A holistic ship model for variable speed generation system on a RoRo vessel

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VICUS Desarrollos Tecnologicos S.L.

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Content

- Background
- Objectives
- Engine model
- Holistic ship model
- conclusion

Background

- EU FP7 project
- TEFLES—Technologies and Scenarios for Low Emissions Shipping
- 3 Technologies & strategies in 3 scenarios

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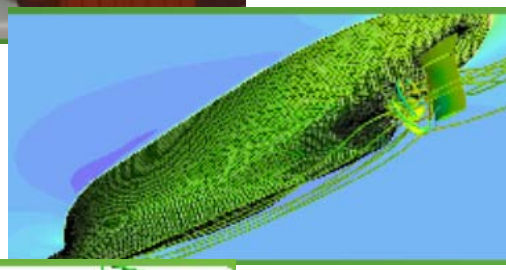
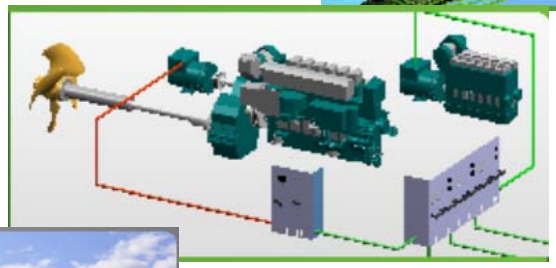
Background

- 3 technologies and strategies
  - After treatment and thermal energy
  - Propulsion & manoeuvring
  - Power generation & propulsion
- 3 scenarios
  - At sea
  - Port approach & manoeuvring
  - At port





Objectives

- Assessment of different technologies on board in terms of emissions and fuel consumption reduction for any desired operating profile during any life time period (for RoRos and Ferries)
- Giving ship owners and ship yards a tool for economic analysis in through the whole vessel life

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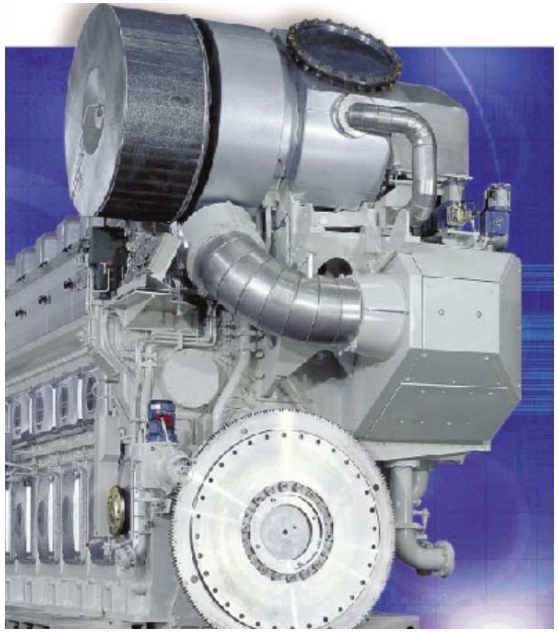
Main engine

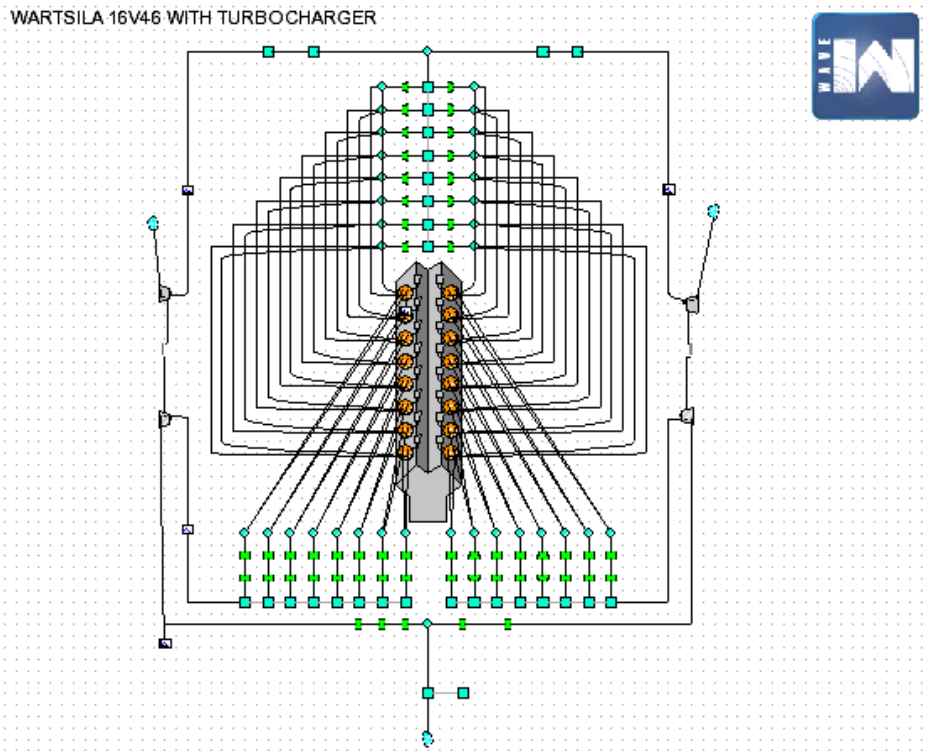
- Wärtsilä 16V46 Engine

Cylinder number	16
Cylinder configuration	V-form
Cylinder bore	460 mm
Stroke	580 mm
Piston displacement	96.1 l/cyl
Number of valve	2 in, 2 exh
Rated speed	500, 514 rpm
Direction of rotation	Clockwise

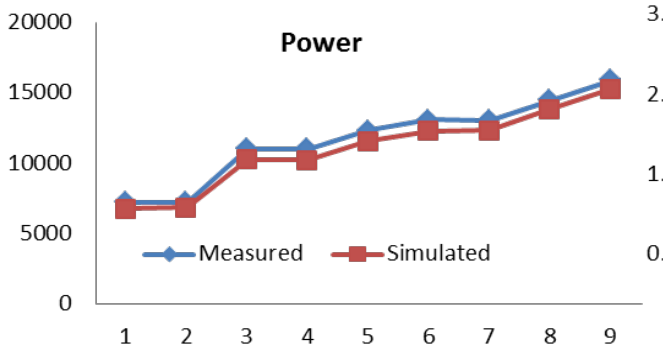


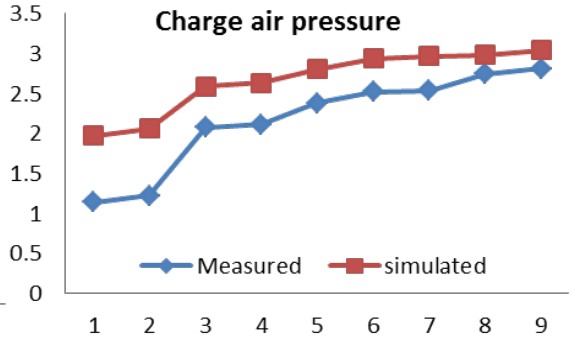
Engine modelling

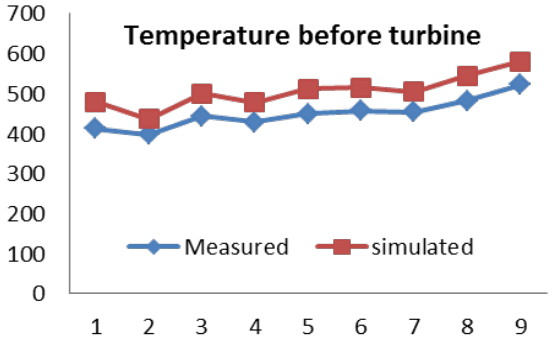
- Based on WAVE®
- Detail engine data from manufacturer
- Integrated with T/C data
- Detailed HFO fuel properties

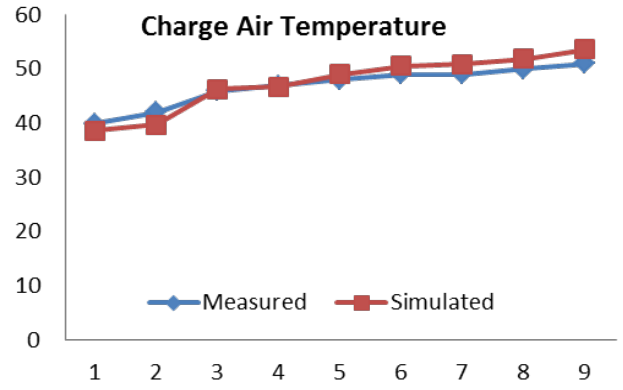


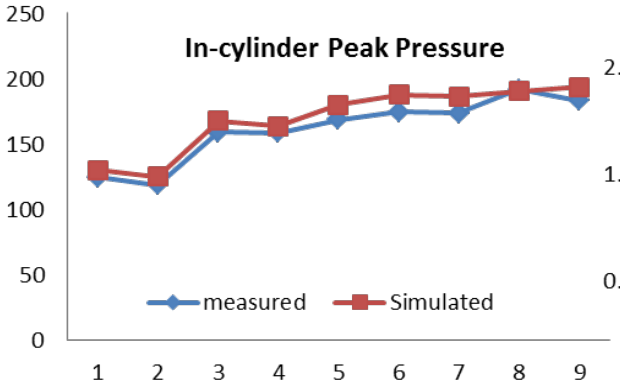
Engine model validation

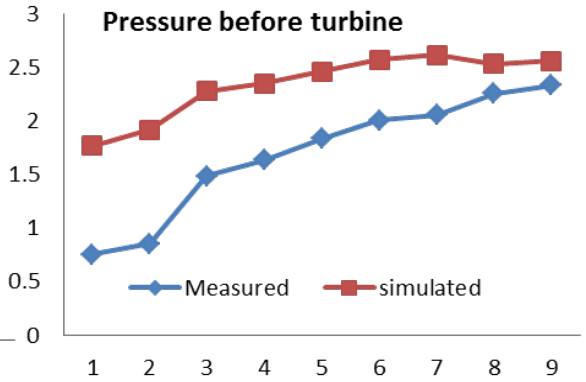












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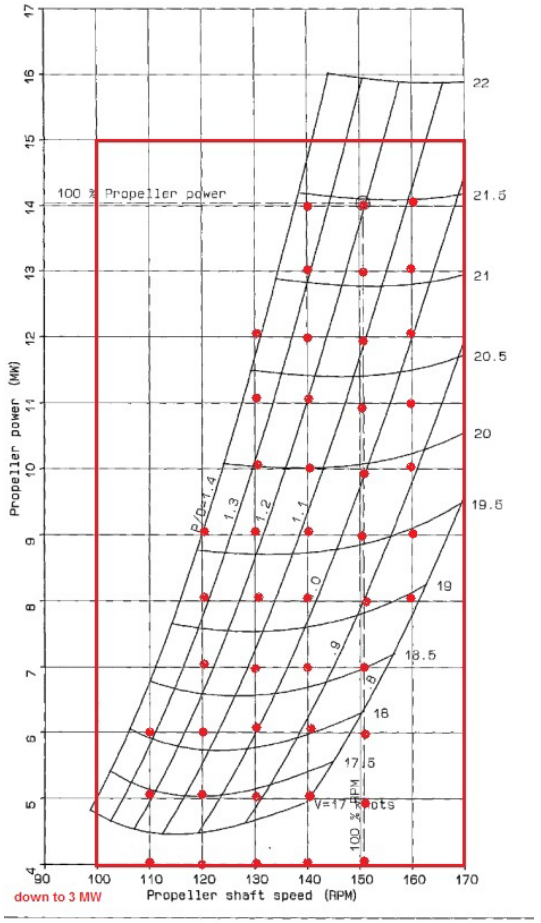
Engine modelling map

- Engine simulation map determined by ship propeller power map
- Nearly 50 points simulated
- Simulation provide maps to ship model for further investigation



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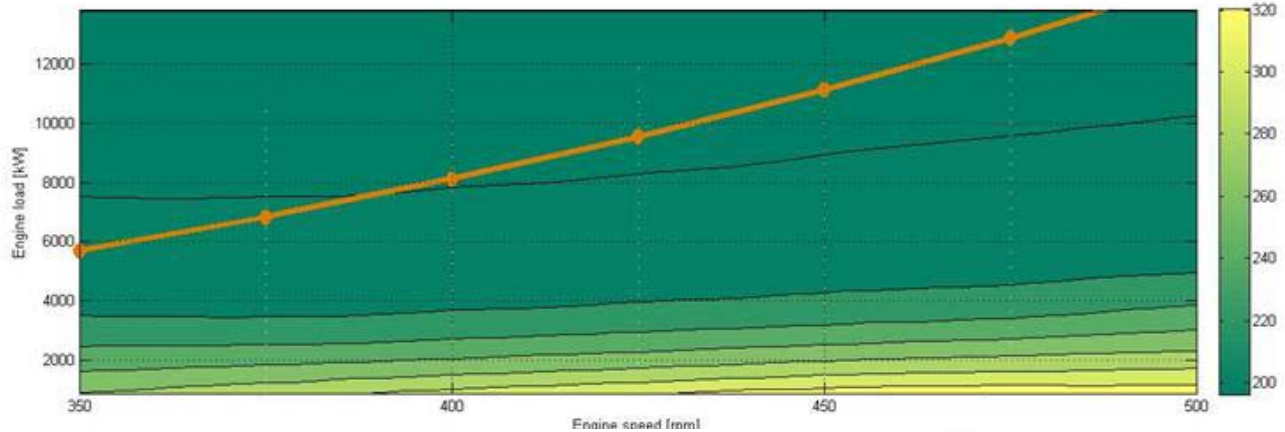
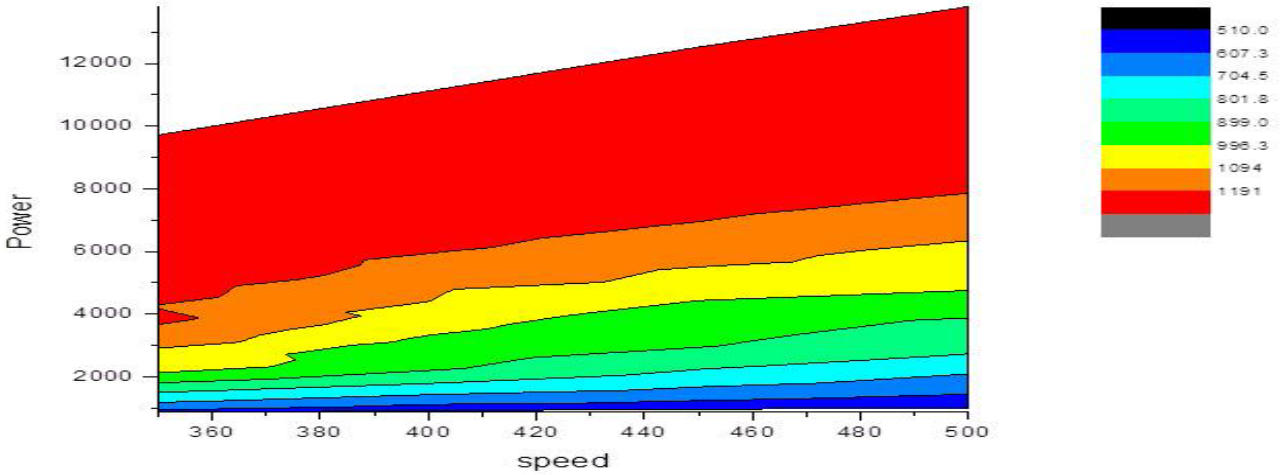
Engine model simulation results

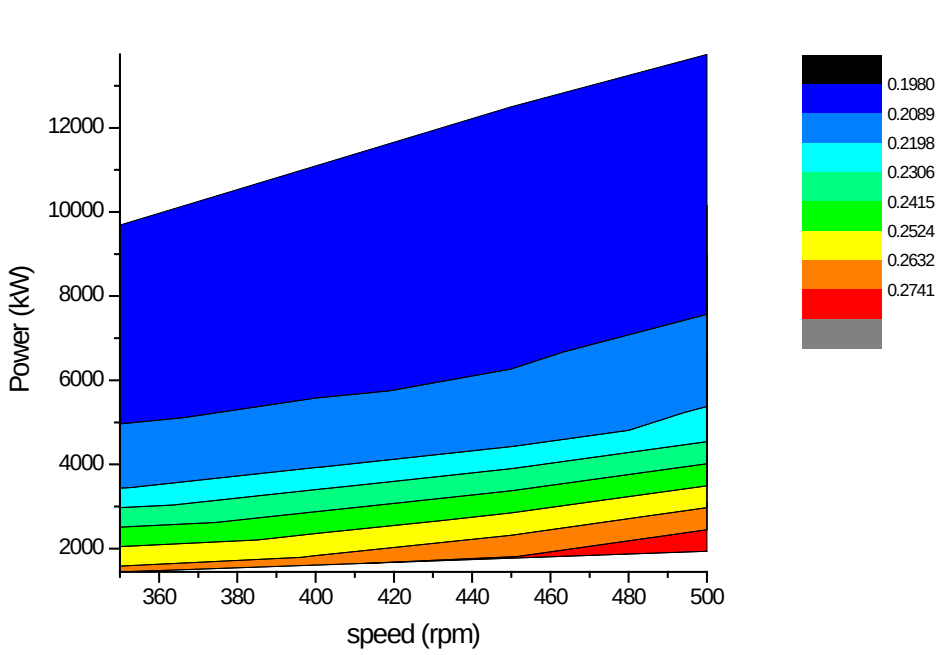


Fuel consumption

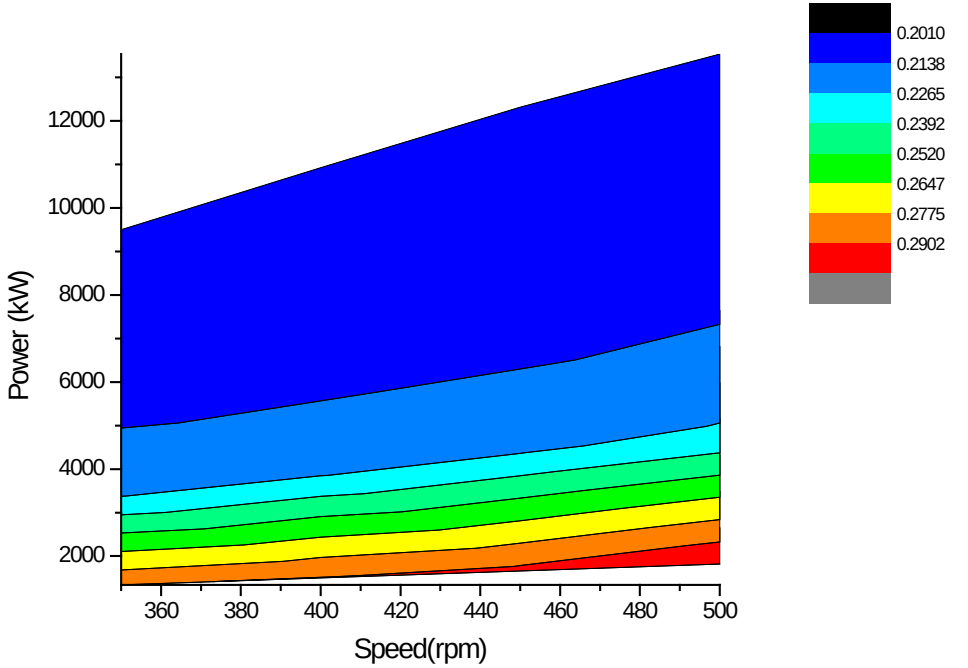


NOx emissions

Sensitivity test of back pressure



0.1 bar back pressure increase



0.2 bar back pressure increase

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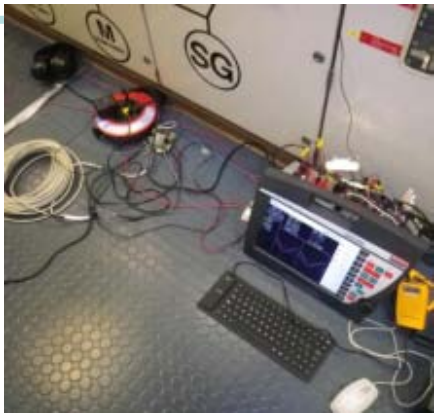
Holistic ship model

- Ship hydrodynamics
- Ship propulsion
- Exhaust energy recovery
- Main Engine emissions
- Auxiliary engines emissions
- Electric network behaviour

Process for the Ship Model

- Sea trials
  - Monitoring of:
    - Propulsion performance
      - Torque in shaft line
      - Shaft rpm
      - Main Engine Fuel consumption
      - Engine Combustion chambers Pressures
    - Ship speed
    - Electric network monitoring
      - Shaft generator
      - Auxiliary gensets
      - Main consumers



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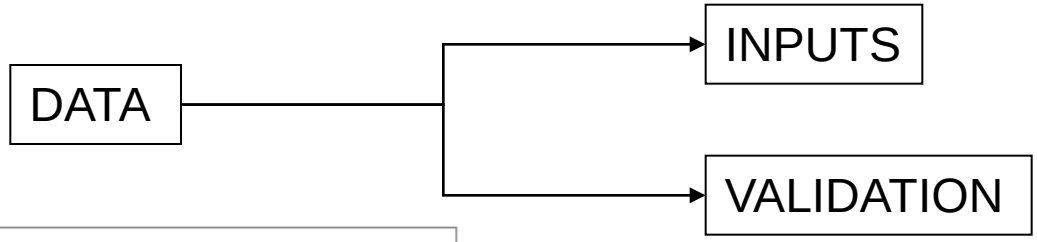
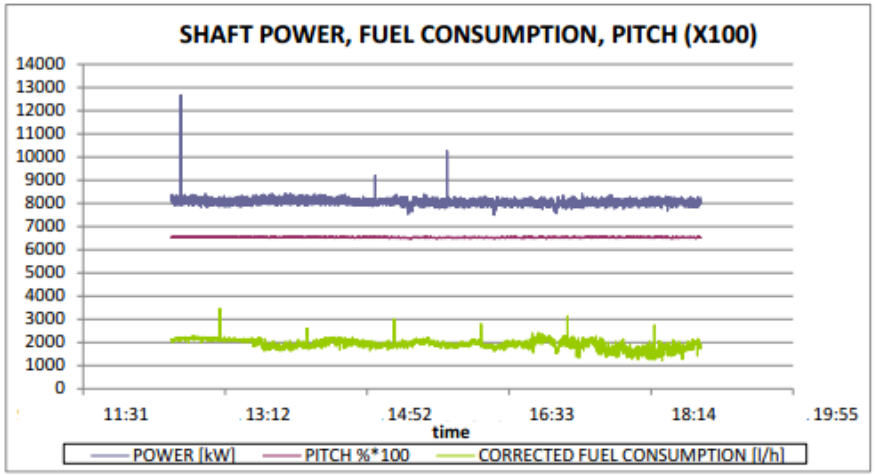
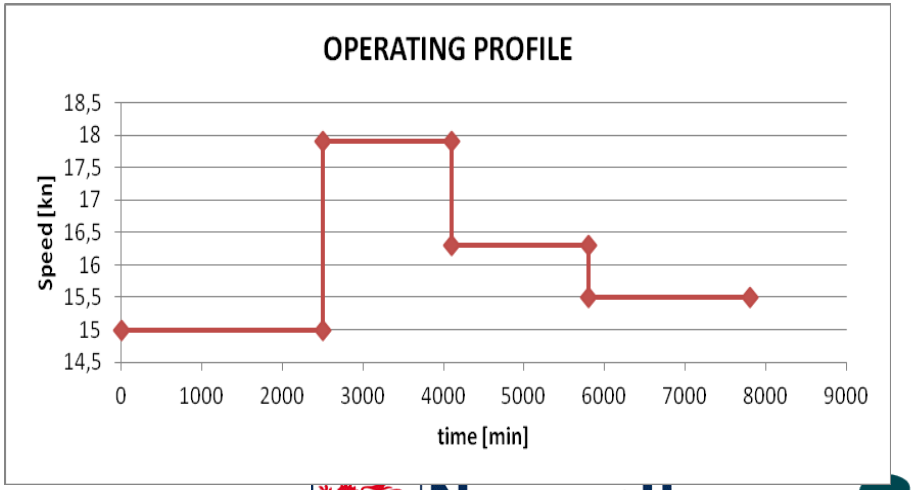
Process for the Ship Model

- Data post processing







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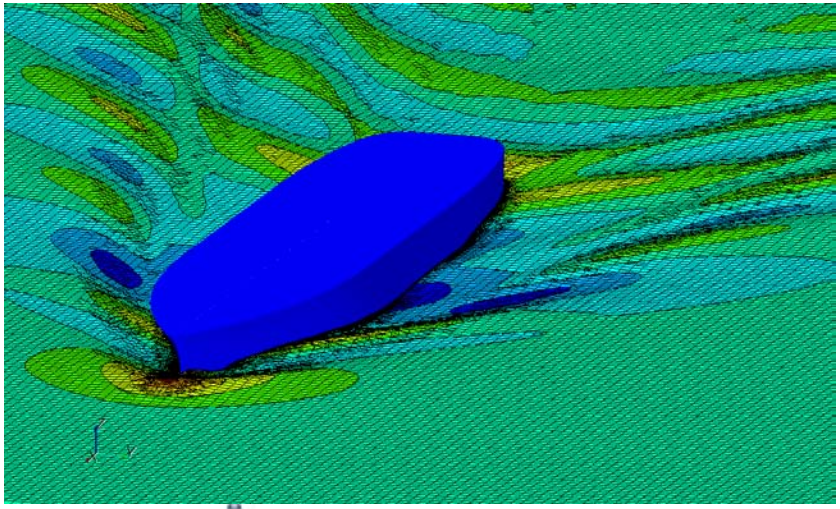
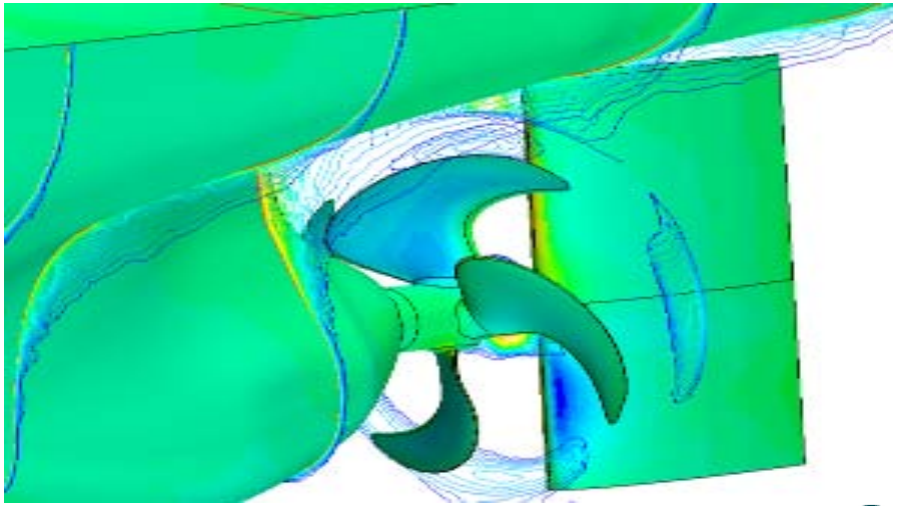
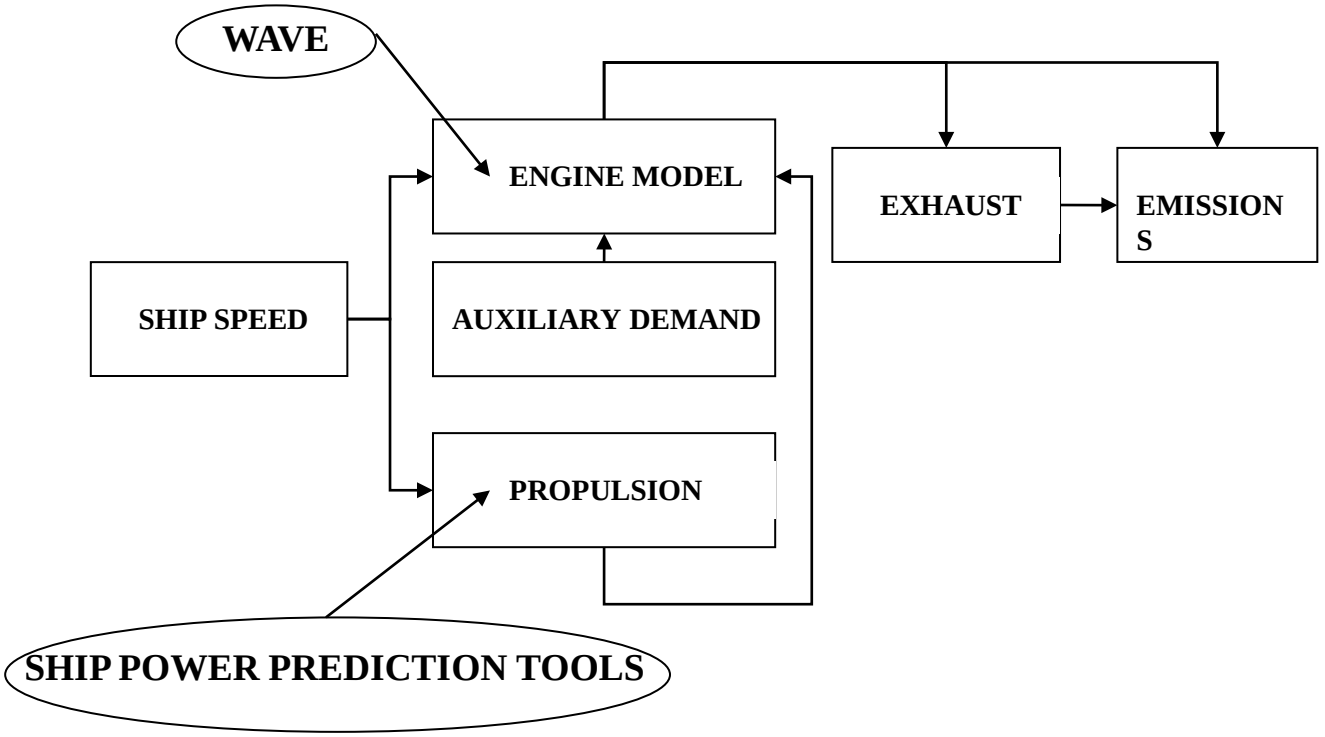
Process for the Ship Model

- Previous calculations for model inputs
  - Results from CFDs for Hydrodynamics, Propulsion and Exhaust devices modelling
  - Validated/aligned with sea trials





Ship Model Diagram



HYDROCOMP Inc. Leaders in performance prediction software

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CD-adapco

MathWorks

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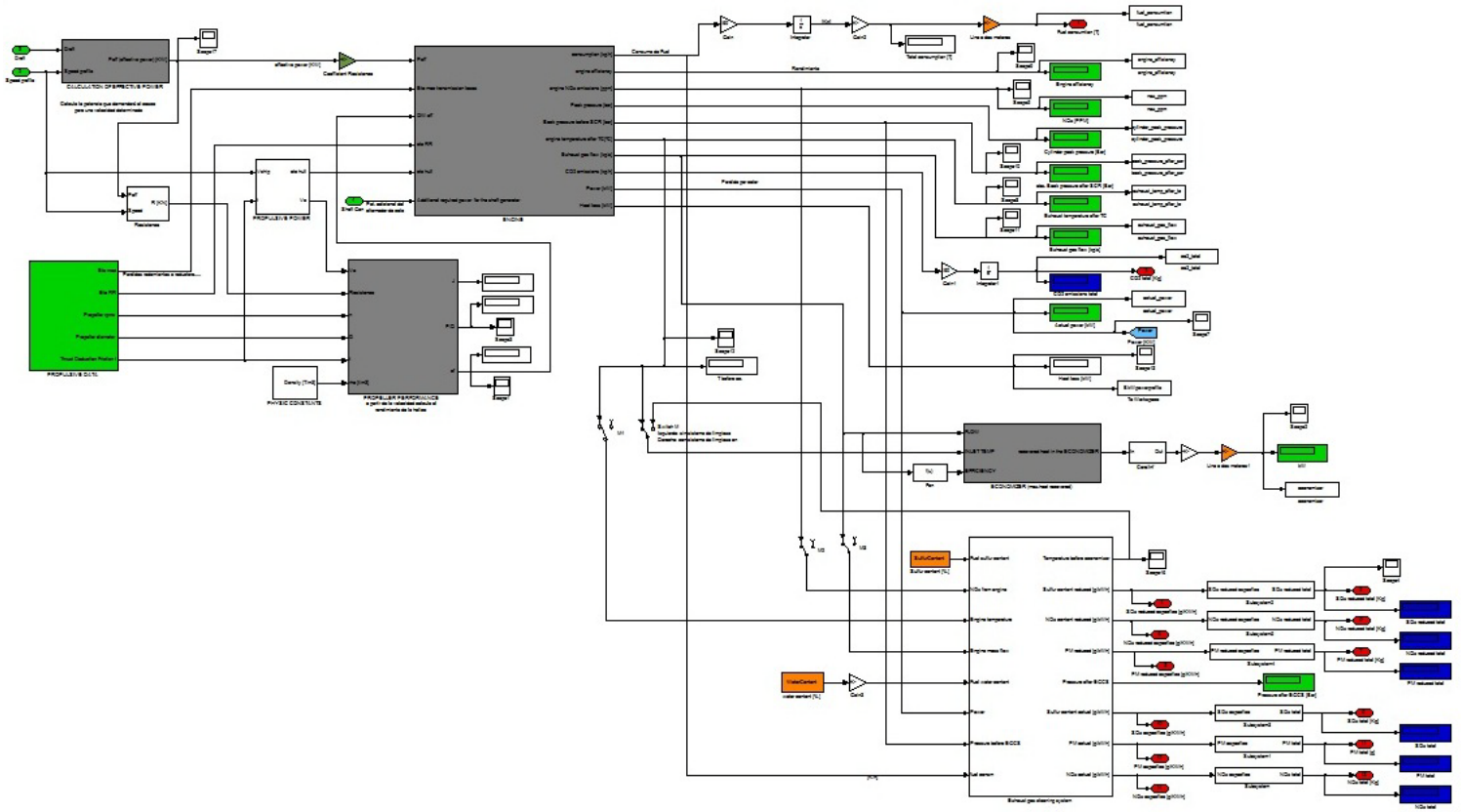
Ship Model

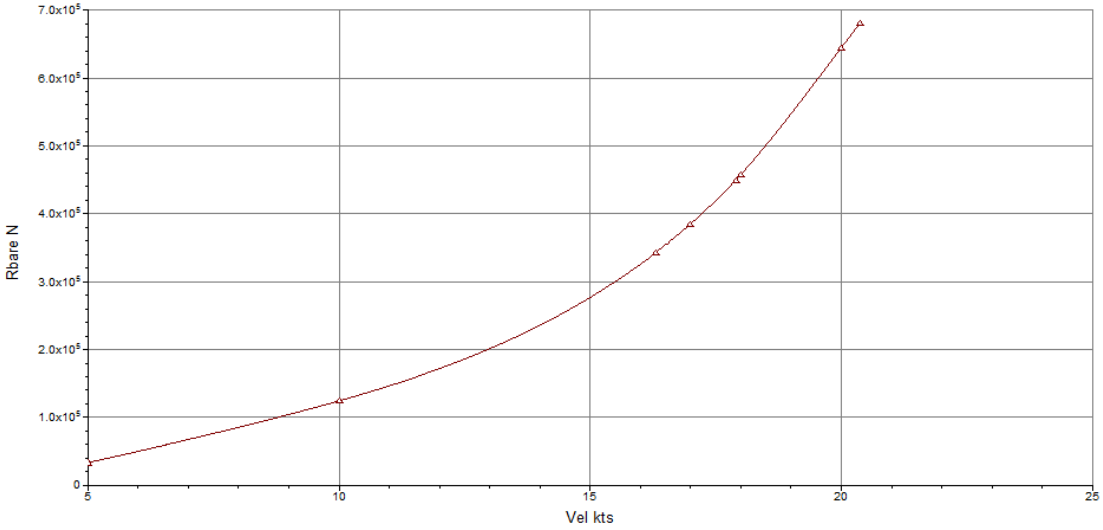


Inputs

- Operating profile
  - propulsion condition
  - auxiliary load
  - route
- Weather conditions

Modules

- Hydrodynamics
  - Resistance calculations
  - Added resistance calculations



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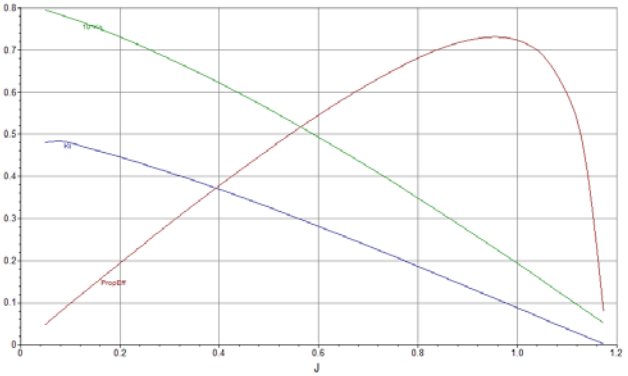
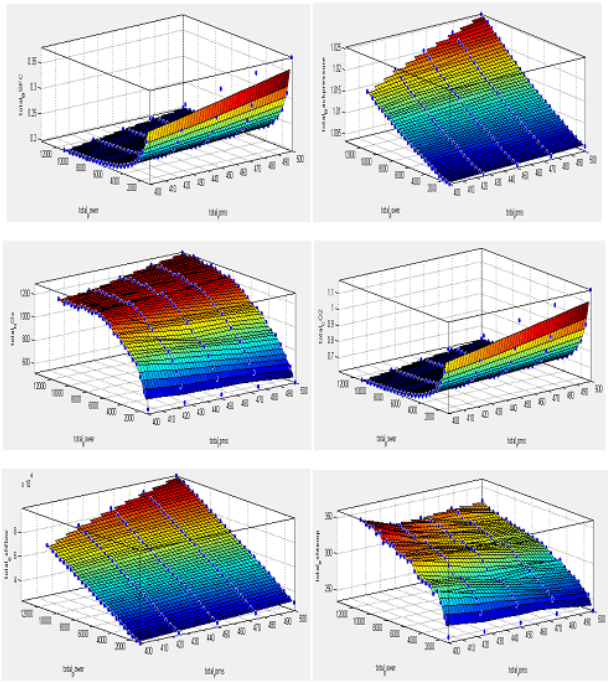
Modules

- Propulsion
  - Propeller efficiency calculation for any condition

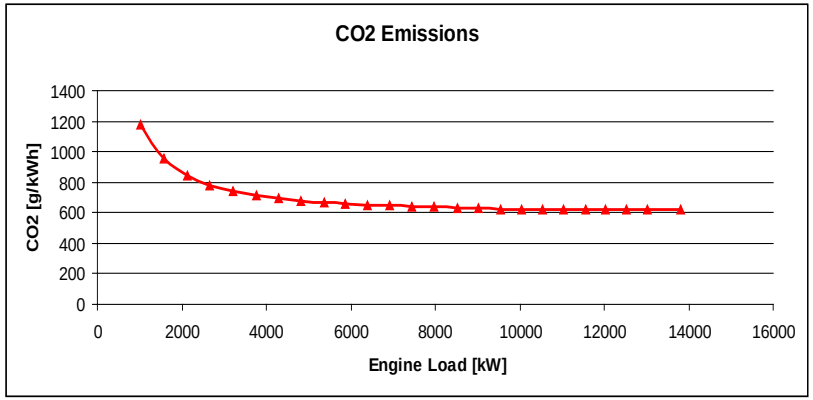


- Main engine module
  - Based on WAVE model, engine maps for efficiency assessment at every instant



Modules

- Main engine Emissions
- Auxiliary engines Emissions and fuel consumption



- Exhaust recoverable energy
  - $\Delta h = \dot{m} c_p \Delta T$
- After treatment module. Dry EGCS emissions reduction simulations

Conclusions

- Two models were developed to investigate the potential of fuel consumption and emissions reduction under the project scheme
- These two models have good accuracy when validated with test data therefore can deliver reliable results

Conclusions (cont.)

- The ship model is capable of simulating different technologies on board
  - Hydrodynamics (hull optimisation)
  - Propulsion (improved propeller efficiency, combinator mode, Full electric, etc.)
  - Electric network (freq. Converters for pumps, fans, etc., variable speed generation SHYMGEN®)

Thank you for your attention

Questions?

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