LIFE-PIAQUO Goal 1
Propeller design by optimization

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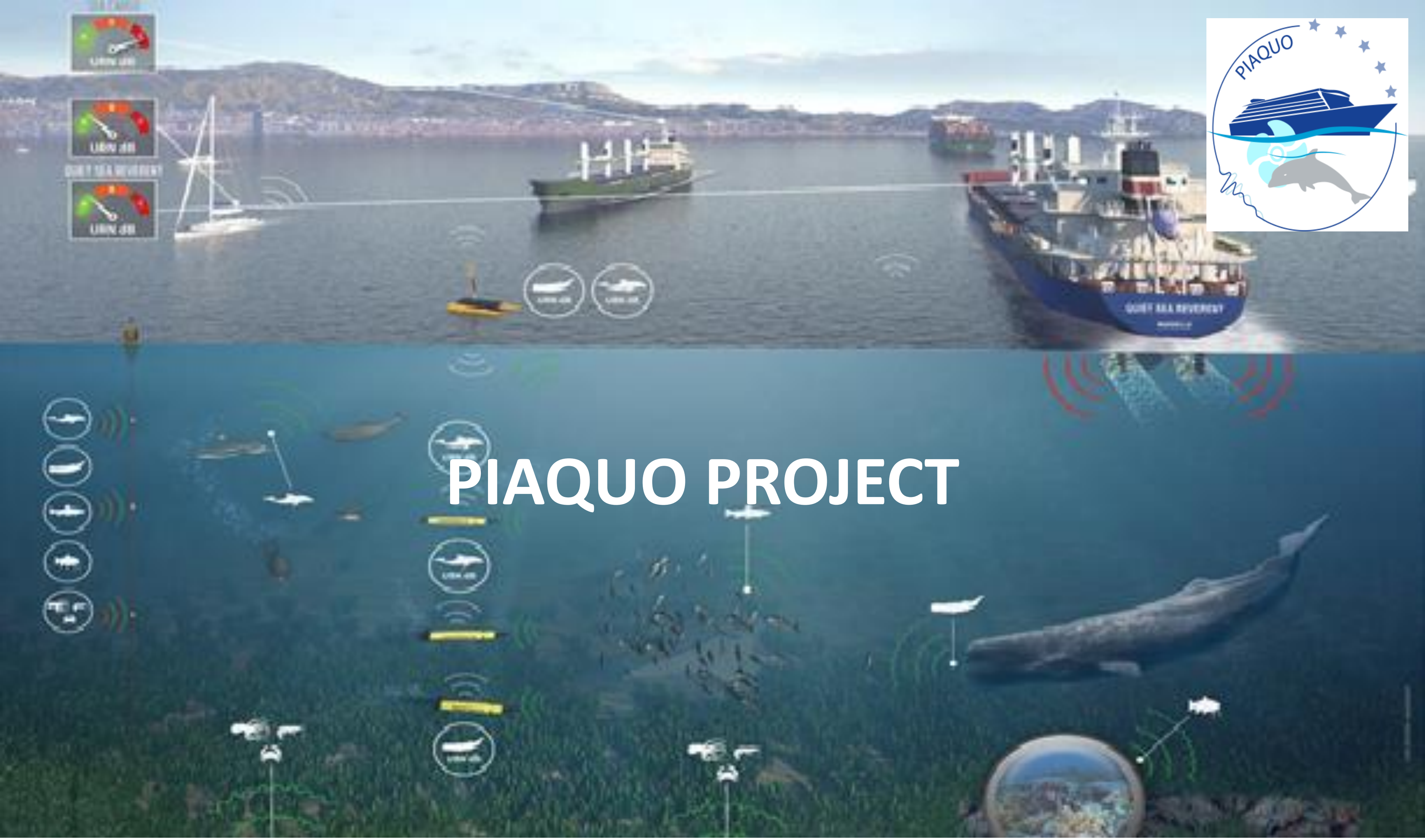
Summary

- PIAQUO project
- Goal 1 overview
- UNIGE activities: design by optimisation
- Previous results
- Conclusions



PIAQUO PROJECT

PIAQUO project

Background

Average **level of noise** in the most patronized seas has **increased by about 20dB in the last 50 years.**

The **radiated noise of working and pleasure boats** is the **main factor** in this growth of underwater noise.

Marine areas with protected species and/or representing zones with **major biological interests** (reproduction, nursery, food…) are located **nearby vessels' routes.**

Recommendations were established to encourage **underwater noise reduction** generated by human activities and **European regulation** is going to oblige the establishment of ambitious actions in this field.

The **European project AQUO (FP7)** has created **tools to estimate the noise generated by maritime traffic and to realize noise cartographies.**

This led to the project **LIFE-PIAQUO - Practical Implementation of AQUO - Underwater noise impact Reduction OF THE maritime traffic AND REAL-TIME adaptation TO ECOSYSTEMS**

PIAQUO project

Main objective is thus to reduce radiated noise generated by vessels and to adapt it in real-time to ecosystems crossed in order to minimize their impacts on the environment.

GOALS:

1. **Practical implementation of ship radiated noise reduction using improved propellers**

2. **Practical implementation of ship radiated noise real-time self-estimation and control**

3. **Inducement of virtuous approaches from ship owners to reduce shipping URN**

4. **Adaptation of the maritime traffic according to the real-time state of marine ecosystems**

5. **Setting a broadcasting service for decision making support to reduce shipping noise impact**

GOAL 1 Overview

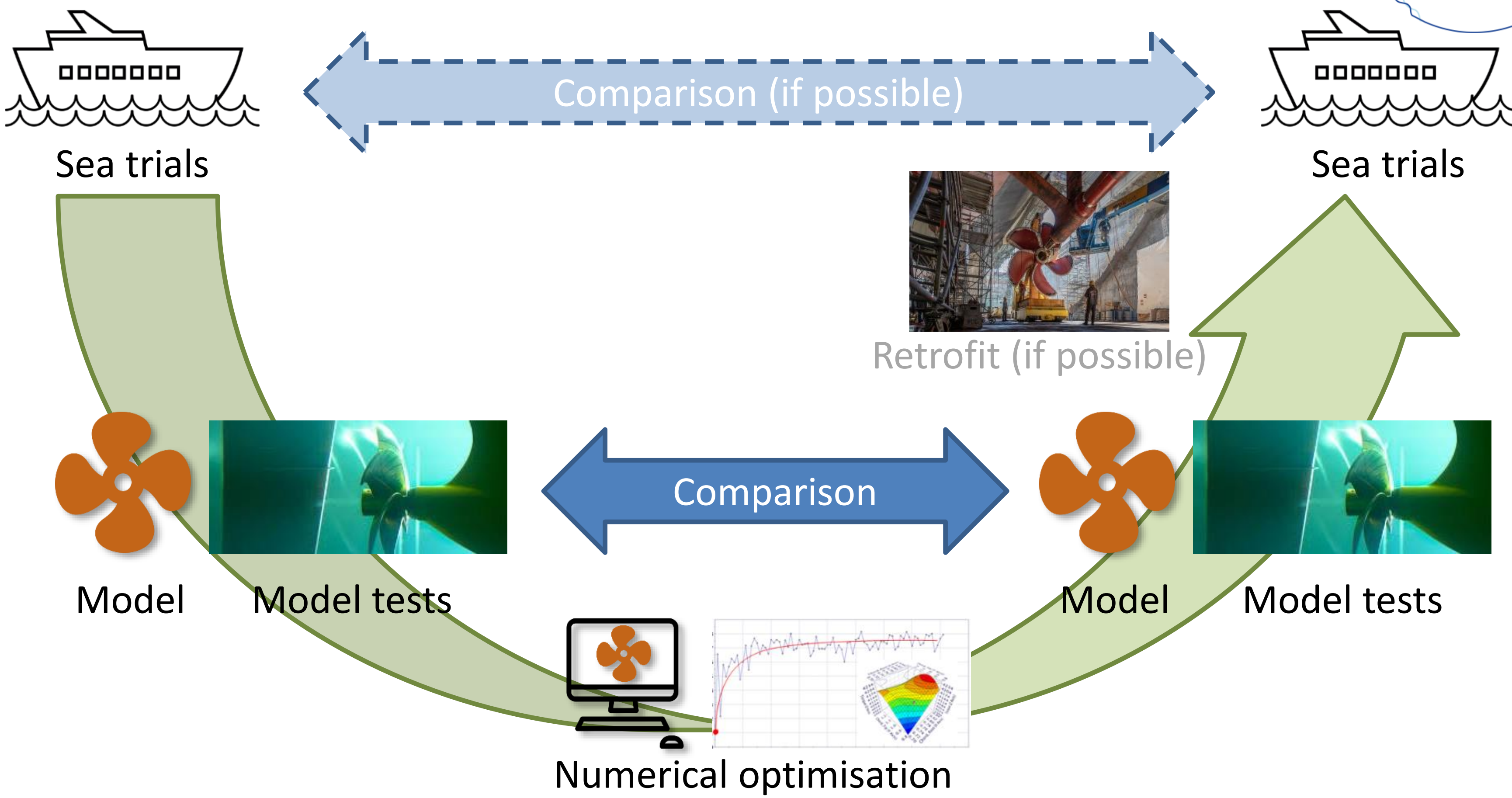
Goal 1 overview

Goal 1: Demonstration on two boats of the possibility of underwater radiated noise reduction via optimized retrofit propellers

Key words :

- Demonstration
- Underwater radiated noise
- Optimization
- Two boats
- Retrofit propellers

Goal 1 overview



UNIGE ACTIVITIES:
Design by optimisation
Small Passenger boat

Ship characteristics

Primero VII

LOA = 27.60 m
LBP = 23.40 m
Bmax = 6.82 m
D = 2.17 m
Δ= 76.5 t (full load)
64.5 t (intermediate*)
46.0 t (light)

*50% consumables and 250 (over 350) passengers: most common condition, used as design condition

List of activities

Task A1.1: Collection of information on existing ships' characteristics and estimation of missing data by modelling

Task A1.2: Realization of model test original propellers and trials in cavitation tunnel and towing tank

Task B1.1: Propellers' design optimizing at the same time noise emission and efficiency

Task B1.2: Realization of model test optimized propellers and trials in cavitation tunnel and towing tank

Task B1.3: Acoustic simulation of original and optimized propellers

Task B1.4: Manufacturing and installation of the full-scale propellers

Task C1.1-1.2: Radiated noise and others parameters measurement before and after retrofit of existing ship

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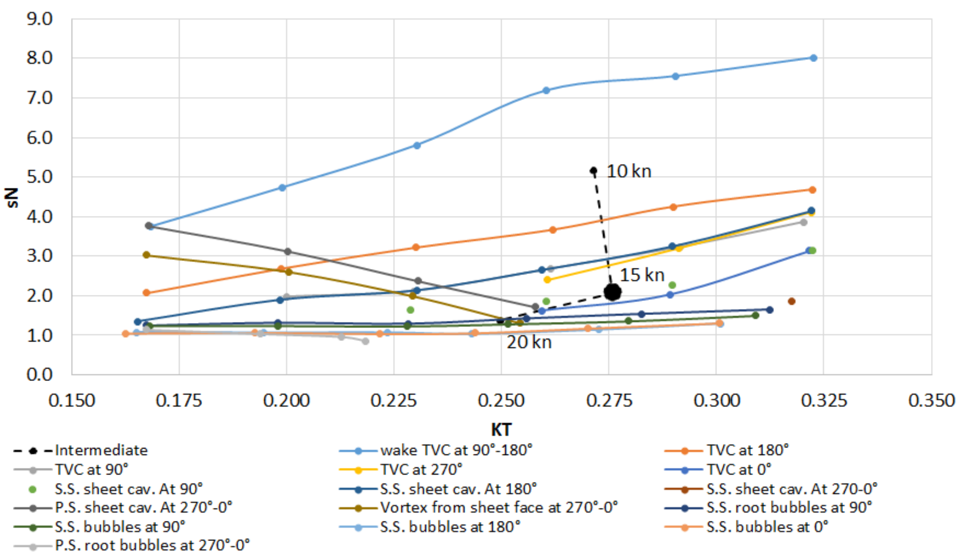
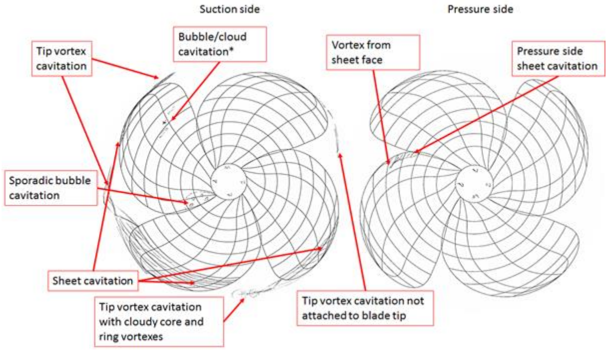
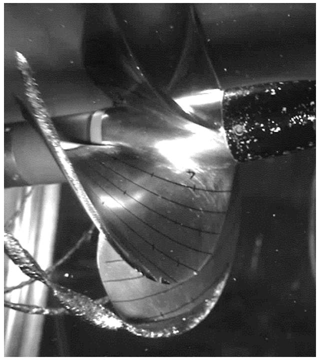
Task A1.2: Realization of 2 model test original propellers and trials in cavitation tunnel and towing tank

Bucket and cavitation observations







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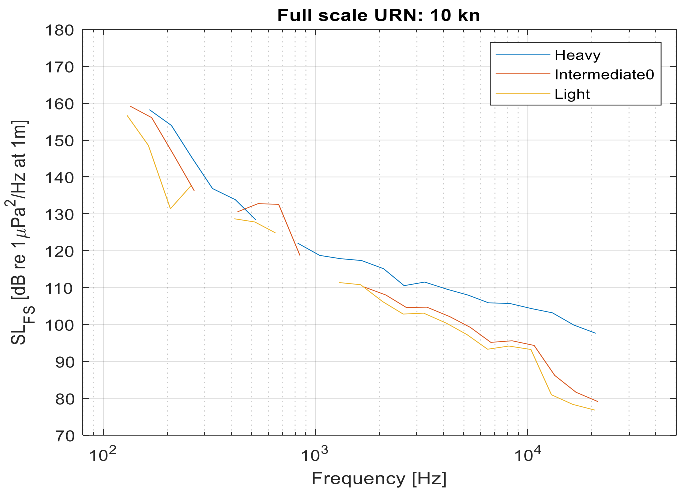
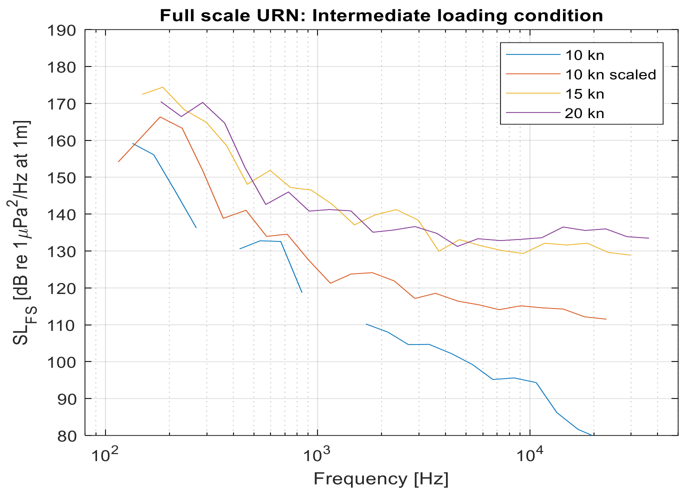
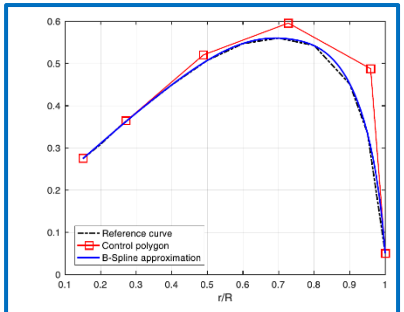
Task A1.2: Realization of 2 model test original propellers and trials in cavitation tunnel and towing tank

Radiated noise measurements

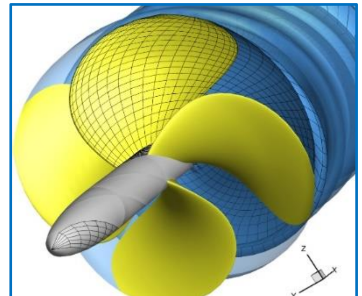




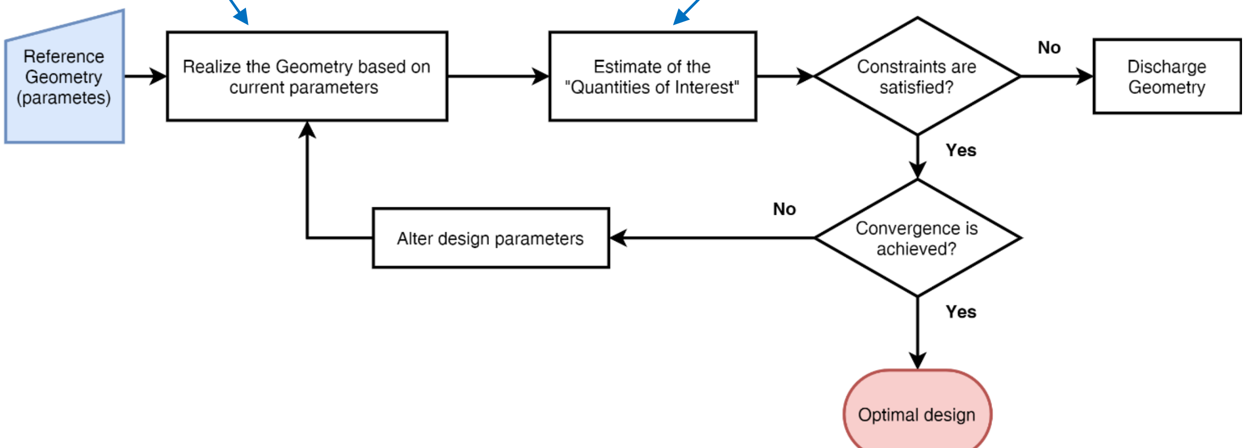
Task B1.1: Propellers' design optimizing at the same time noise emission and efficiency



- **Parametric description using B-Splines;**
- **35 free design variables;**



- **BEM for the estimation of QOI;**
- **18 design objectives/constraints at different propeller functioning conditions** (cavitation/boat speed/engine matching)



Task B1.1: Propellers' design optimizing at the same time noise emission and efficiency

Selected geometries are further analysed by means of:

- Unsteady cavitating BEM calculations
- Steady non cavitationg RANS calculations at equivalent conditions
- Unsteady non cavitating BEM calculations + ETV model for the estimation of radiated noise

This allows to select the optimal propeller based on higher level computational results, including the non-stationary evolution of cavitation at different propeller functioning point and an estimation of propeller radiated noise.

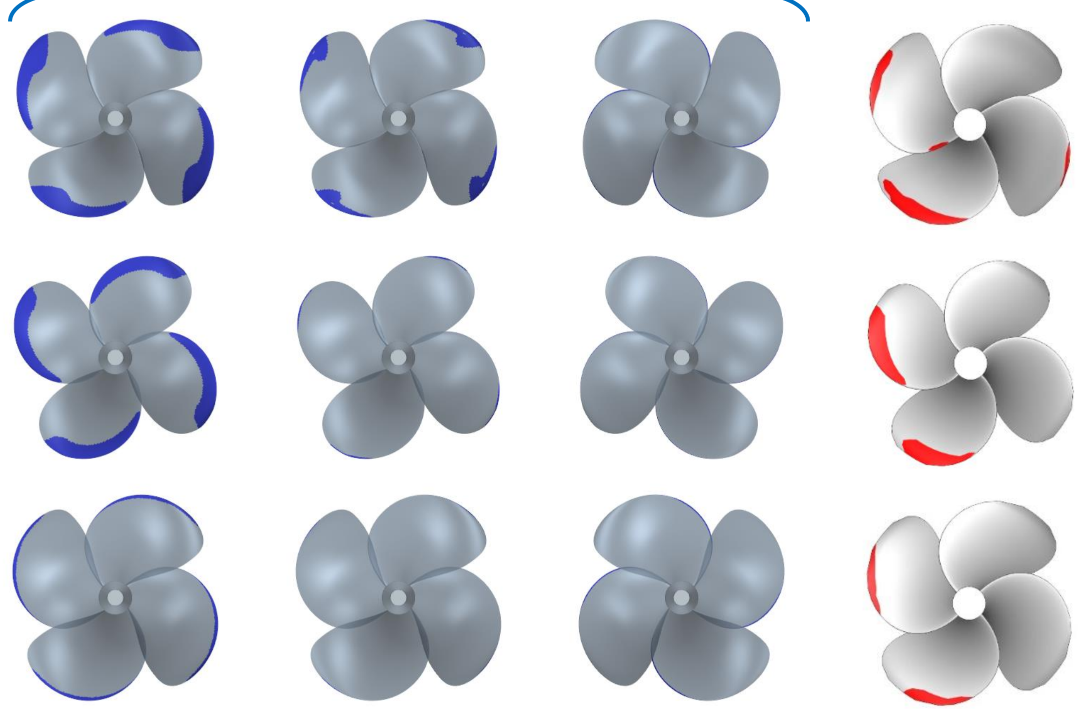
Task B1.1: Propellers' design optimizing at the same time noise emission and efficiency

Equivalent RANS (cavitation inception) | **Unsteady cavitating BEM**

Reference Propeller (DETRA design)

ID 102773

ID 52214



J_{eq} = 0.65, suction side | J_{eq} = 0.80, suction side | J_{eq} = 0.95, pressure side | Fully unsteady, Inter. Disp., 400kW

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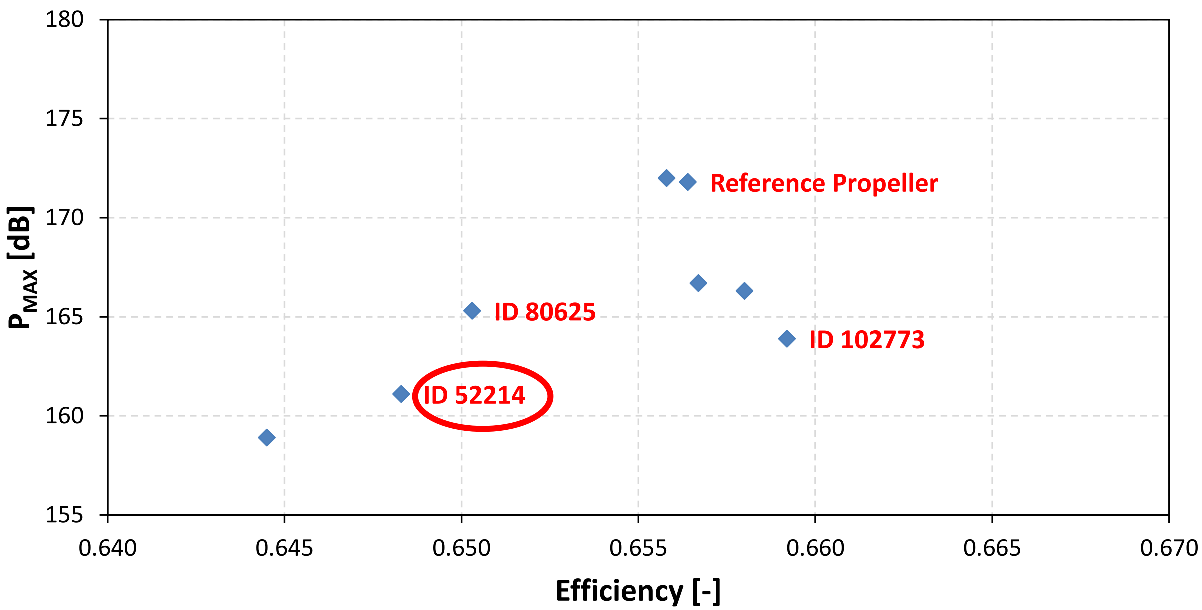
Task B1.1: Propellers' design optimizing at the same time noise emission and efficiency



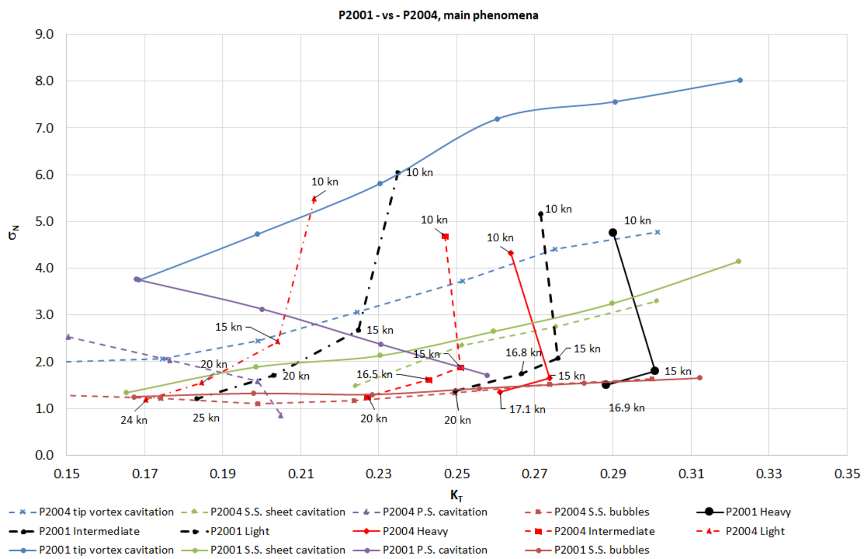
ETV calculations (maximum vortex peak pressure vs propeller efficiency for different propellers)

Efficiency and pressure reduction are conflicting objectives, as expected. Some designs are able to reduce noise keeping or slightly improving efficiency.

ID 52214 propeller has been chosen in order to emphasize noise reduction for the sake of model and full scale tests, accepting a slight efficiency reduction (about 0.1 kn reduction at constant power for reference configuration @ 400 kW).

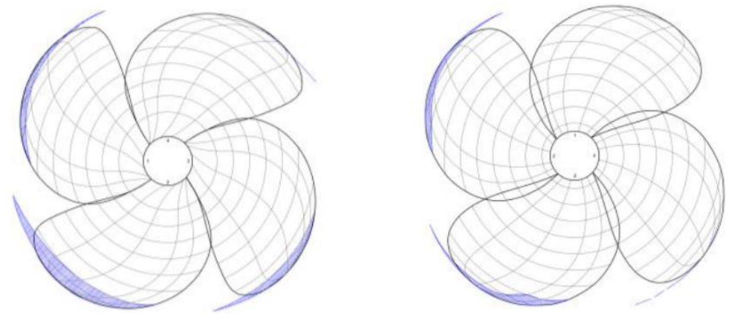
Task B1.2: Realization of 2 model test optimized propellers and trials in cavitation tunnel and towing tank

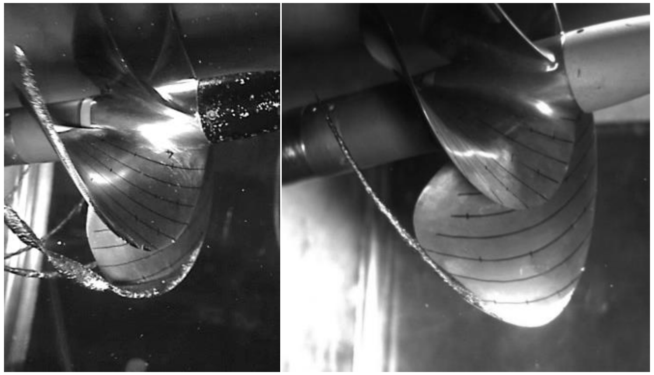
Bucket and cavitation observations



15 kn, intermediate

Reference prop. (P2001) vs Optimized prop. (P2004)





Achievements of optimization:

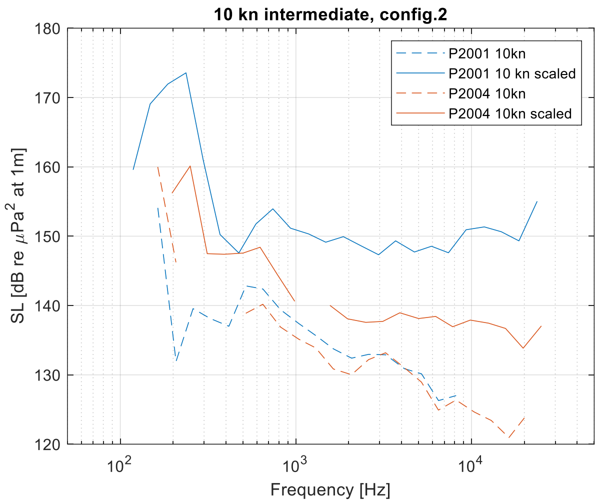
- Cavitation inception is significantly improved
- Suction side sheet cavitation is reduced
- Pressure side cavitation is almost eliminated

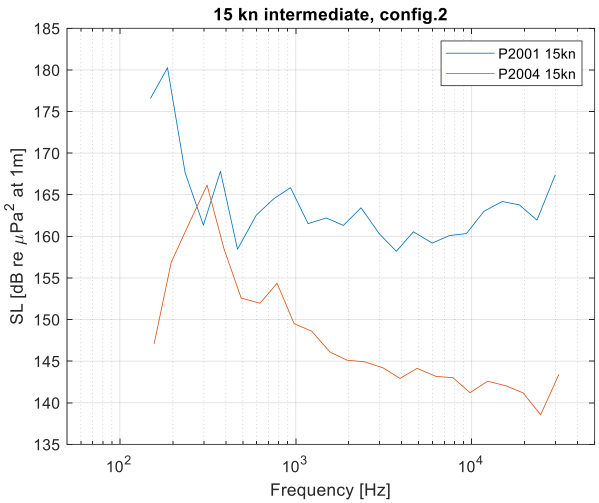
Task B1.2: Realization of 2 model test optimized propellers and trials in cavitation tunnel and towing tank

Radiated noise measurements

P2001 = reference prop.

P2004 = optimized prop.



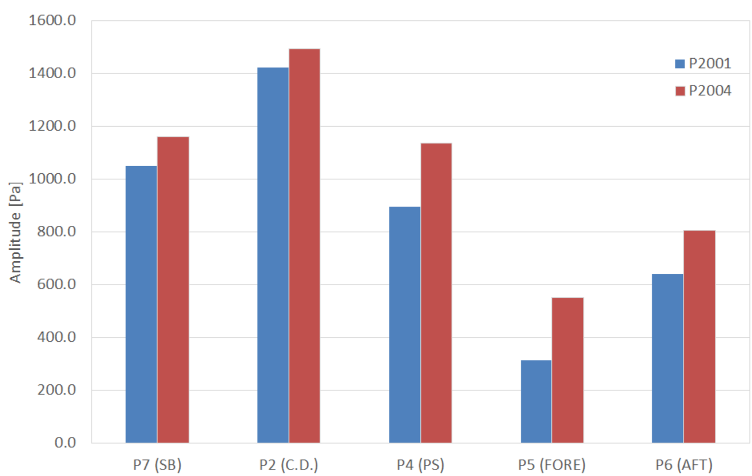


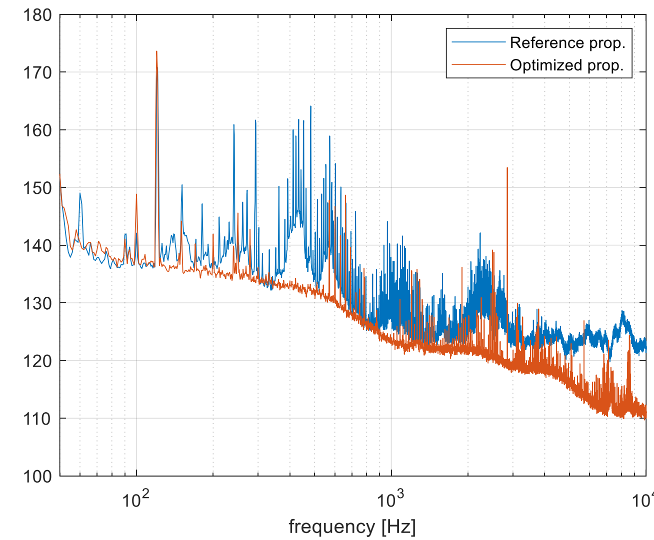
- $V_S = 10\ kn$: Noise levels are similar considering the actual operational conditions without any scaling, since both propellers are not cavitating (P2001 is at inception).
- $V_S = 10\ kn$ scaled: scaling the operational conditions to account for viscous effects on tip vortex cavitation, differences are remarkable: noise levels for the optimized propeller are on alverage 10 dB lower
- $V_S = 15\ kn$: the optimized propeller is significantly less noisy also for this condition because of the large differences in cavitation extent, especially the size of tip vortex cavitation: on average a 15 dB reduction is observed

Task B1.2: Realization of 2 model test optimized propellers and trials in cavitation tunnel and towing tank

Pressure pulses measurements

15 kn intermediate





Hull pressure fluctuations at blade rate are almost equal between the two propellers.
Broadband fluctuations are instead reduced with the optimized propeller because of reduced cavitation

P2001 = reference prop.

P2004 = optimized prop.

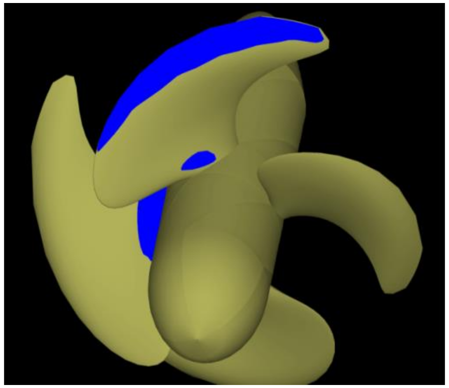
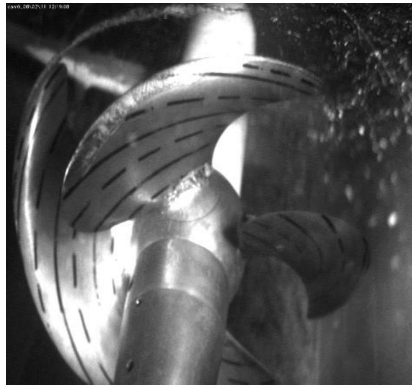
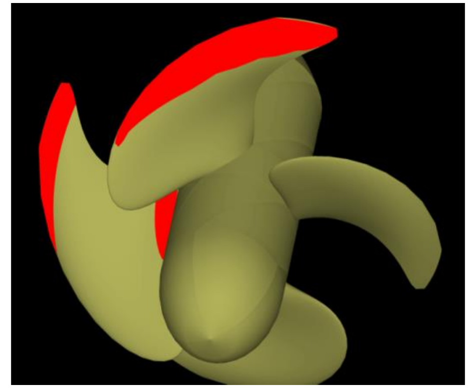
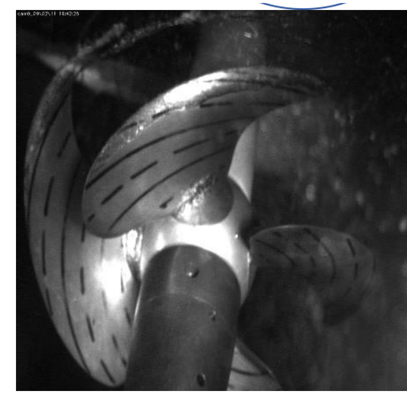
Previous results

SILENV Project (FP7 project) - Ferry

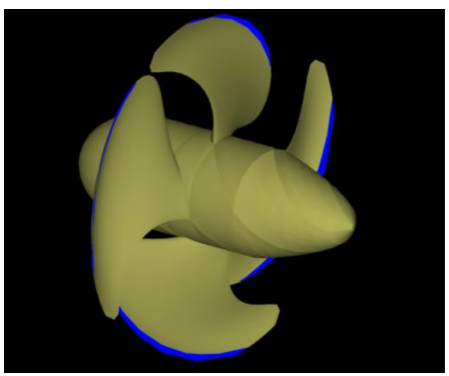
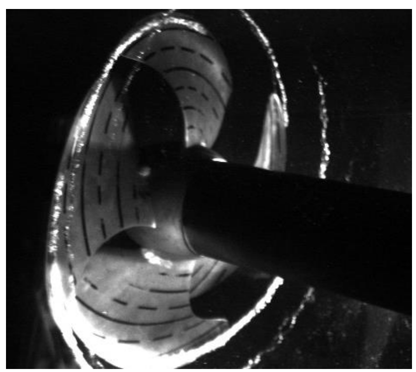
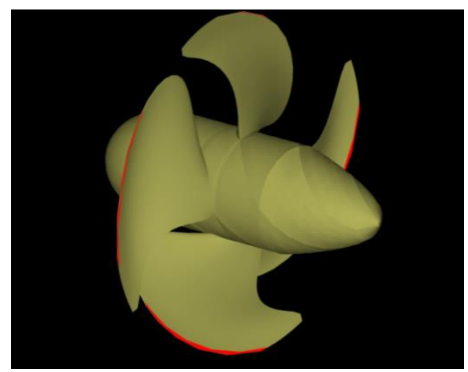
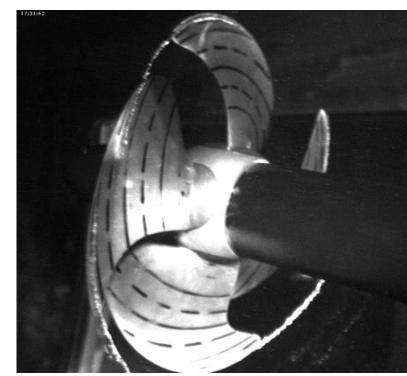
Original

Optimised

Design Pitch

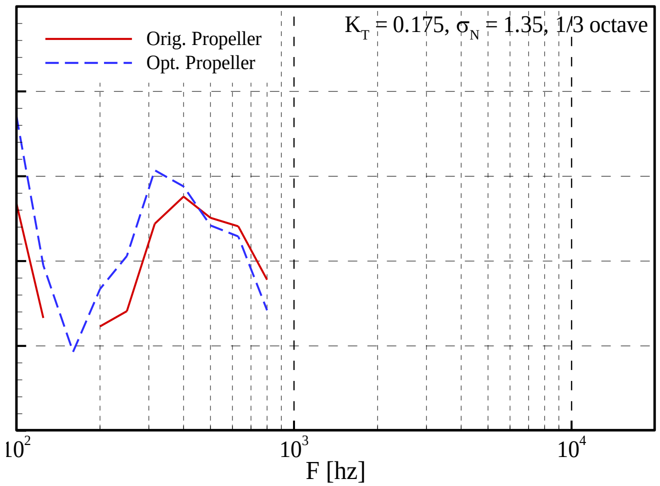





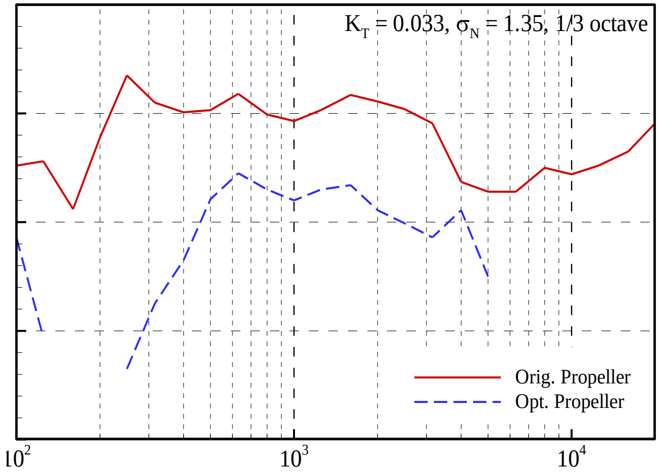
Reduced Pitch

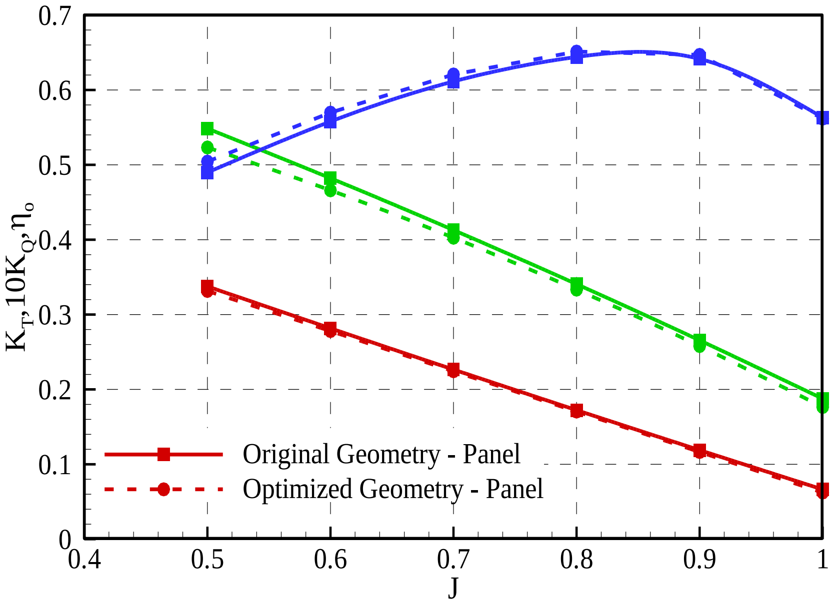





SEVENTH FRAMEWORK PROGRAMME

SILENV Project (FP7 project)



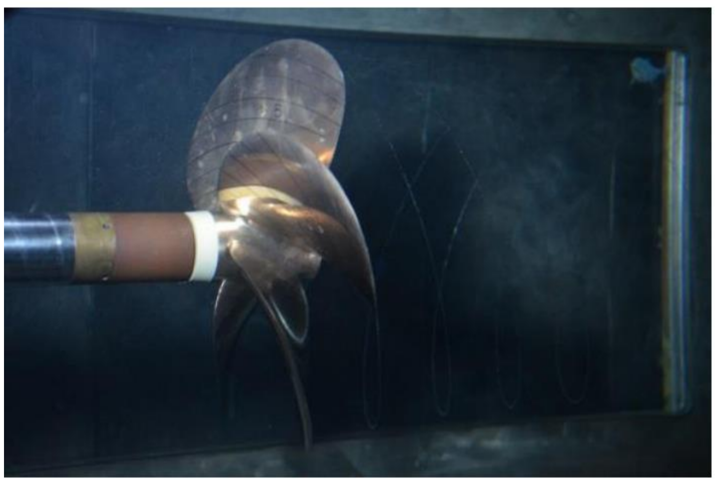




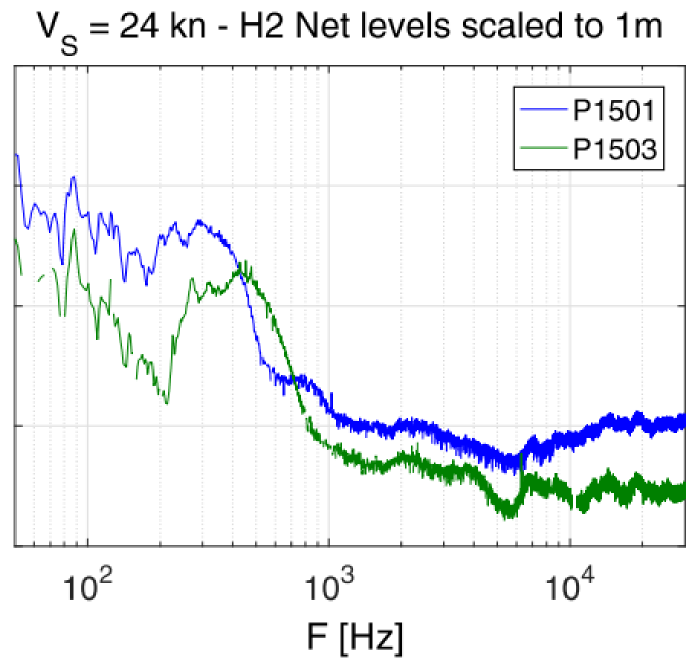
No full scale data

SEVENTH FRAMEWORK PROGRAMME

ABC Project (Italian MISE Project) – Leisure Boat



About 1 kn increase @ full scale
(no URN data available)



ABC – Advanced Boat Concept
Progetto n. C01/0889/00/X19

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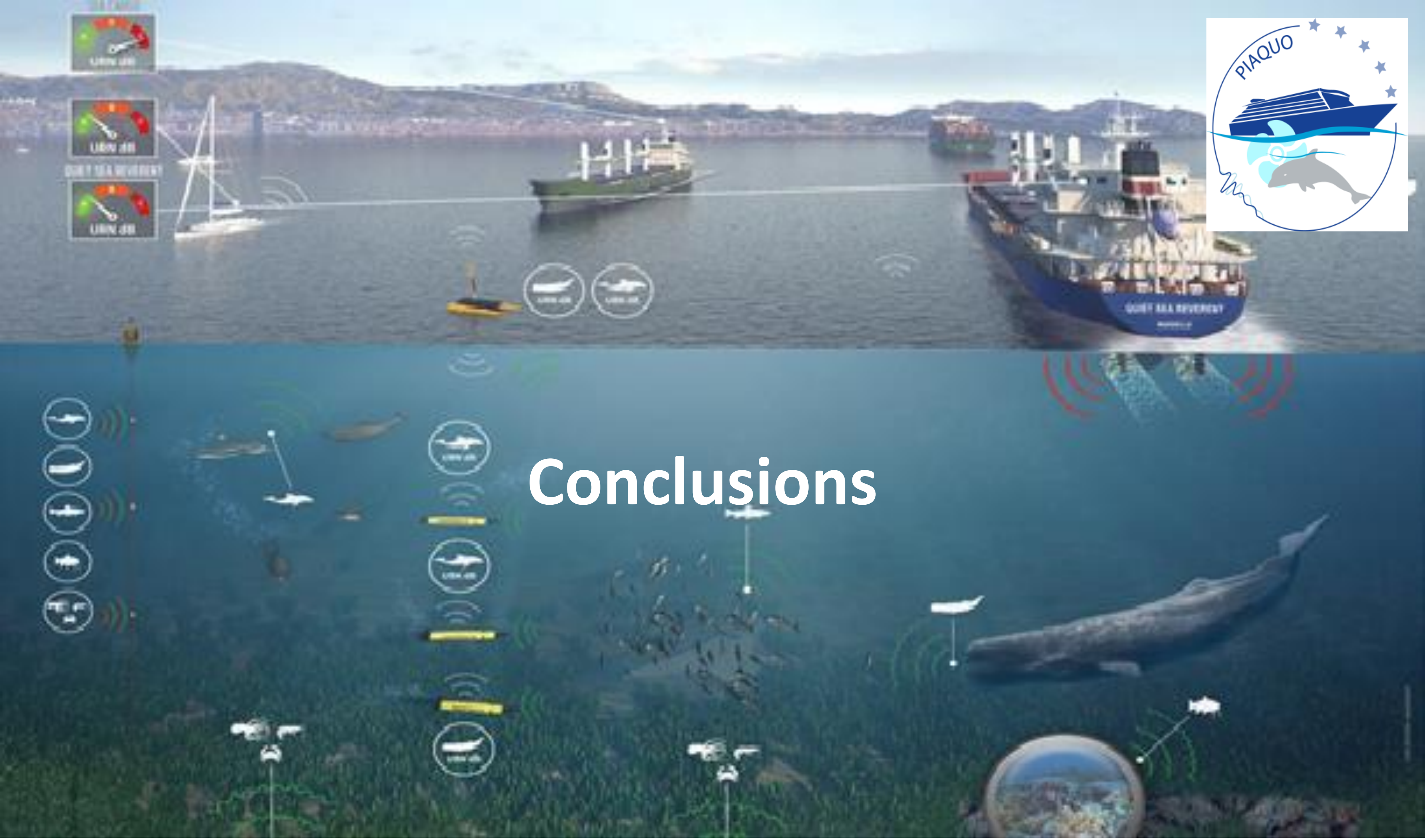
Conclusions



Conclusions

An overview of PIAQUO Project as a whole has been given, focusing on Goal 1 activities

Propeller design by optimisation has proven to be an efficient way of designing retrofit propellers with lower URN

Efficiency increase and Noise reduction are conflicting objectives; nevertheless, a trade-off is possible with URN improvements (5-10 dB) and (at least) constant efficiency

Sea trials are still missing for a final confirmation

Further analyses and cases need to be considered in order to make this conclusion more general