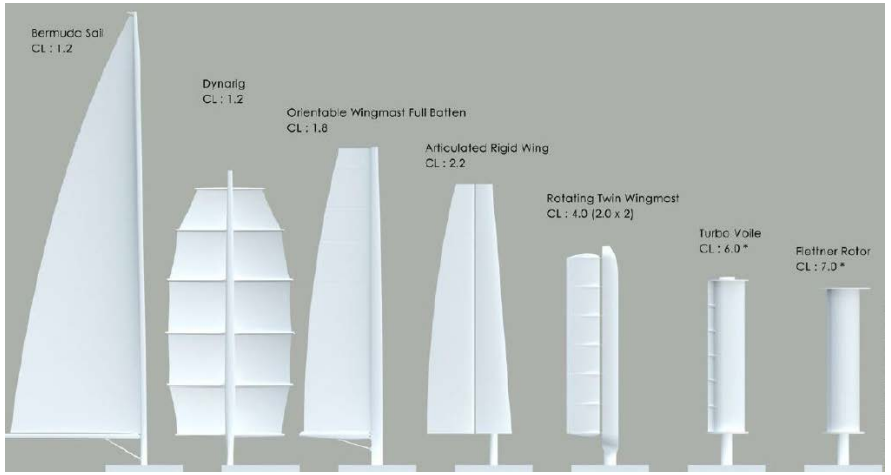
Wind Propulsion

- Throughout the lifetime of the center, the topic of wind propulsion has gained massively increased interest
- A very good example of the benefits of such a centre to enable :
  - 2019-2020: Initial tool development in Zero emission cruise case
  - Spinoff Cruizero 2020-2023, ZeroCoaster 2020-2023
  - 2020: Method development and production of the SOBC-1 benchmark vessel
  - 2021: Development and piloting of hybrid model test technique
  - 2022->: Development of route optimization tools (Spinoff IPN Ecorouter)
  - 2023->: Spinoff KSP Wind



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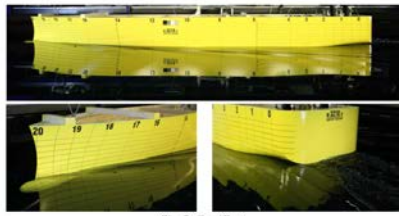
Regrets 😢 (Or future ambitions 🧐)

- Manoeuvering, coursekeeping and Steering losses
- Even better (!) tools for added power in oblique seas (i.e. accuracy + speed)
- Other ship and propulsion types (for instance high speed vessels, SOV's etc)
- Closer integration between numerical models/digital twins and model tests (and full scale trials)
- Work further on the utilization of full scale data analyses

Model test campaign 1

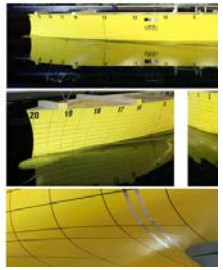
- Calm water tests with stock propellers
  - Open water test of stock propellers/pods
  - Resistance tests for two draughts
  - Test matrix where propeller rotation direction and pod toe-out angle is varied
  - Propulsion tests for two draughts
  - Measurement of 3D-wake field in propeller plane
  - Streamline paint test
- Main objectives
  - Verify resistance and propulsion performance, identify possible improvements
  - Optimize pod toe-out angle and propeller rotation direction
  - Provide input to propeller design
  - Investigate flow pattern for alignment of appendages (e.g. bilge keels, stabilizer fins, etc)



Wave Profiles 15knots

Model test campaign 2

- Calm water tests with design propellers
  - Open water test of design propellers/pods
  - Resistance tests for two draughts
  - Propulsion tests for two draughts
  - Load variation tests
- Main objectives
  - Verify performance with design propellers
  - Obtain load variation factors required for sea trial analyses



Oppdraget: Et skip som går Bergen - Kirkenes med lavest mulig energiforbruk. Da må det tusenvis av simuleringer til

Når Havyard Design & Solutions utvikler de nye kystruteskipene er tusenvis av små og store endringer og justeringer testet med simulatorverktøy mange ganger.

Model test campaign 3

- Free running seakeeping tests in head seas
  - Measurement of speed loss in 3 irregular sea states for 4 levels of constant power, taking into account torque limitations of the drive train.
  - Safe Return to Port (SRtP) tests taking into account torque limitations of the drive train
  - The above mentioned tests were carried out with and withoutthe Wavefoil® system.
- Main objectives
  - Establish involuntary speed loss and power curves in head seas for a variety of sea states
  - Verify SRtP Compliance (ability to maintain 6 knots in BF8 head seas and head wind, with one dead propulsor)

Model test campaign 4

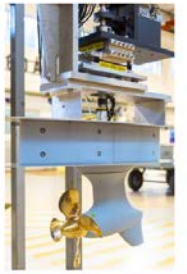
- Detailed studies of added resistance in regular waves
  - Towing tests in head seas regular waves, for a range of wave periods and two different wave heights
  - Propulsion tests in head seas regular waves, for a range of wave periods and two different wave heights
  - The above mentioned tests were carried out with and without the Wavefoil® system.
- Main objectives
  - Derive Added Resistance quadratic transfer funtions with and without Wavefoil®
  - Investigate and quantify the effect of waves on propulsive efficiency, and whether propulsive efficiency in waves are affected by the introduction of Wavefoil®

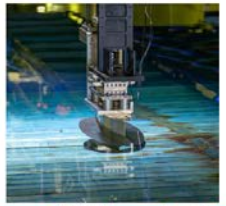
Model test campaign 5

- "PMM tests"
  - Captive model tests with measurement of hull forces, when the hull is forced through prescribed planary/horizontal motions (surge, sway, yaw) in forward speed
- Main objectives
  - Derive manoeuvering coefficients, as required for establishing a numerical model able to simulate manoeuvering.

Model test campaign 6

- Thruster tests
  - Open water tests with the thruster alone, mounted on force balance. Tests are carried out for operating points in all four quadrants, and for a range of steering angles.
- Main objectives
  - Derive thruster forces, as required for instance for establishing a numerical model able to simulate manoeuvering.





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NEW TOOL UNDER CONSTRUCTION!

Live from NHTS 2028

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Ting å få med

- IPIRIS / VERES3D
- Vindpropulsjon
- Luftsmøring
- Caser, WW, og Grieg
- Case, Zero emission
- Friksjonsmotstand
- ESD-er
- Kystruten
- Modelltest-teknikker
- Rollen og viktigheten av modellforsøk
- SOBC-1