



SMART
MARITIME



GYMIR SIMULATION FRAMEWORK

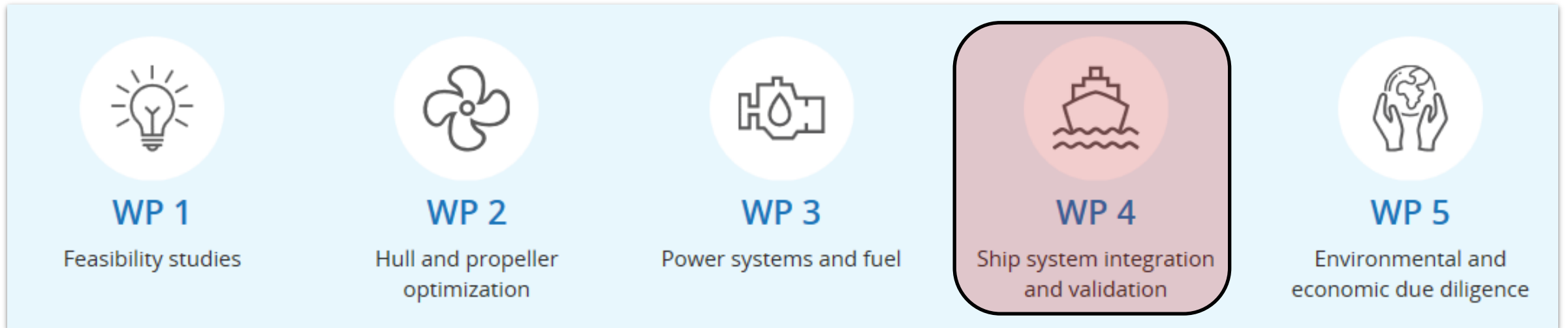
Jon S. Dæhlen, SINTEF Ocean

June 20, 2023 - Trondheim

sf = Centre for
Research-based
Innovation

The Research Council of Norway

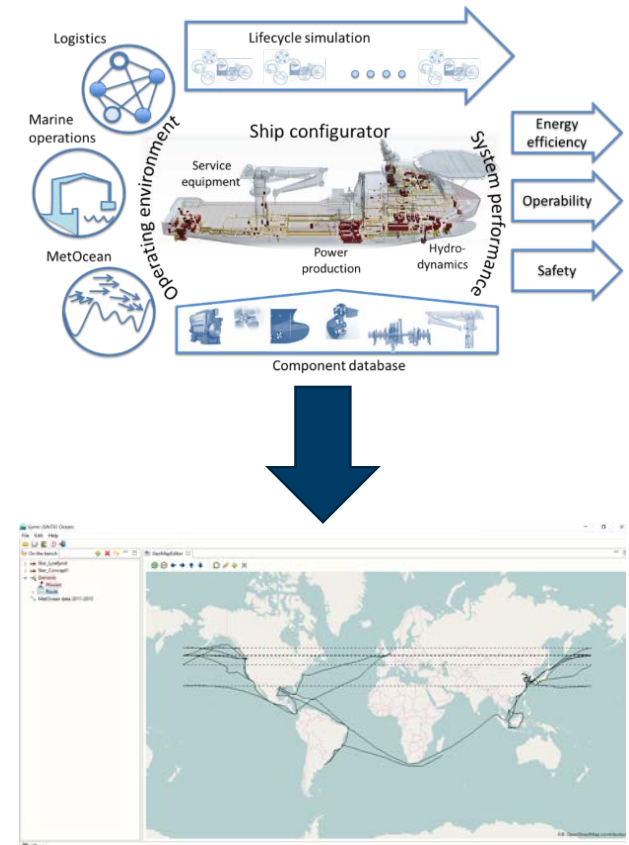
GYMIR Simulation Framework



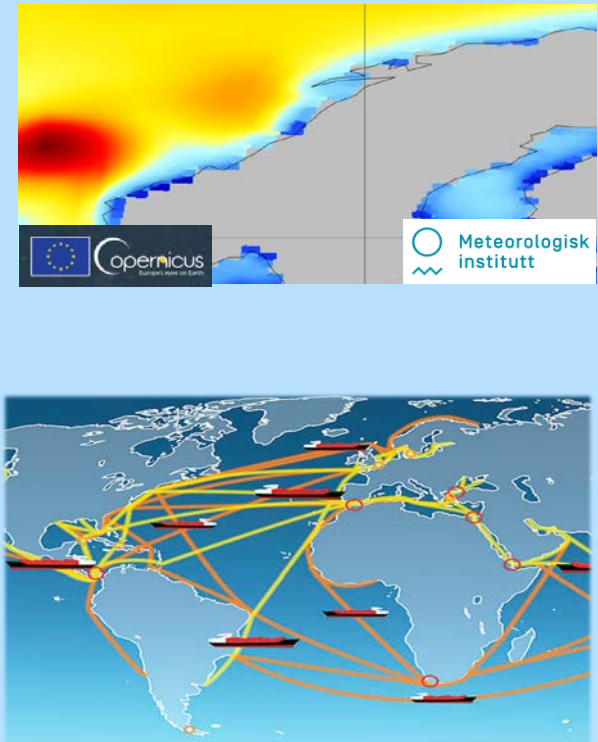
GYMIR Simulation Framework

From Smart Maritime Network meeting **October 2016**:

- “GYMIR is an application for early-stage design assessment, simulating the long-term performance of a ship in realistic operational profiles”
- “Models of different ship sub-systems can be integrated (i.e. Hull and Propulsion models from WP2 and Power System models from WP3)”

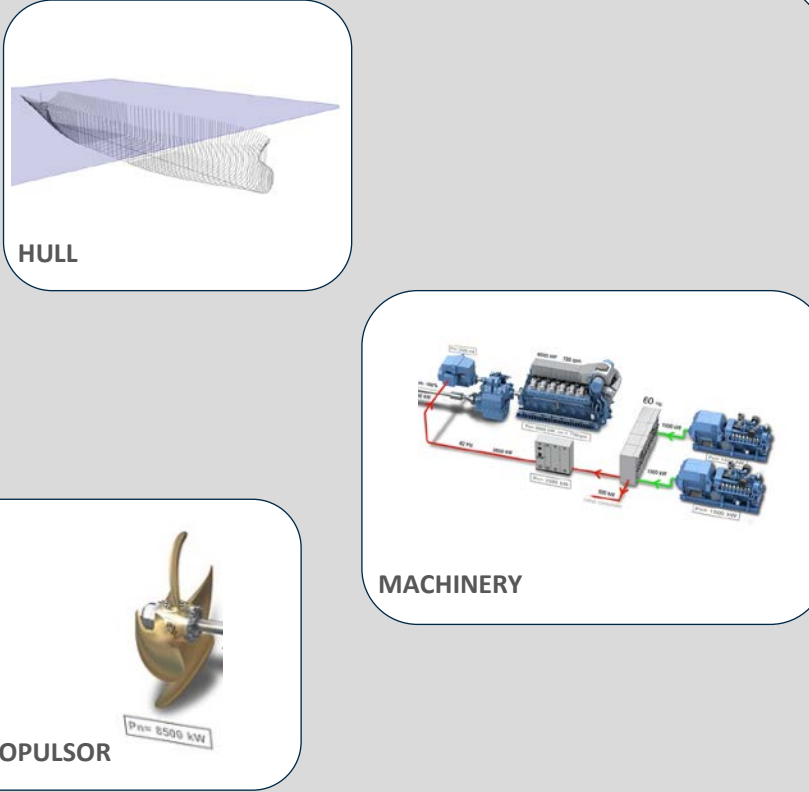


GYMIR Simulation Framework



The 'Realistic Operational Scenario' block contains two images. The top image is a heatmap of a coastal region, likely the North Sea, with a color gradient from blue (low) to red (high). It includes logos for 'opernicus' and 'Meteorologisk institutt'. The bottom image is a map of the world showing shipping routes with colored lines and ship icons.

REALISTIC OPERATIONAL SCENARIO



The 'Ship System Model' block contains three sub-images: a 3D wireframe model of a ship's hull labeled 'HULL'; a schematic diagram of a powertrain system with various components and power flow arrows labeled 'MACHINERY'; and a 3D model of a propeller labeled 'PROPULSOR' with a tag indicating 'P_{max} = 8500 kW'.

HULL

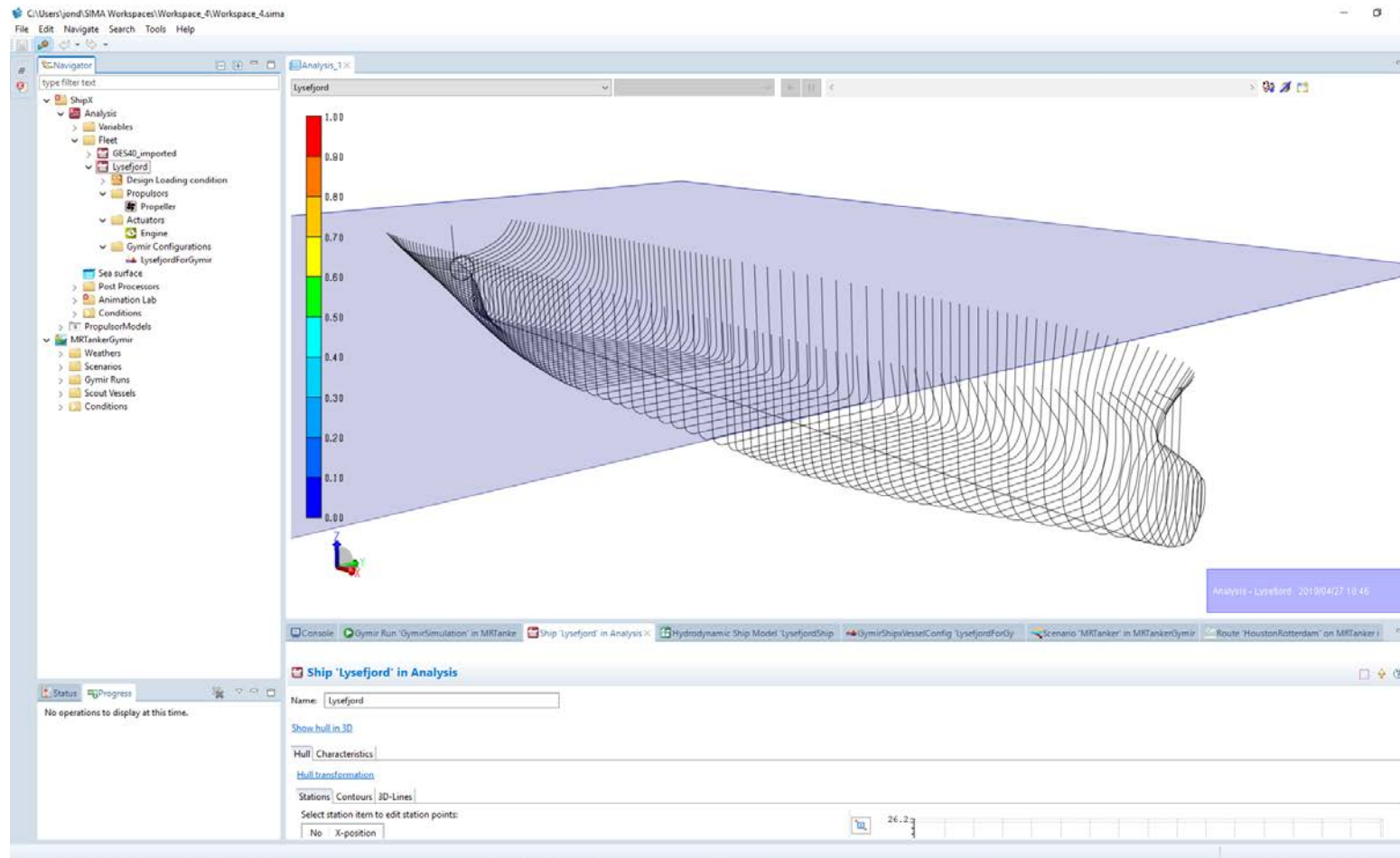
MACHINERY

PROPULSOR

SHIP SYSTEM MODEL



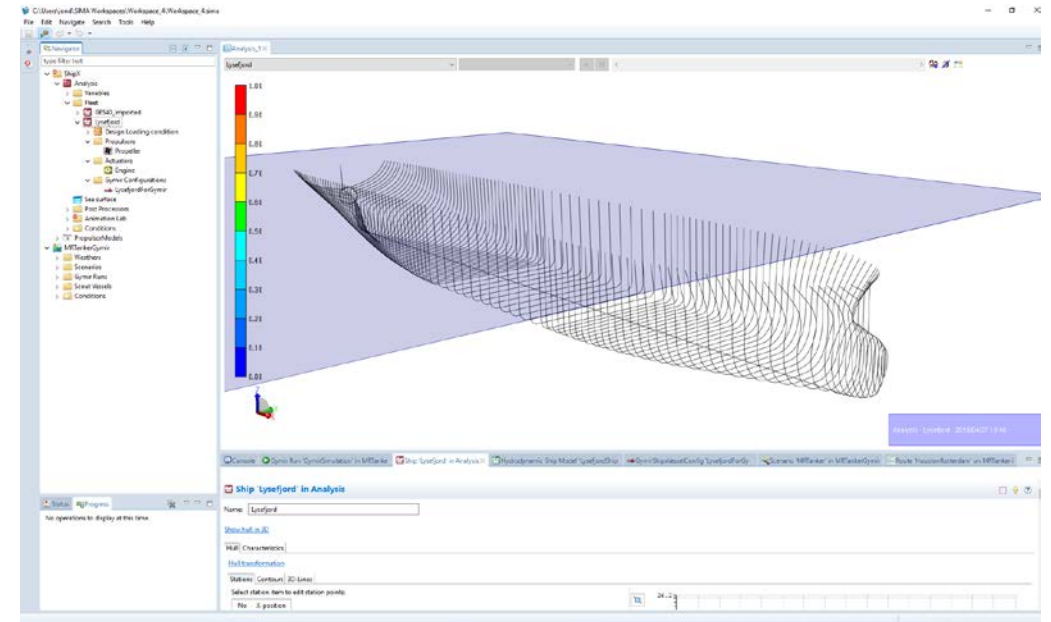
GYMIR SIMULATION FRAMEWORK: SHIP MODELS



GYMIR SIMULATION FRAMEWORK: SHIP MODELS

Ship model is developed in the ShipX workbench using 3D-model of the hull as input.

- Considers calm water resistance and added resistance from wind and waves
- Parametrized propulsion model to account for hull interaction losses



GYMIR SIMULATION FRAMEWORK: POWER PLANT

☰ SINTEF Marine Machinery Configurator

Simulation Control

↑ ▶

Fuel consumption [kg]	Hydrogen consumption [kg]	Electric energy consumption [kg]	Energy stored total [M.J]	CO2 emissions [kg]	NOx emissions [kg]	Running hours - Gensets [hr]	Running hours - Fuel Cell [hr]	Action
0	0	0	0	0	0	0	0	🗑️ 📄 📁

Gymir Simulation Input

↑

System Configuration

📁 ↑

Name
Machinery system for Zero-coaster

Propulsion Type
ELECTRIC

Load limit
0 %

Fuel Storage +

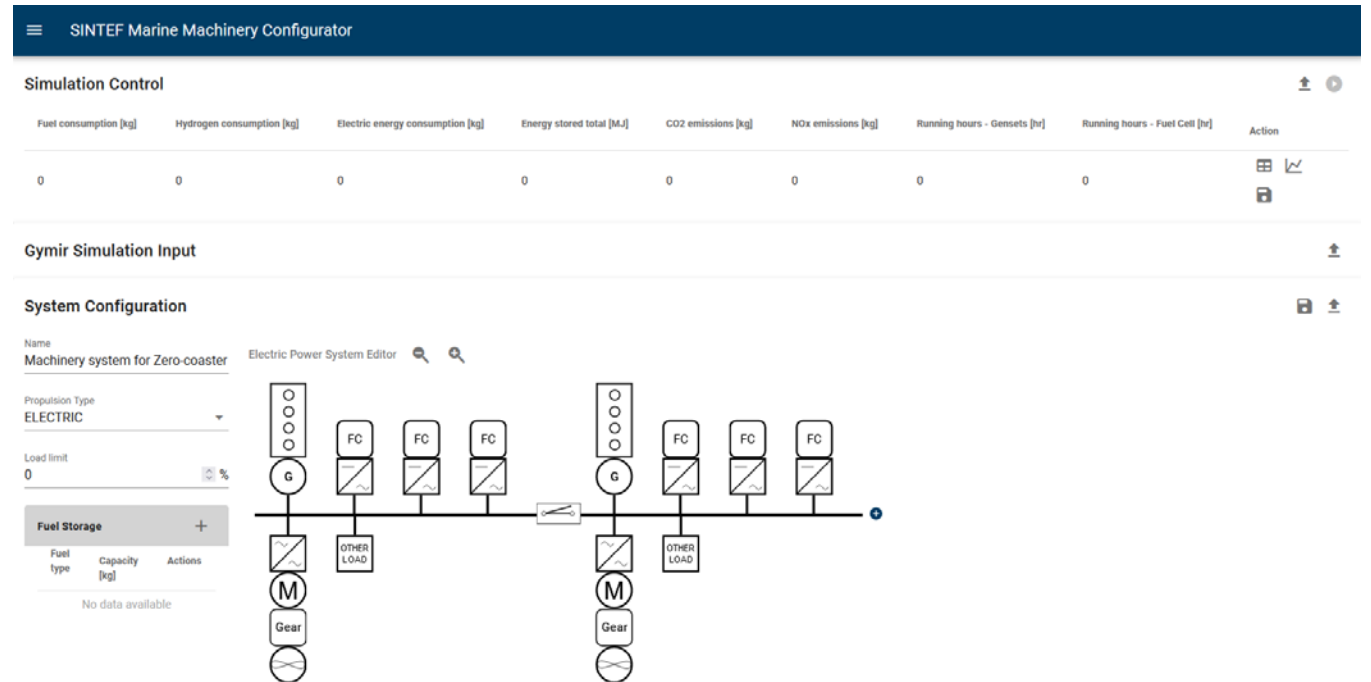
Fuel type	Capacity [kg]	Actions
No data available		

Electric Power System Editor 🔍 +

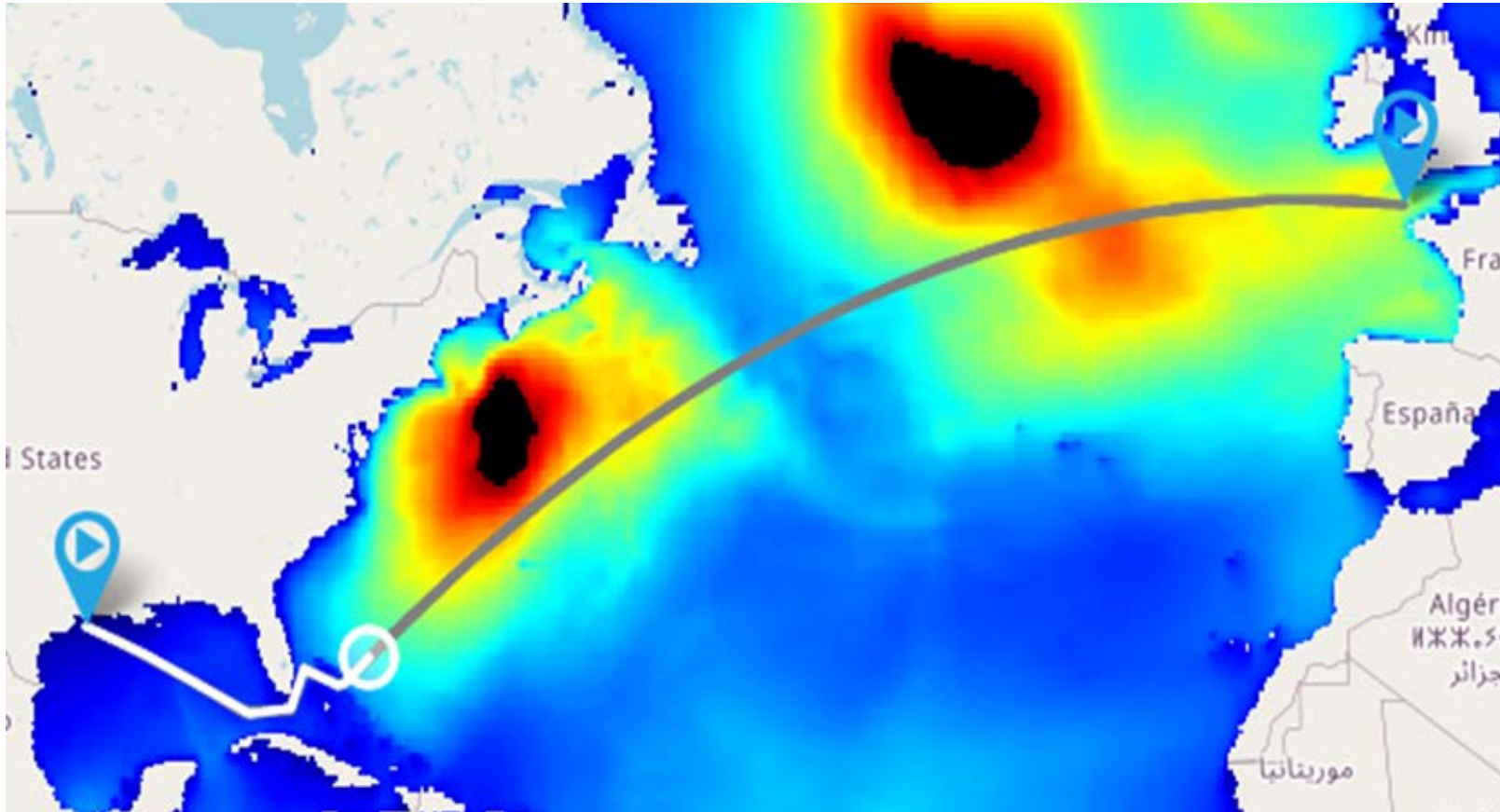
GYMIR SIMULATION FRAMEWORK: POWER PLANT

Graphical configuration tool for power plant simulation.

- Mechanical, hybrid or electric
- Required propulsion power from GYMIR is calculated into fuel consumption and emissions



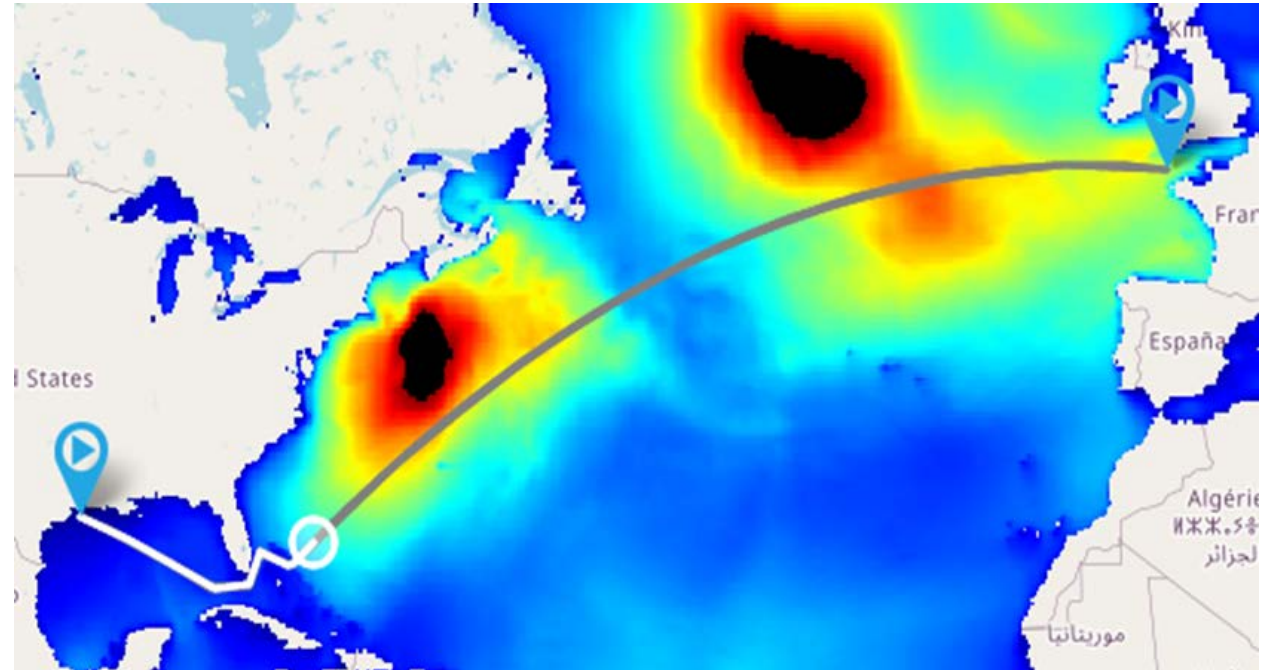
GYMIR SIMULATION FRAMEWORK: WEATHER



GYMIR SIMULATION FRAMEWORK: WEATHER

The ship operation is evaluated in historical/hindcast metocean data

- Data retrieved from metrological organizations, e.g. met.no, ECMWF, Copernicus etc.
- Wind, waves and sea current



GYMIR SIMULATION FRAMEWORK: SCENARIO



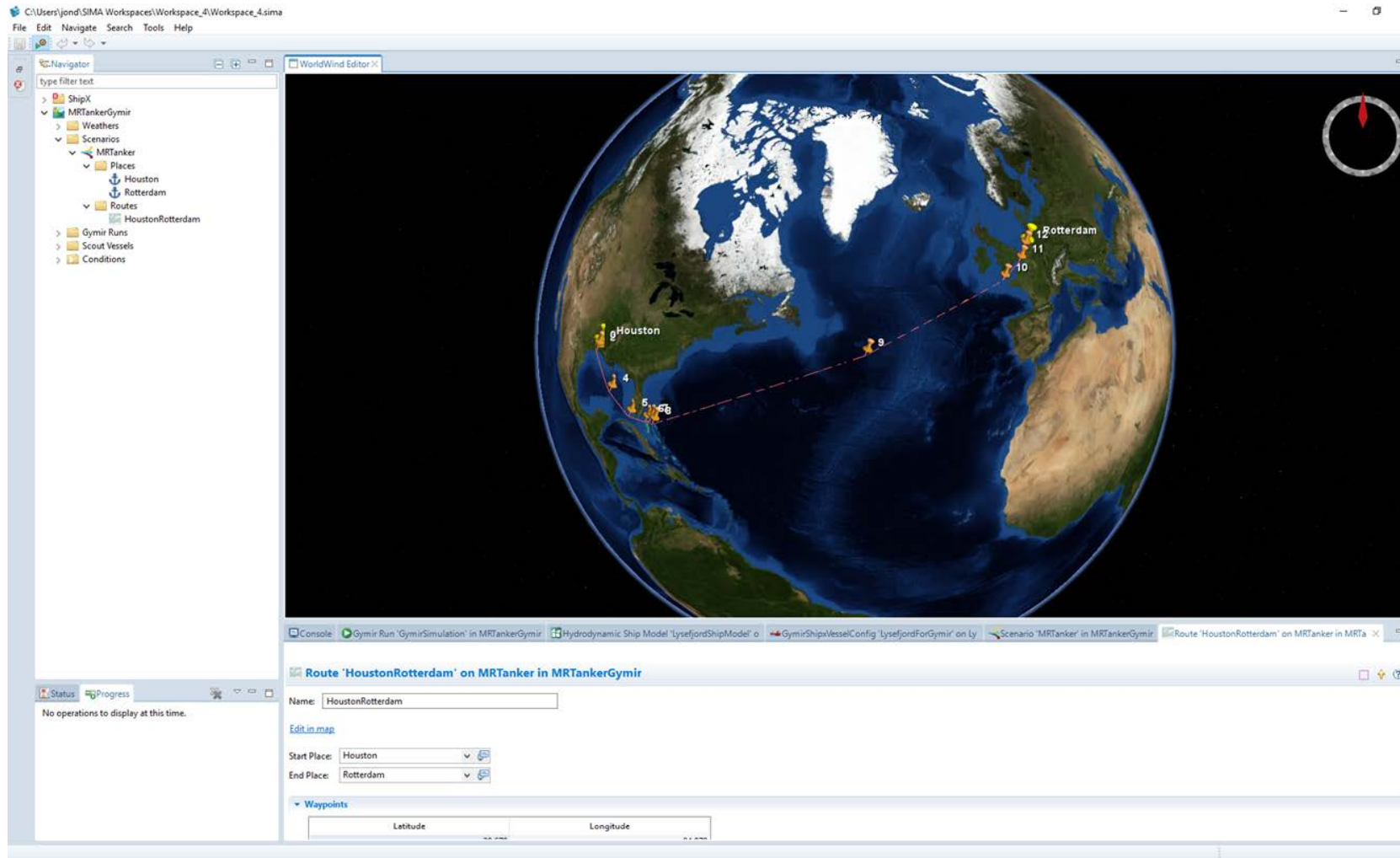
GYMIR SIMULATION FRAMEWORK: SCENARIO

Graphical scenario editor to set up route, speed and events

- Sailing, station keeping (DP) and harbour visits
- Different speed policies for voluntary and involuntary speed loss



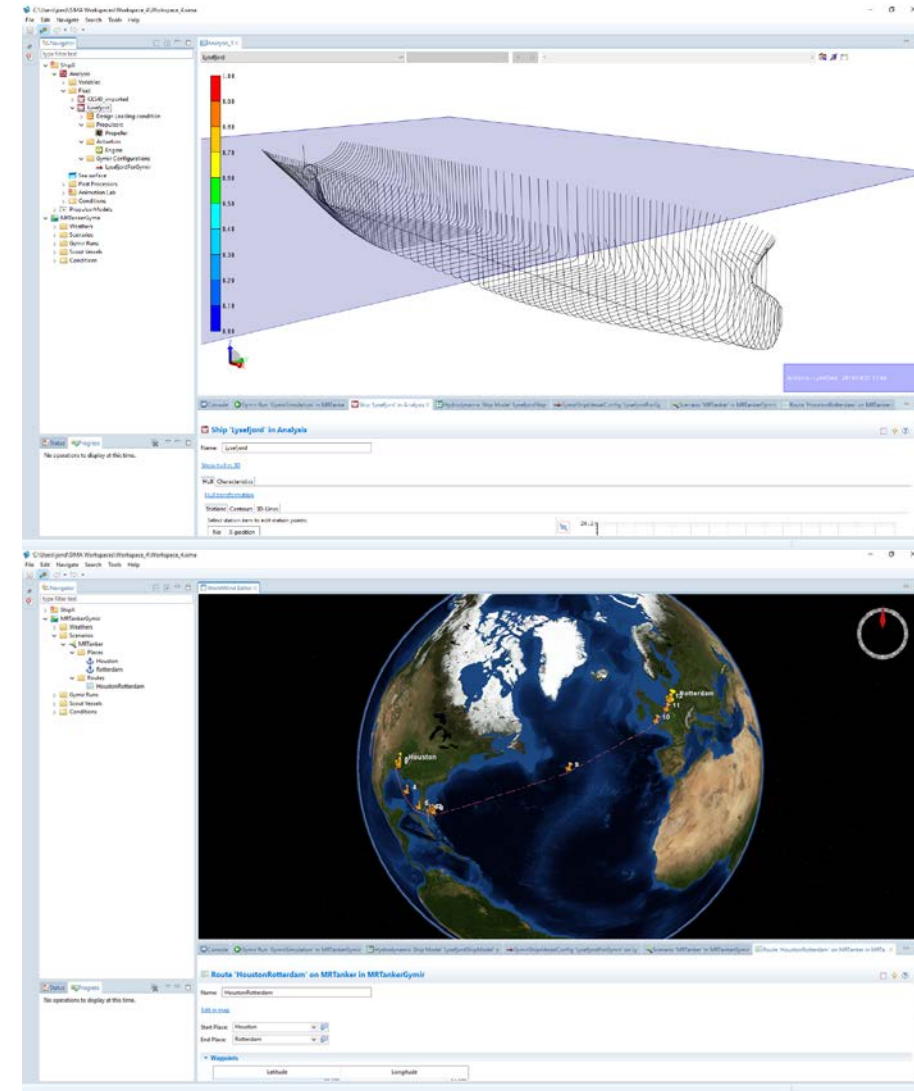
GYMIR in SHIPX Workbench



GYMIR in SHIPX Workbench

GYMIR simulations available alongside other ship design tools

- Common ship model for dynamic (VeSim) and GYmir simulations
- Easy to integrate GYmir into design work flow



Use Cases



WP 1

Feasibility studies



WP 2

Hull and propeller
optimization



WP 3

Power systems and fuel



WP 4

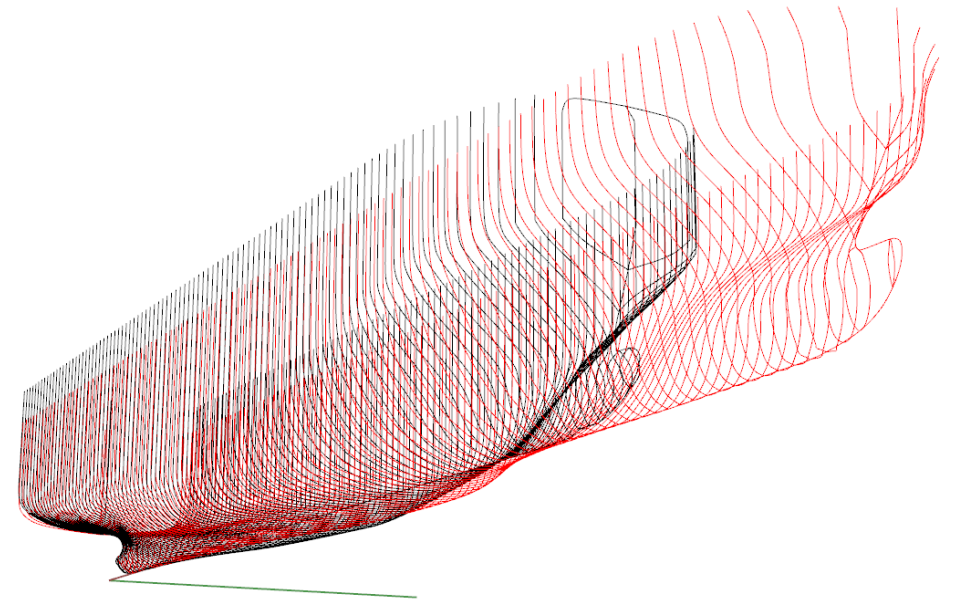
Ship system integration
and validation



WP 5

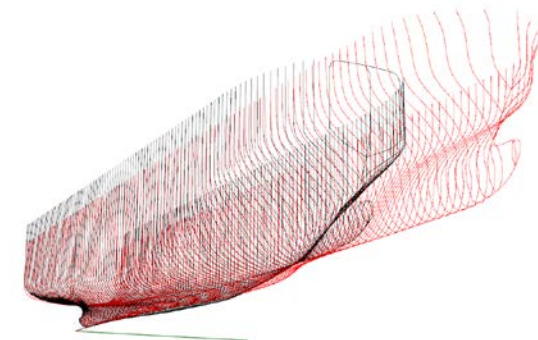
Environmental and
economic due diligence

Use Case: RoRo vessel

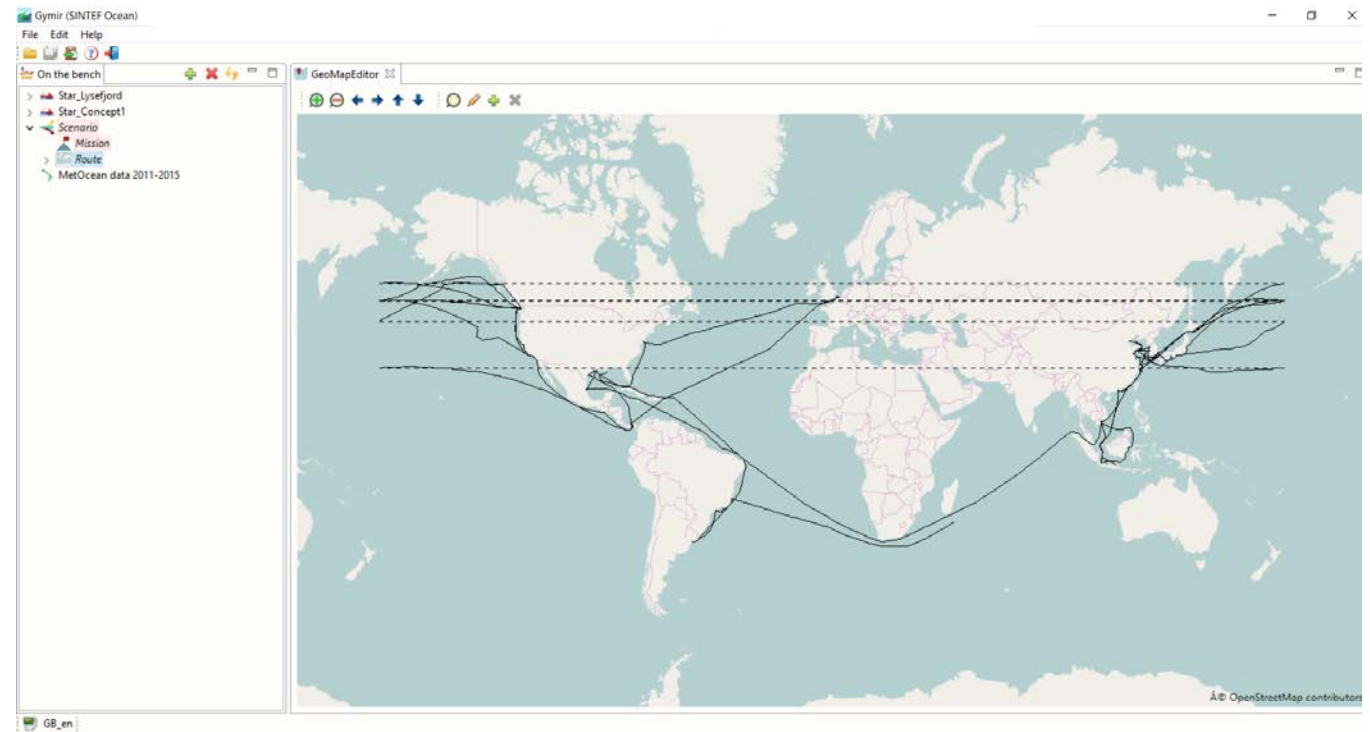
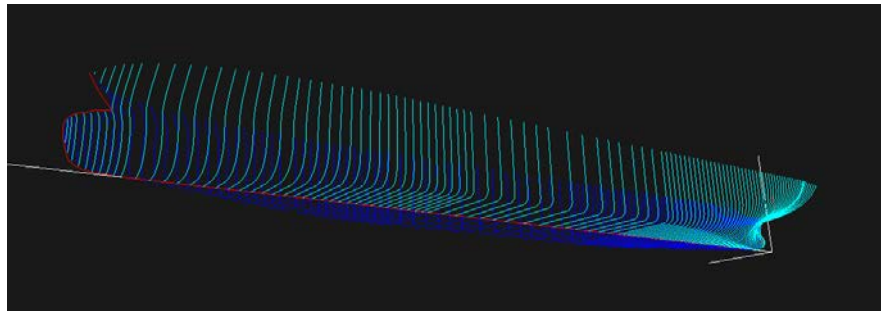


Use Case: RoRo vessel

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%)	

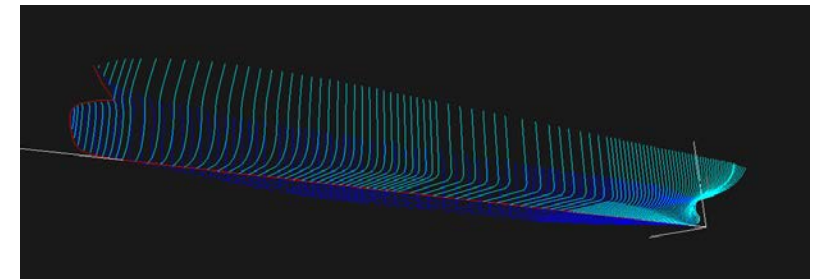


Use Case: Cargo vessel



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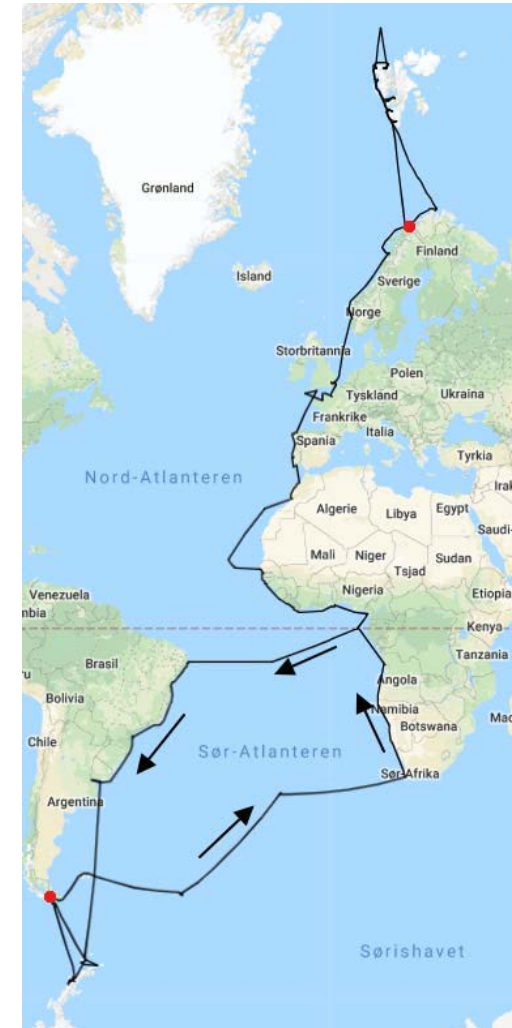
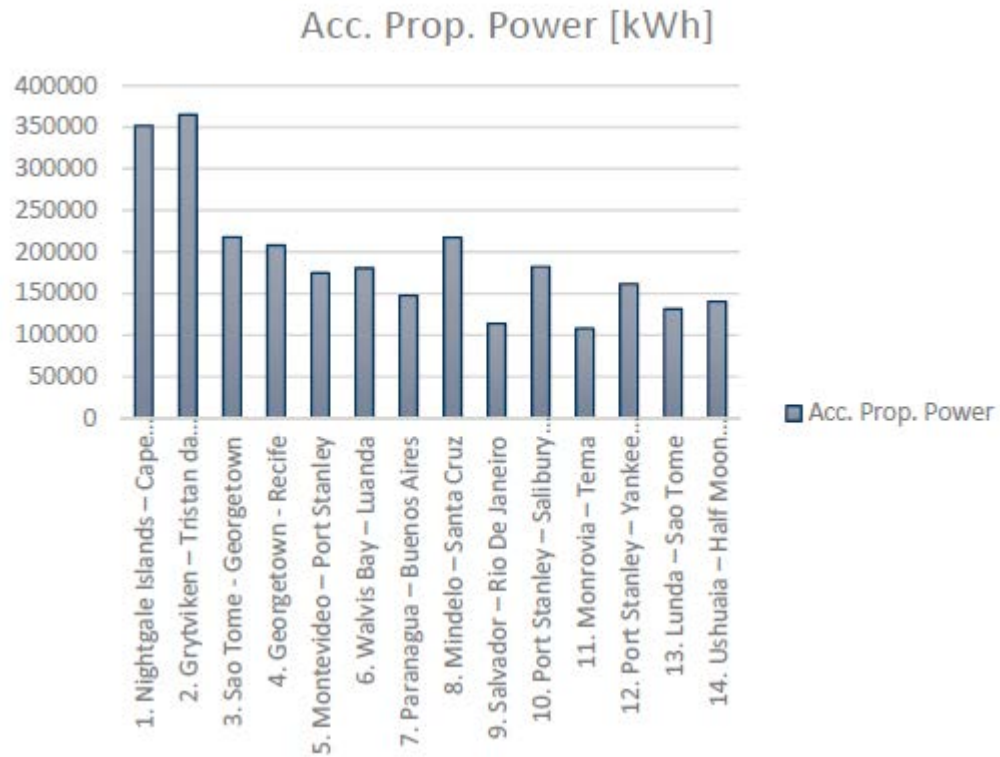
Parameter	Star Lysefjord	Star Concept 1	
Fuel consumption (sailing)	35,3 t/day	40,5 t/day	+ 15 %
Distance	418knm (15,9 kn)	417 knm (15,8 kn)	- 0 %
DWT	48.000 t	60.000 t	+ 25 %
"Sea Margin" (resistance increase)	14 % (Waves 12%, Wind 2%)	12 % (Waves 10%, Wind 2%)	
Transport cost	0,77 \$/ktonmile	0,71 \$/ktonmile	- 8 %



Use Case: Zero-emission cruise



Use Case: Zero-emission cruise



Use Case: Havila Kystruten



Looking back..

GYMIR has proven to be a promising tool both in research and applied in industry, however:

- We have not been able to lift GYMIR to a production level required for commercialization. It's still suffering from prototype issues and is not sufficiently user friendly.
- Some methods developed by PhD-students in the center could have been “fast-tracked” to the industry through GYMIR and ShipX, however there has been a lack of focus on this.

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