Solutions for the design and operation of wind assisted vessels

Natural propulsion in ship design conference, New York, November 16 2021

About D-ICE

We are a team of 23 PhDs & Engineers aiming to solve real & complex industrial challenges for Maritime & Energy industries.

Main ambitions

- Develop & Produce Clean Energy
- Reduce Greenhouse emissions
- Improve Safety at Sea

Technical & Commercial Partnerships

Multiconsult · NUMECA INTERNATIONAL · DG Energy

Key figures

- Founded in 2015
- Offices in Nantes & Paris (France)
- Turnover about ~850k€ (2019)
- 15+ clients / 45+ projects
- 100% independent

Hydrodynamics. Robotics. Control Systems. Artificial Intelligence. Software Engineering. Ice Mechanics.

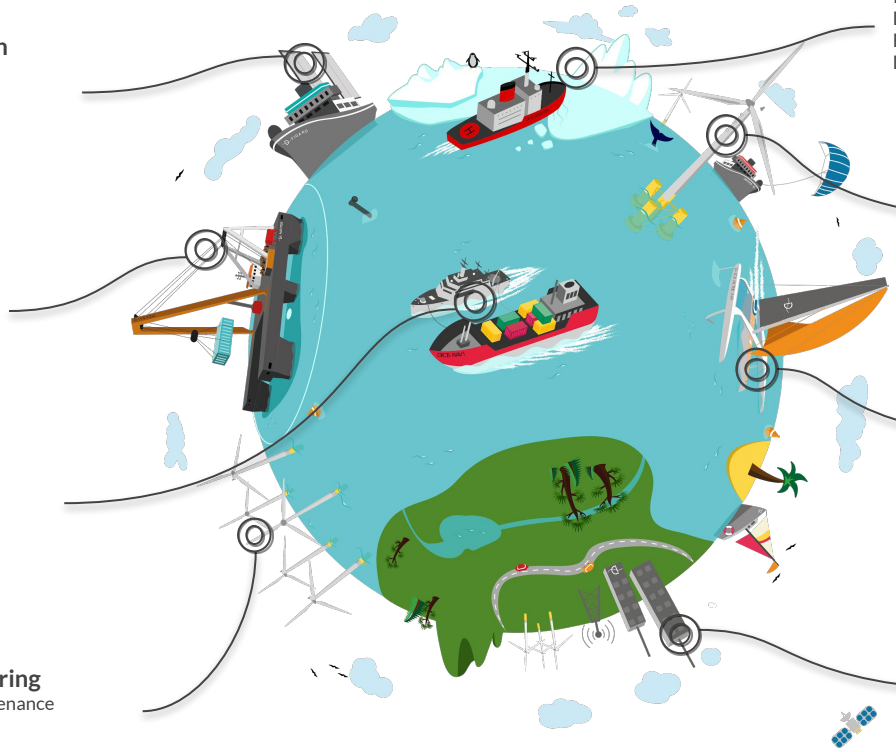
Our Expertise

Wind Assisted Propulsion Engineering & Services
Statistical weather routing
Modelling & Simulation
Control Systems

Dynamic Positioning Services & Engineering
Design, Specifications
Simulations
Commissioning
R&D

Offshore Engineering
Hydrodynamics studies (BEM, CFD)
Modelling & Simulations
Metocean Analysis
Operations Planning & Design

Offshore Wind Engineering
Transport, installation & Maintenance
Modelling & Simulations
Control Systems



Ice Engineering
Design, Modelling & Simulations
Basin Tests & Full Scale Tests
DP & Control Systems

Floating Offshore Wind Engineering
Transport, installation & Maintenance
Modelling & Simulations
Control Systems

Weather Routing Services
Route optimization & planning
Metocean analyzis
Remote support

R&D Engineering & Services
Modelling & Simulations
Applied Mathematics
Big Data
A.I
Computer Vision
Control Systems

Methodologies & Tools for Design

Methodologies & Tools for the Design of WASP

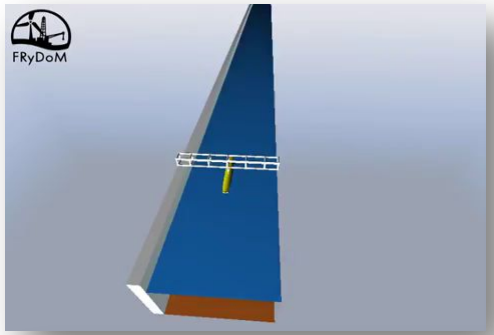
FRyDoM

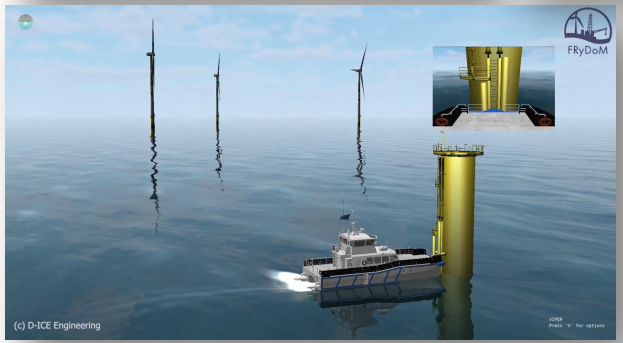
- Project initiated in 2016
- Strong ongoing developments
- Evolutions & Maintenance by D-ICE

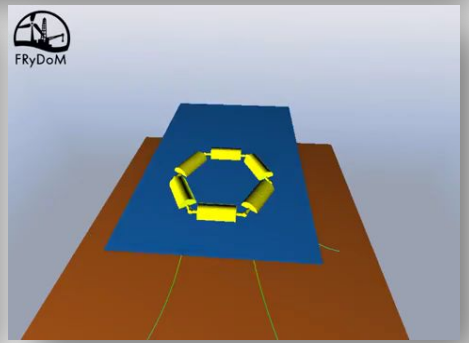
This work was carried out within the framework of the WEAMEC, West Atlantic Marine Energy Community, and with funding from the Pays de la Loire Region

FRyDoM

Physics-based modelling and simulation framework dedicated to complex marine platforms, structures, systems and operations.







Constrained Multibody Dynamics

Advanced Hydrodynamics

Advanced Control Systems

Propulsion & Actuators

Complex Mooring

Embeddable Framework

Python/CMake/C++14

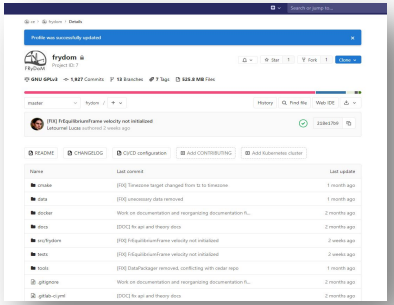
Industrial-Grade Software

Open Source Core & Enterprise Edition

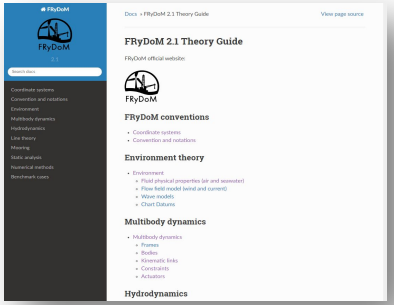
frydom.org
theory.frydom.org
register.frydom.org

FRyDoM

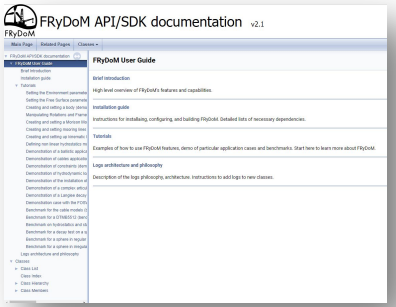
FRyDoM Community Edition (CE)



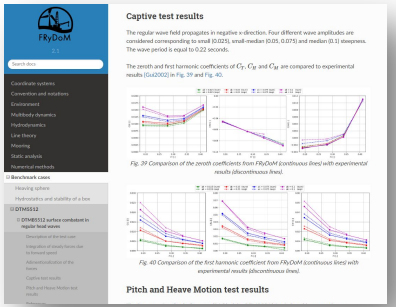
Professional Development Platform (Gitlab)
Frydom-ce.org



Theory Guide
theory.frydom.org



Code documentation (API/SDK)
api.frydom.org

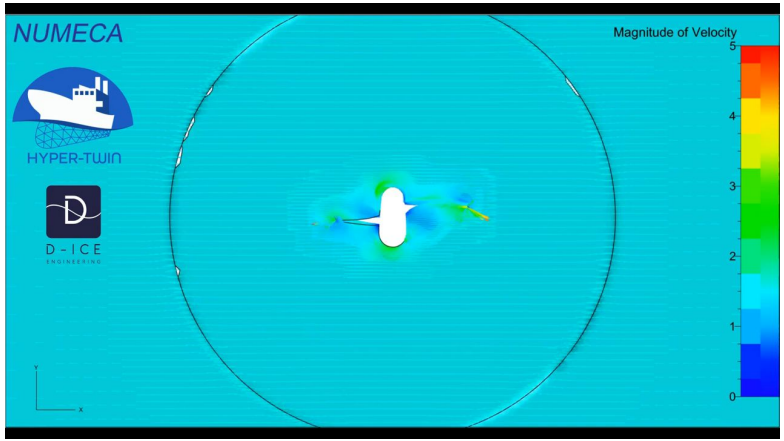


Several automated Benchmarks

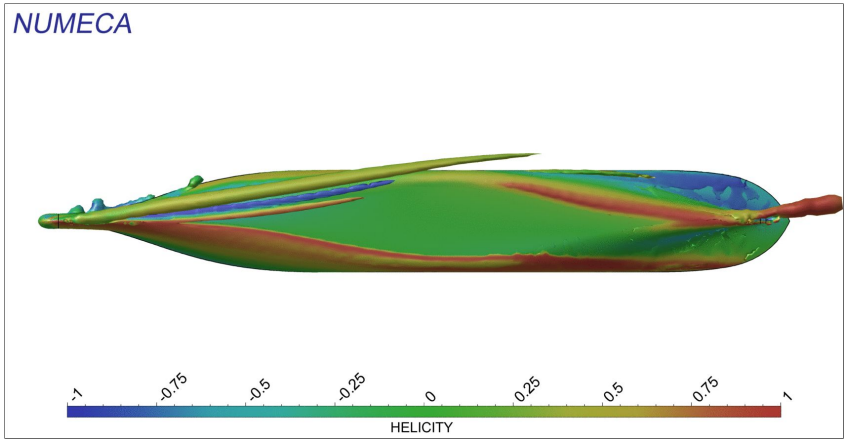
FRyDoM CE
www.frydom.org

FRyDoM

Achieving High-Fidelity - Coupling with CFD (NUMECA Fine™/MARINE)



Propulsion in strong current conditions



Planar Motion Mechanism (PMM) Simulation

FRyDoM

- Modelling & Simulation of WASP with Rotor Flettners
- Flettner rotors are independent bodies fixed to the ship with constraints and modelling of Magnus Effect
- 3D real-time vizualisation with VIPER

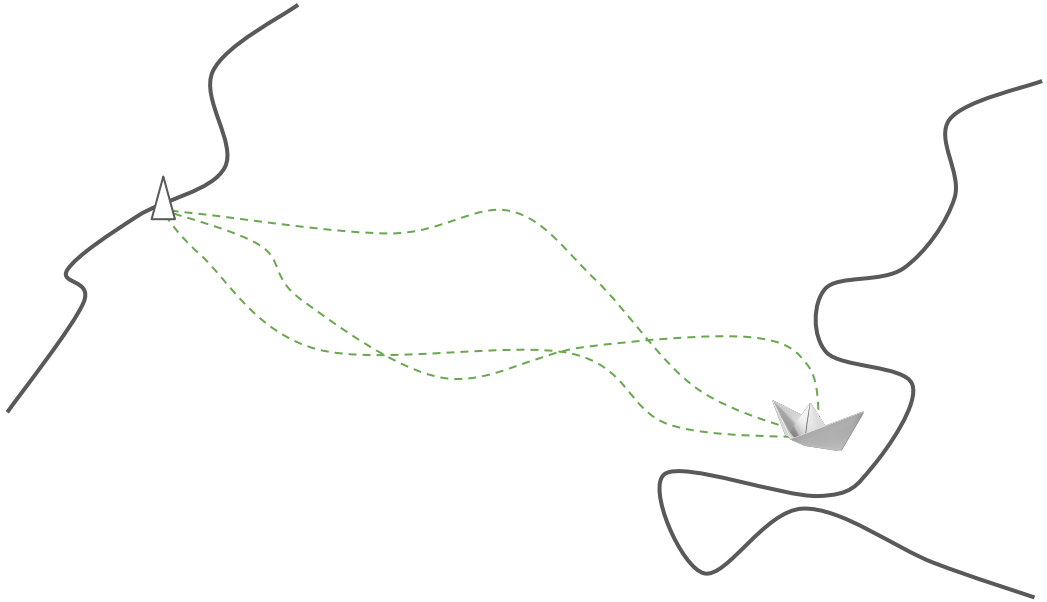
Methodologies & Tools for the Design of WASP

- Better mastering & understanding of the underlying physics is fundamental
- High-Fidelity Modelling approaches are crucial to evaluate
    - General performances of the design
    - Load assessment
    - Ship Stability
    - VPP (Velocity Performances Program)
    - Etc.

But how to assess the concept and maximize the performances (wind assistance, auxiliary power production …) ?

Weather routing - *Generalities*

Problem: Finding the best route or set of routes from a position to another regarding some optimization criterias and constraints



Weather routing - *Generalities*

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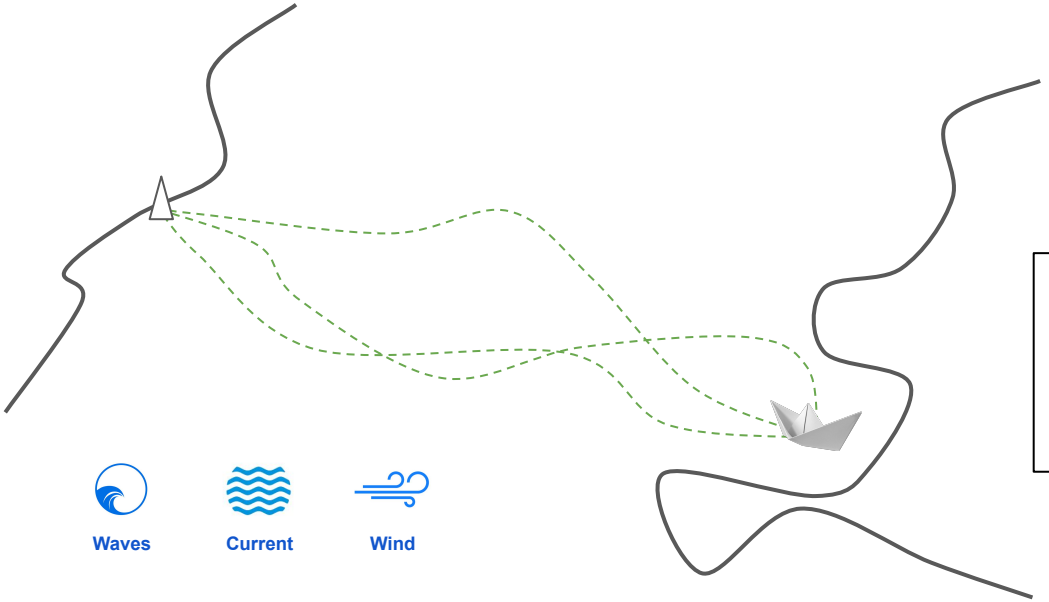

- Various environmental fields which strongly impact ship behaviour

Weather routing - *Generalities*

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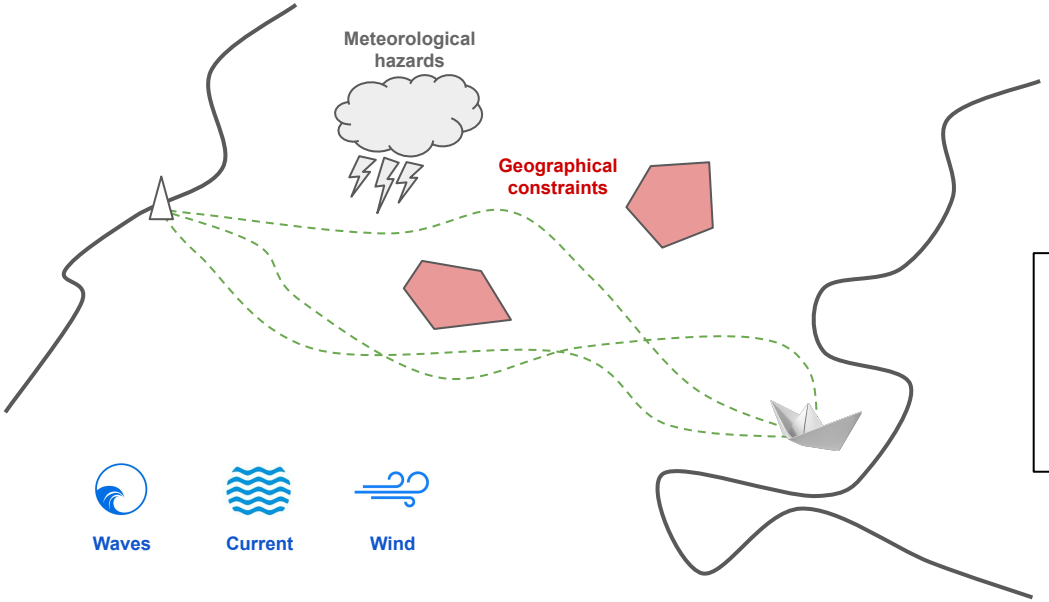
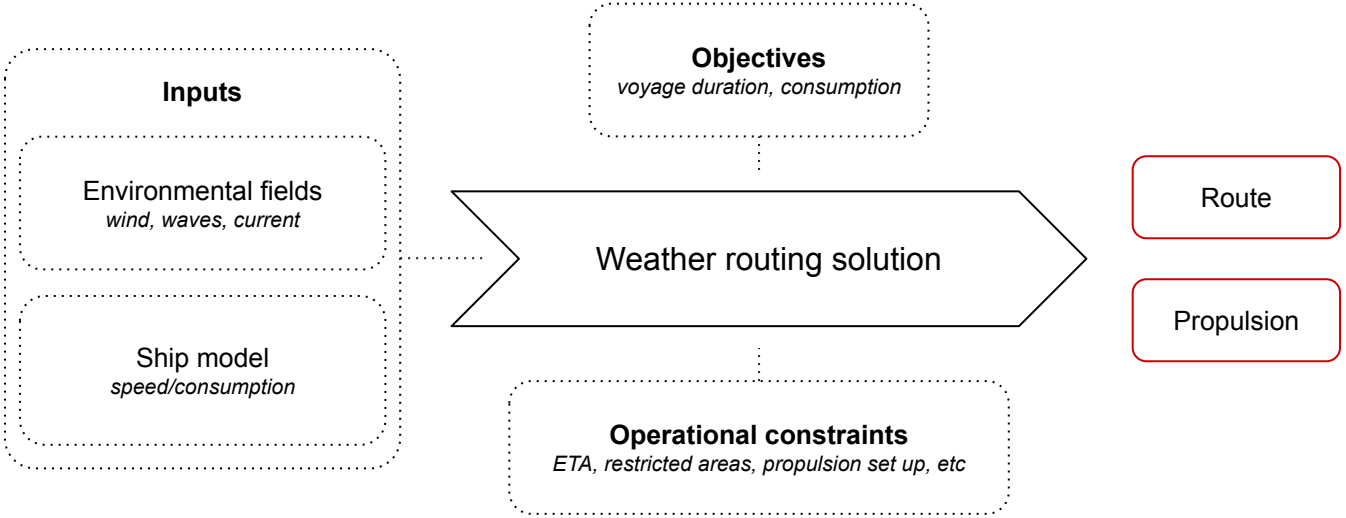


- Various environmental fields which strongly impact ship behaviour
- Many constraints including for safety reasons

Weather routing - *Generalities*



Few observations:

- two different approaches for weather routing of motor ship or sailing ships
- no off-the-shelf solutions for hybrid propelled vessels
- ships becoming more complex needing various constraints and multi-objective optimizations

Weather routing - *Solution*

Approach based on graph theory with last generation algorithms

- mono and multi-objective optimization
- tailorable and flexible
- sailing, motor, and hybrid ships

What led us compute route optimization **with the same solution** for

★ sailing ships

Weather routing - *Solution*

Approach based on graph theory with last generation algorithms

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What led

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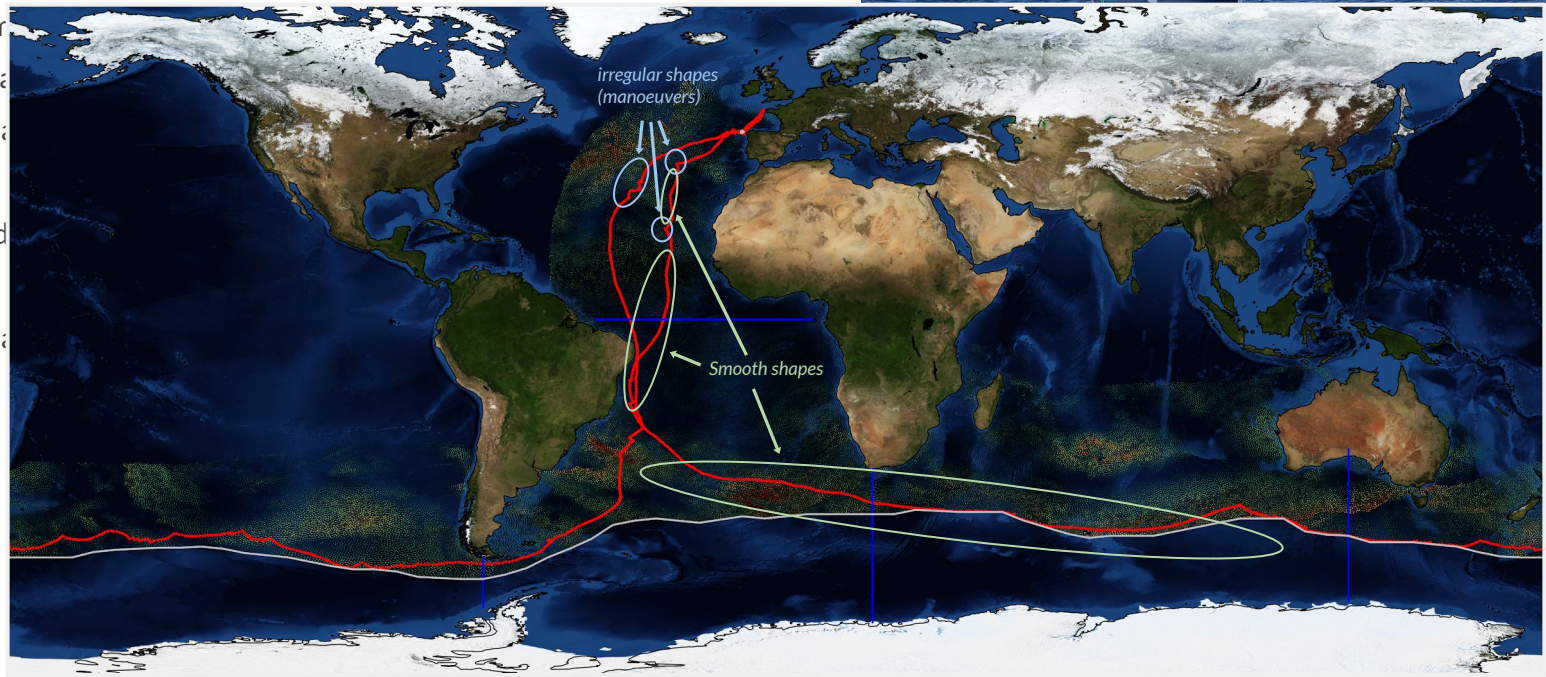

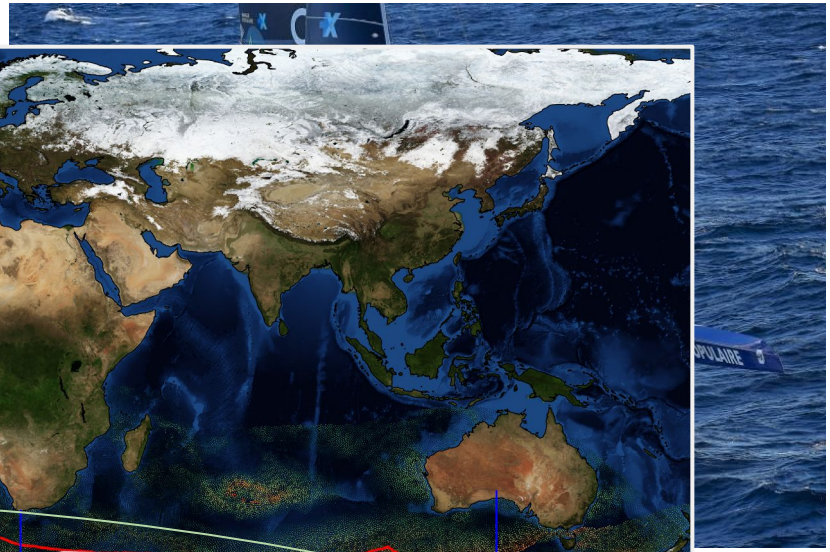

Weather routing - *Solution*

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- mono and multi-objective optimization
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What led us compute route optimization **with the same solution** for

★ sailing ships

★ conventional ships

Weather routing - *Solution*

Approach based on graph theory with last generation algorithms

- mono and multi-objective optimization
- tailorable and
- sailing, motor

What led us compute

★ sailing ships

★ conventional

Weather routing - *Solution*

Approach based on graph theory with last generation algorithms

- mono and multi-objective optimization
- tailorable and flexible
- sailing, motor, and hybrid ships

What led us compute route optimization **with the same solution** for

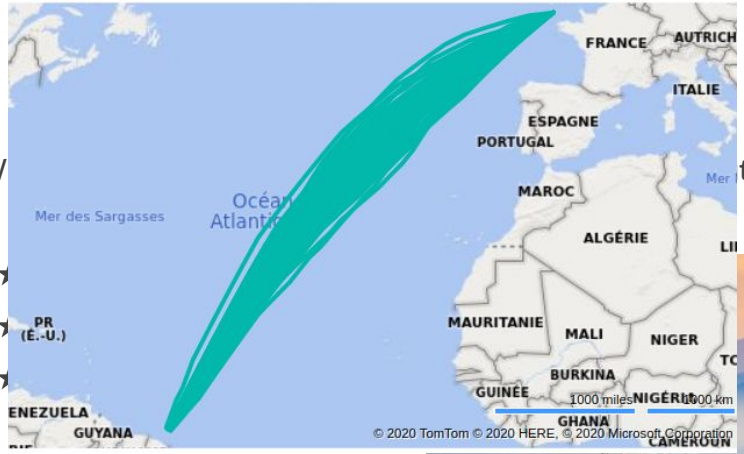
★ sailing ships
★ conventional ships
★ hybrid ships

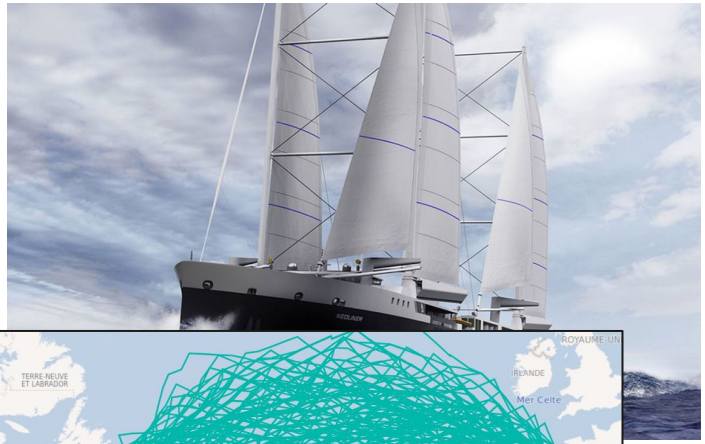
Weather routing - *Solution*

Approach based on graph theory with last generation algorithms

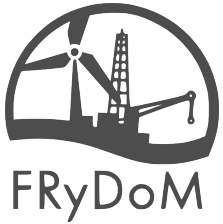
- mono and multi-objective optimization

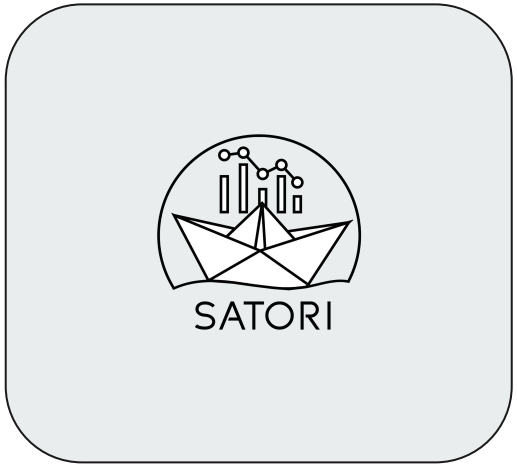
W **tion** for





Methodologies & Tools for the Design of WASP



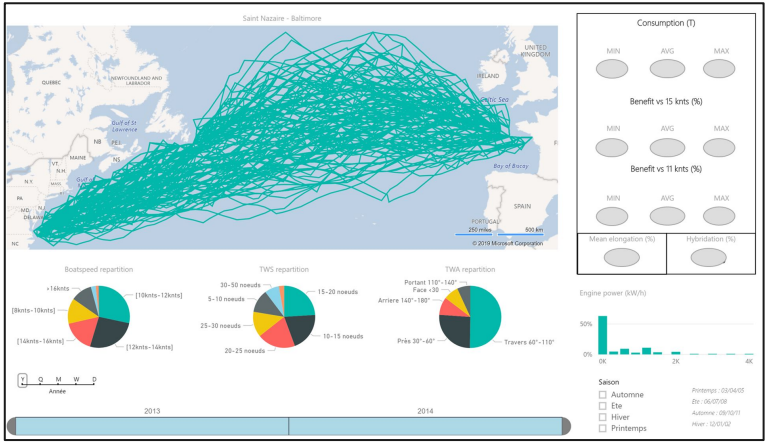


SATORI

Propose a solution for **ship owner**, **naval architects**, and **solution developers** to launch statistical weather routing studies by **their own**, online.

From historical weather datas get statistics to:

- Evaluate benefits & payback of a wind assist solution
- Validate your ship performances & associated business model
- Optimize your design

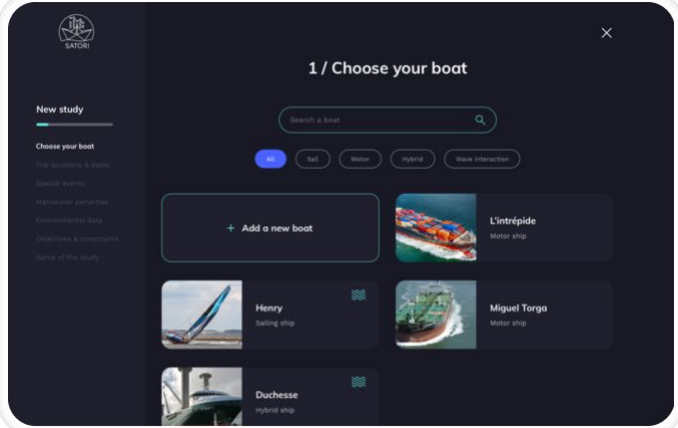


Project duration 18 months
Funded through CMEMS User Uptake Program
Market release: November 2020

SATORI

1. **Define your study** : create an account, upload your ship performance data and submit your calculation

- *mechanical, sailing, or hybrid propulsion*
- *ETA, waypoints, canal*
- *First / Last departure dates and frequency*
- *Manoeuvrer penalties*
- *Polar tables of the ship*
- *Waves speed loss calculation*
- *etc*



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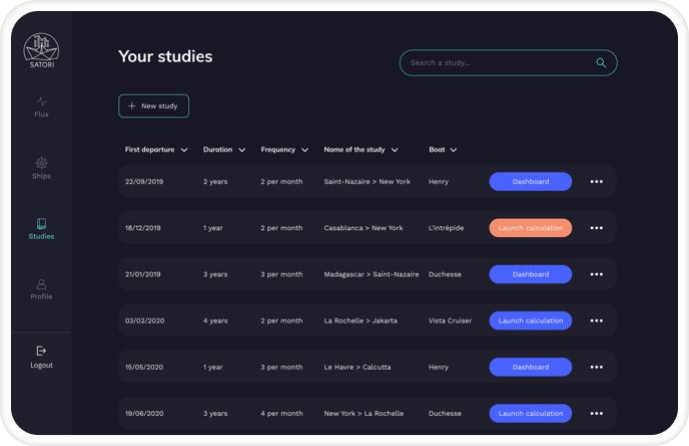
SATORI

1. **Define your study** : create an account, upload your ship performance data and submit your calculation
2. **SATORI calculates all optimal routes**

- *Automatic cloud computing and notification at the end*



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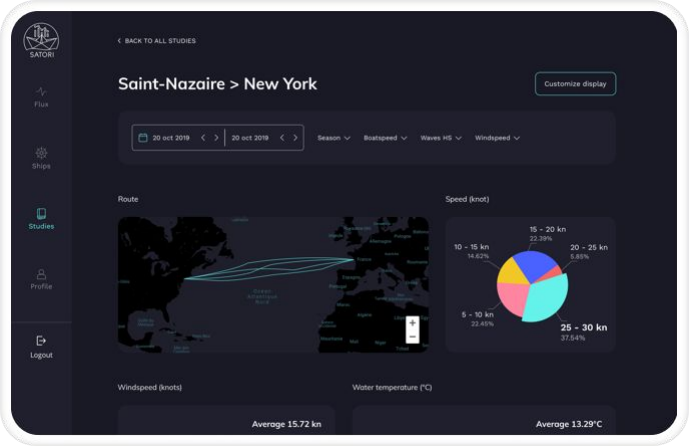
SATORI

1. **Define your study** : create an account, upload your ship performance data and submit your calculation
2. **SATORI calculates all optimal routes**
3. **Create your dashboard** : analyze your results through our dynamic visualization

- *Online customization*
- *Various visuals (map, pie chart, bar chart, scatterplots, density map)*
- *Interactive filtering from visuals selection*
- *Share functionality*



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SATORI

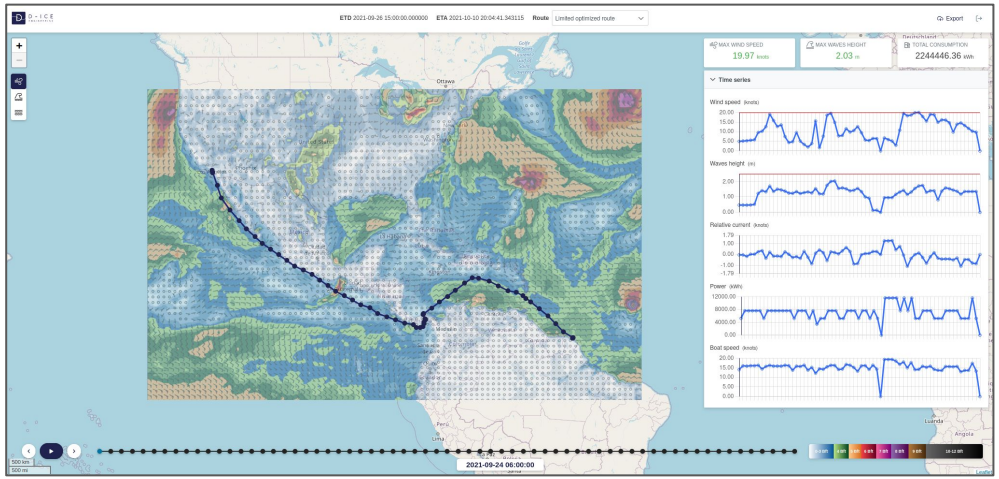
The objective of this service is to make studies cheaper to integrate weather routing during the whole design process

-> Service is operational since november 2020 : **~ 210k computed routes** during last year

Some references on statistical route optimization

Operations

Operational routing



- Optimization of route and engine power
- integration of tailorable constraints (ETA, navigation area, maximum motions, etc)
- Daily tailorable report & dynamic visualization
- 24/7 assistance
- Wind /waves / current environmental fields

About 5 to 10% of fuels savings expected + safety

OCEANiCS

- Cutting-edge Navigation System towards **Autonomy** at Sea
- Full Features
  - ECDIS
  - Conning
  - **Weather Routing**
  - DP & Autopilot & Track Control
  - Sails Management
  - Cameras & Docking Sensors Management
  - Situational Awareness
  - Collision Avoidance
- Tailorable & Evolutive system
- User Centered Design (UI/UX)
- Cost Effective, Sea Proven & Type Approved Hardware
- Cutting-edge algorithms powered by AI, nonlinear control, nonlinear optimization & nonlinear filtering
- Strong ongoing R&D (auto-docking, perception based control, etc.)

Rewarded Innovation

Conclusion

- Improved and cutting-edge tools and methods are crucial for addressing new shipping challenges
- Wind Assistance is a very credible solution in the global picture
- Use of consistant tools, approaches and concept at all stage is mandatory
- Innovative systems will be installed in near future to demonstrate the full performances
- Disruptive concepts (e.g. High Fidelity Digital Twins) are promising for continuous improvements

FRyDoM

SATORI

Real Challenges. True Solutions.