# ABB Marine
# Silent marine research with Azipod propulsion

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*ABB Marine & Ports*

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# Well positioned across global markets


**ABB** is a technology leader in **electrification** and **automation**, enabling a more sustainable and resource-efficient future.

The company's solutions connect engineering know-how and software to optimize how things are **manufactured**, **moved**, **powered** and **operated**.

ABB Purpose
We enable a low-carbon society
We reach carbon neutrality in our operations by 2030 and partner with our customers and suppliers to reduce their emissions.
Integrity
We promote social progress
We take care of our people and promote social progress with our partners, suppliers and in communities.
Transparency
We preserve resources
We embed circularity by reducing waste, improving recycling and fostering reusability.

# ABB in Finland

## Key figures

**2.3 bn €**
Revenues (2022)

**~ 130 mn €**
Investment in research and development

**~ 5 300**
Employees

**Production**
in Helsinki, Vaasa, Porvoo and Hamina

**~ 1/7**
of personnel working in research and development

**~ 800**
Summer interns

# Fully decentralized business model with 20 divisions

| BUSINESS AREA | Electrification | Motion | Process Automation | Robotics & Discrete Automation |
|---|---|---|---|---|
| |  |  |  |  |
| DIVISION | Distribution Solutions | IEC LV Motors | Energy Industries | Robotics |
| | Smart Power | Large Motors & Generators | Process Industries | Machine Automation |
| | Smart Buildings | NEMA Motors | Marine & Ports | |
| | Installation Products | Drive Products | Measurement & Analytics | |
| | Power Conversion[1] | System Drives | | |
| | Service | Motion Service | | |
| | E-mobility[2] | Traction | | |

1. Divestment announced. Expected to be completed in H2 2023. 2. Reported as part of "Corporate and Other" as of Q1 2023.

# Azipod® propulsion key facts and figures

## Key facts and figures

**~90**
Icebreakers or ice-going vessels

**25+**
Vessel types equipped with Azipod propulsion

**~610**
Azipod units in operation or on order

**~110**
cruise vessels ordered with Azipod propulsion

**18,000,000+**
Azipod operational hours in total

**30**
Years of successful operation

1 **Unrivaled manouvering**
Superior maneuverability to improve safety

2 **Icebreaking**
Proven and reliable gearless propulsion technology

3 **Dual Acting Ship concept**
CAPEX: No need for Line icebreakers, independent operations in ice

50% less ice resistance in astern mode

4 **Hydrodynamic efficiency**
Low noise and vibration

OPEX: fuel efficiency increase up to 20 percent

5 **Sustainability**
Electric propulsion technology provides a platform for transition to zero carbon operations, Energy Agnostic solution

# Azipod® gearless propulsion family

## Power range 1…22MW – with proven technology

| | Azipod® D | Azipod® M | Azipod® XO | Azipod® XL | Azipod® ICE | Azipod® VI |
|---|---|---|---|---|---|---|
| Power (MW) | 1 – 7.5 | 7 – 14.5 | 14 – 22 | 14 – 22 | 2 – 5 | 6 – 17 |
| Cooling | Air + Se | Air + Sea | Air | Air | Sea | Air |
| Motor type | PM or indu | PM | Synchronous | Synchronous | PM | Synchronous |
| Max ice class | PC 6 | PC6 | PC6 | | PC 3 | PC2 |

NEW !

| Azipod® DI |
|---|
| 2 – 6.5 |
| Air + Sea |
| Induction |
| PC 3 |



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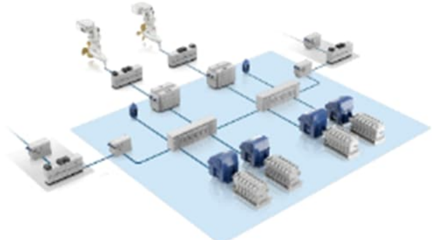
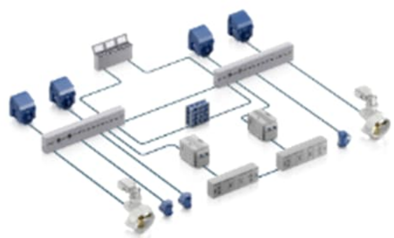
# Electric propulsion is a future-proof concept

Path to improve energy efficiency and to decarbonize shipping

## Electric power and propulsion systems as a backbone of electric and hybrid vessels



**Up to 10% reduced fuel consumption** with AC solutions



**Up to 27% reduced fuel consumption** with DC solutions

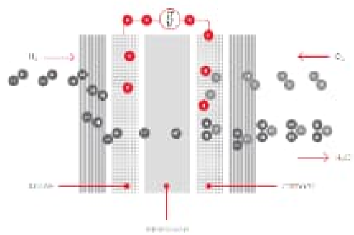
## Azipod® electric propulsion

**Additional 10% increased energy efficiency** with Azipod® electric propulsion

## Energy storage

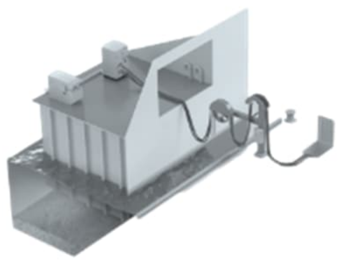
**Hybrid or fully electric operation** with stored energy and charging solutions

## Fuel cells



**Zero-emission** operation with hydrogen fuel cell power system

## Shore connection



**98%** greenhouse gas emissions eliminated in port call

# Activities related to URN

Topics:

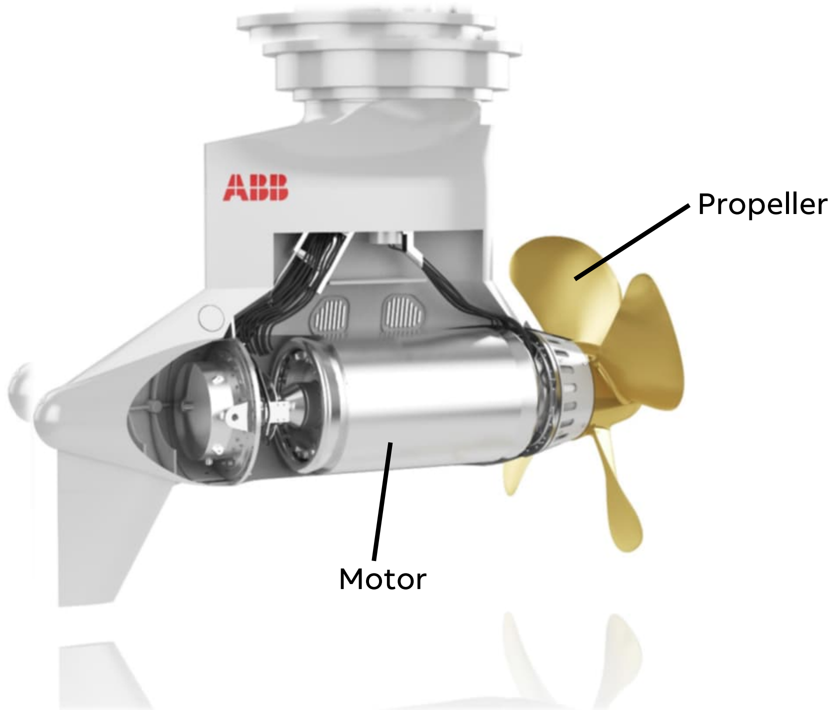
1. Introduction
2. Fully coupled URN simulations
3. Project CLUE (Continuous Logging of Underwater noise Emissions)
4. Silent designs for research vessels
5. Takeaways

# Introduction

Noise sources of Azipod propulsor

Main sources of Azipod underwater noise are:

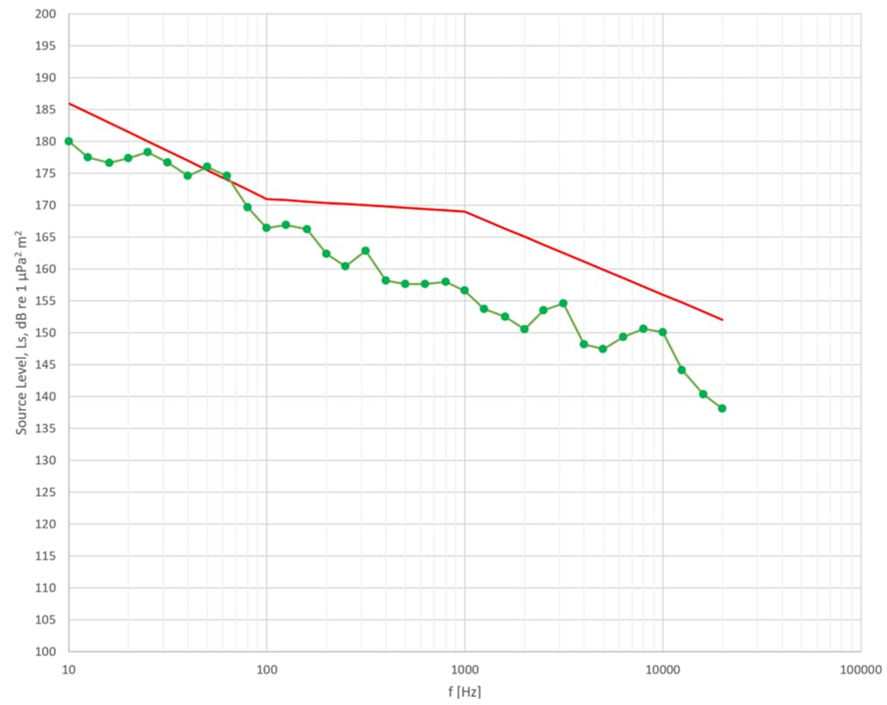
1. **Electro-magnetic noise – propulsion motor**
2. Hydrodynamic noise – propeller
3. *Structure borne noise caused by Azipod module frame excitations, structure and form*



# Introduction

## Electro-magnetic noise

- The motor is supplied with frequency converter for speed & torque control
- The curve shows a far-field measurement result from a seatrial (green) together with limit curve (red)
- The converter manifests itself at frequencies around 3, 6 and 9 kHz
- The peaks are related to converter switching frequency



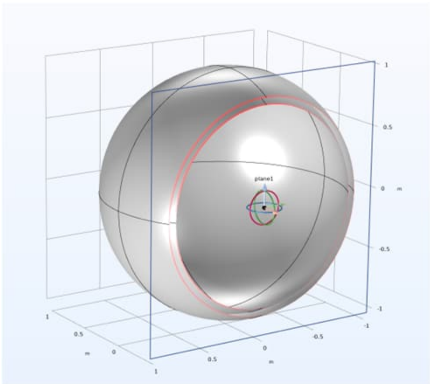
# Fully coupled URN simulations

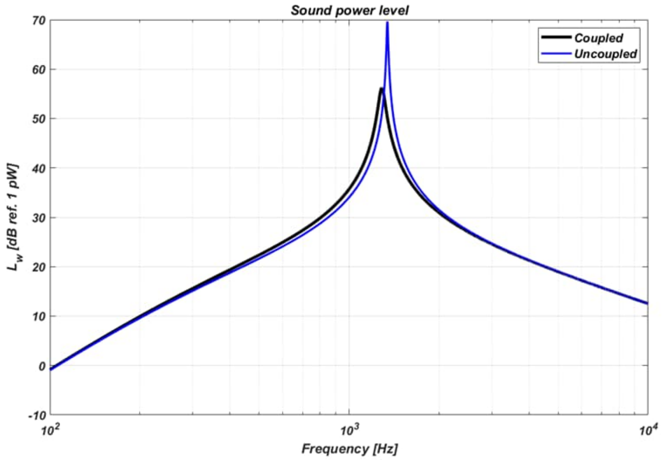
Analytical sound radiation problem solution for hollow pulsating sphere immersed in fluid

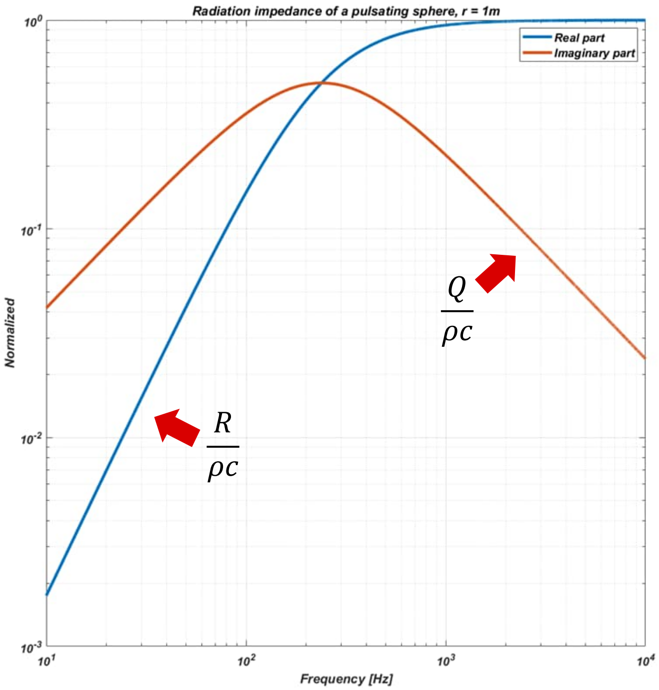
$$-\omega^2(m + m_{rad})u + j\omega c_{rad}u + k(1 + j\eta)u = F \qquad c_{rad} = RA, m_{rad} = \frac{QA}{\omega}$$

An example:

- Steel sphere of 1 m radius, wall thickness 5 cm, $F$ = 1 N, $\eta$ = 0.01
- Immersed in water

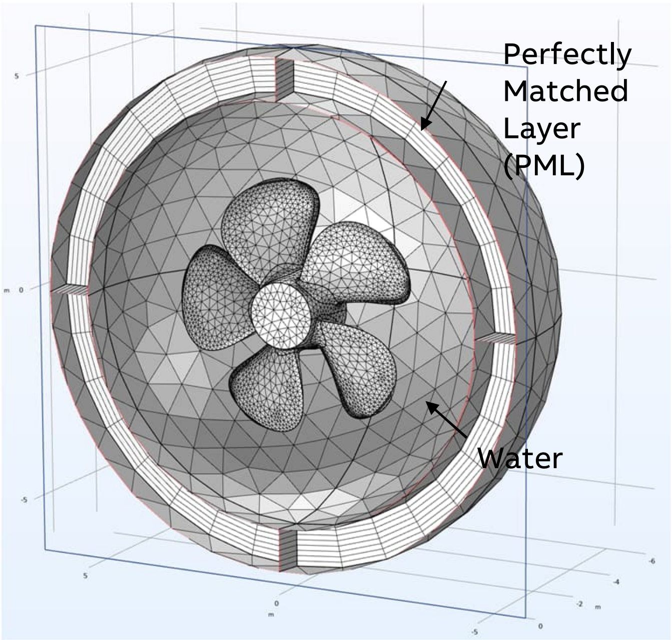


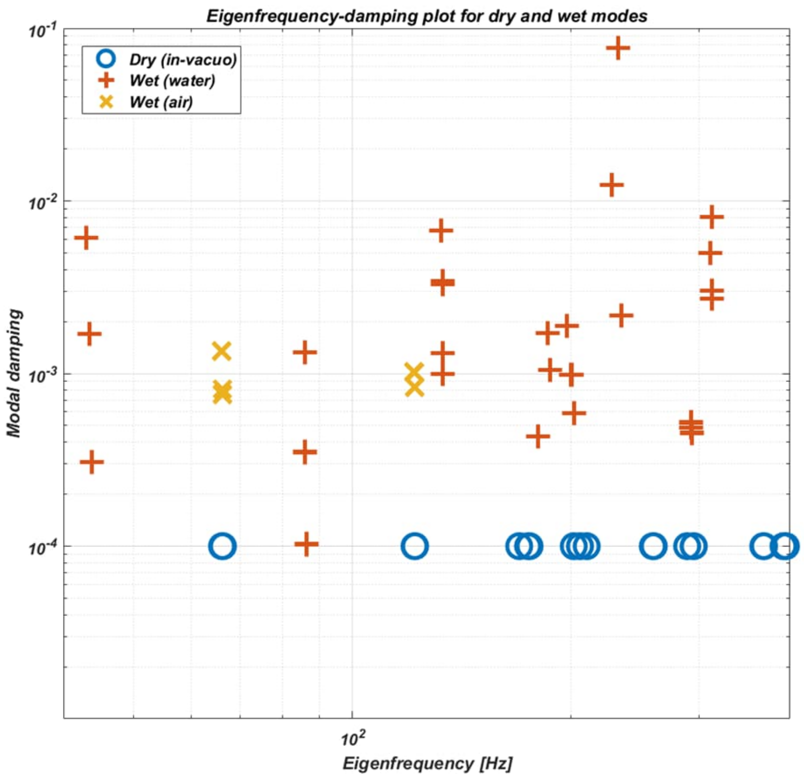


# Fully coupled URN simulations

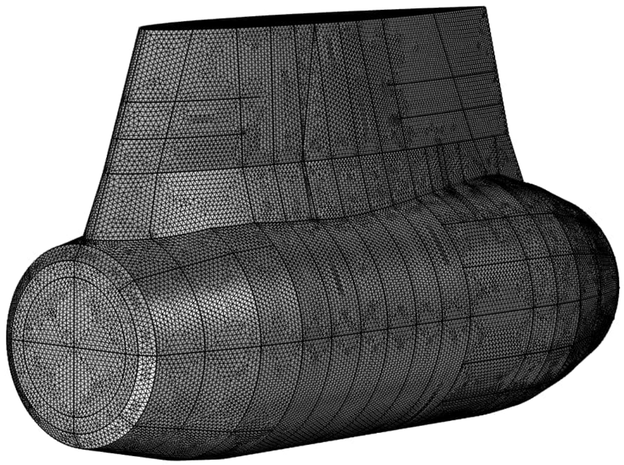
Dry vs. Wet eigenmodes

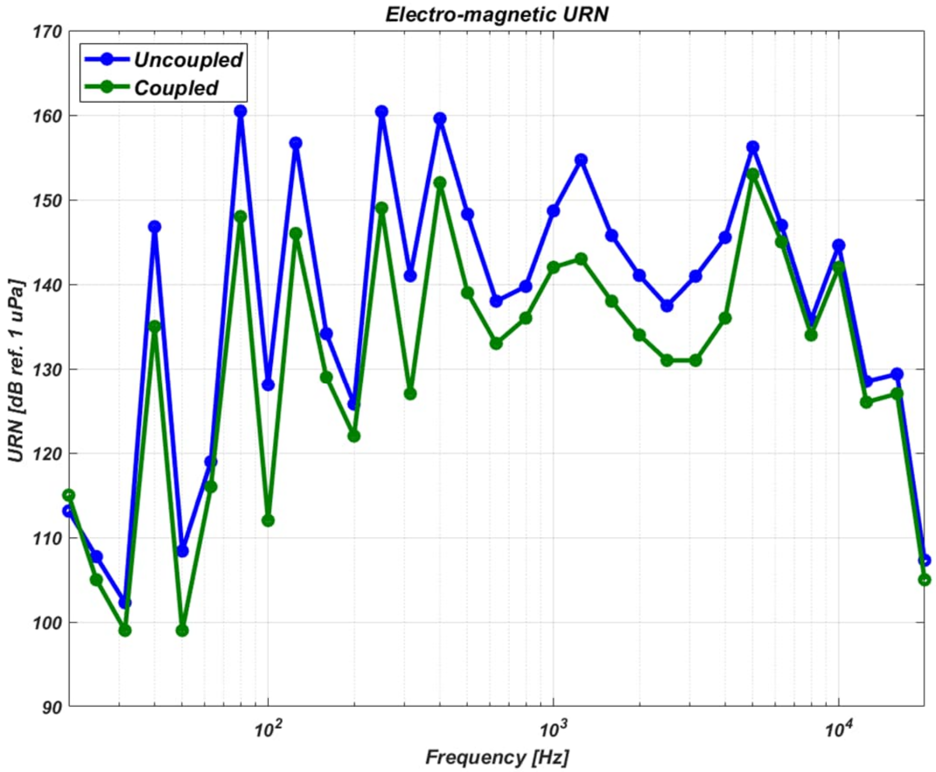


# Fully coupled URN simulations

Electro-magnetic URN







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# CLUE - Continuous Logging of Underwater noise Emissions

## Why measure underwater noise continuously?

- Currently, underwater noise is measured only during seatrials.
- URN is normally measured in **far-field** using stationary hydrophones with a distance to the ship (costly & comprehensive procedures).
- Verification measurements are usually based on a set of two fixed operating conditions (11 knots and 80% MCR)
- URN emissions during off-design conditions are largely unknown
- DNV's simplified methology (**near-field** method) using pressure sensors mounted through the hull increases flexibility
  - ✓ Cost-effective and enables continuous monitoring of URN (propeller noise)
  - ✓ **However, podded vessels have a larger range of characteristics which currently is not well captured by the near-field method (electro-magnetic noise)**

# CLUE - Continuous Logging of Underwater noise Emissions

How to measure underwater noise from a vessel with Azipods continuously?

- CLUE is an initial development study, prototype design of measurement system for URN which will be built and tested in-situ with a vessel using Azipod propulsion (duration 2 years – started 1.4.2022).
- Partners: **ABB+DNV+TC (Transport Canada)**
- Real time monitoring of source levels during all operating conditions including acceleration, deceleration and maneuvering of the vessel will be studied.
- The project will develop a system to be able to detect occurrence of unfavourable operating conditions of the vessel causing excessive cavitation or other unwanted effects.
- The current near-field method is augmented by vibration measurements from the motor inside the Azipod.
- Correlation between near- and far-field measurements will improve estimates of noise from the Azipod (calibration)




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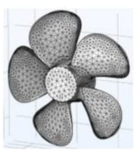
# CLUE - Continuous Logging of Underwater noise Emissions

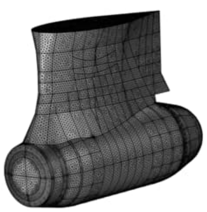
System overview

**PROPELLER NOISE:**

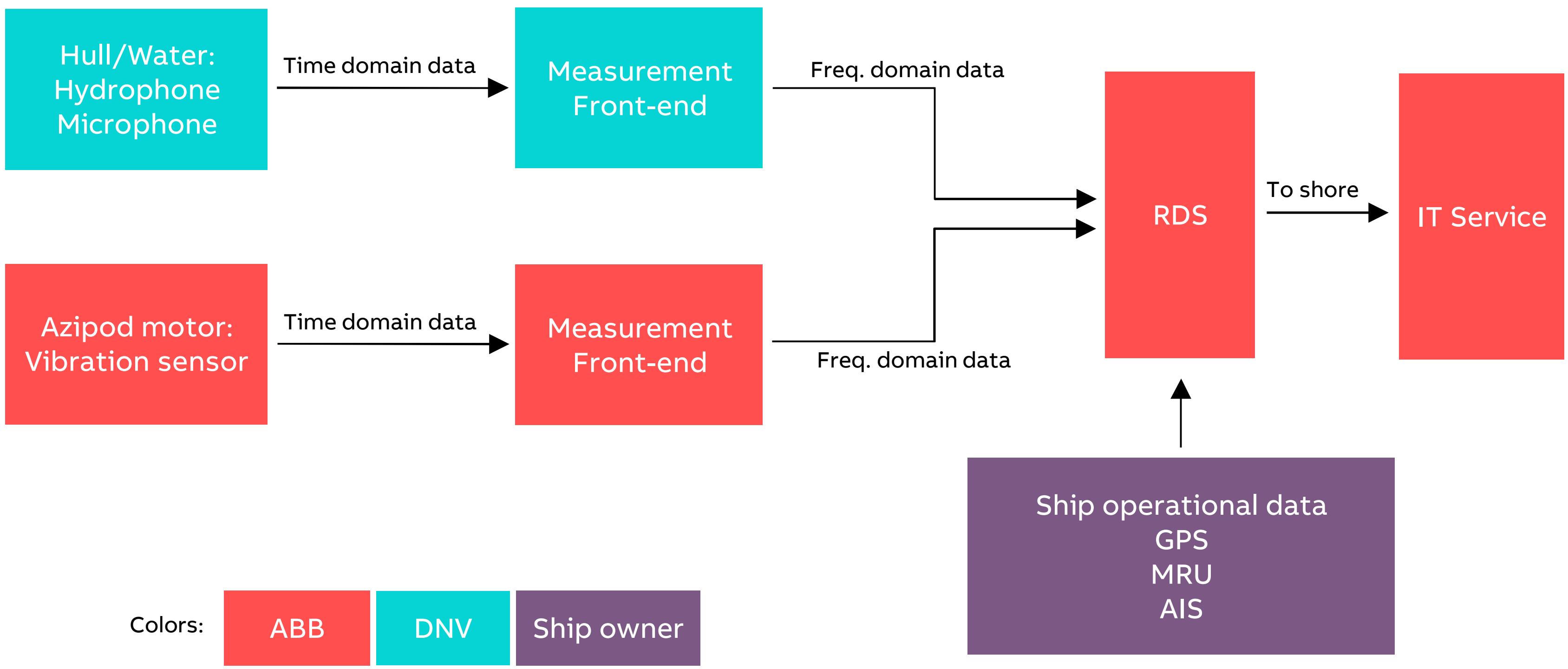


**Digital Twin**

**MAGNETIC NOISE:**

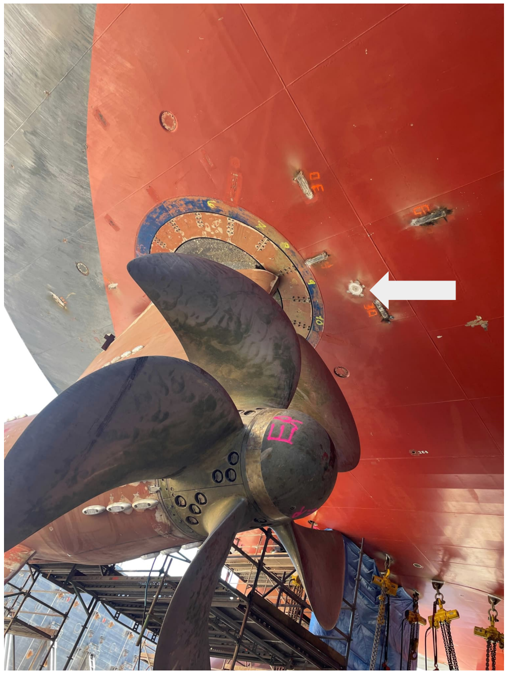


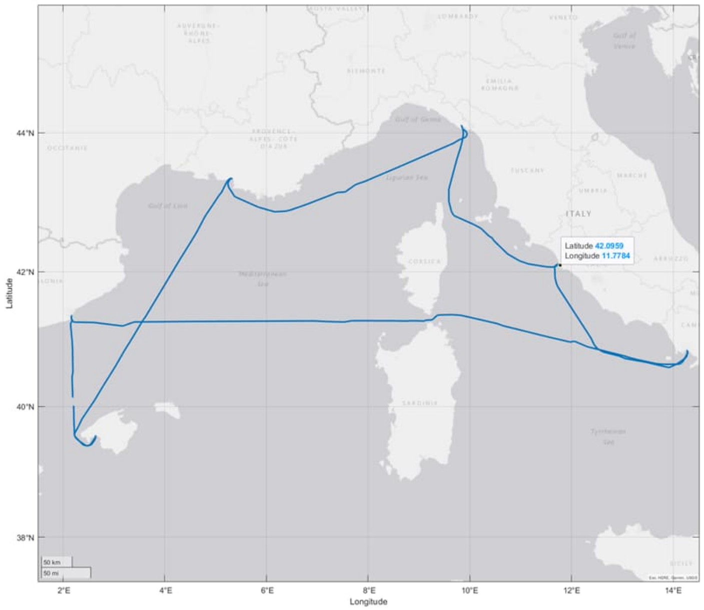
**Digital Twin**



# CLUE - Continuous Logging of Underwater noise Emissions

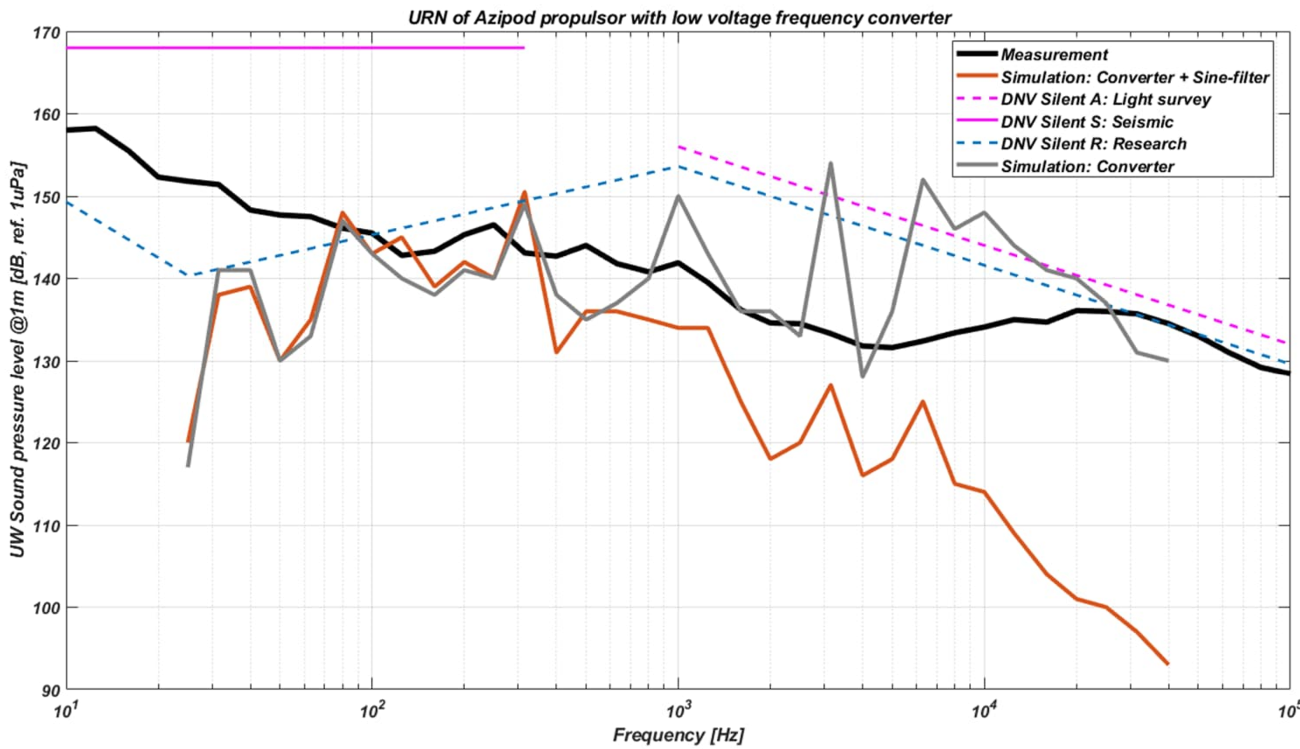
Data collection/measurement period 1.4-15.10.2023





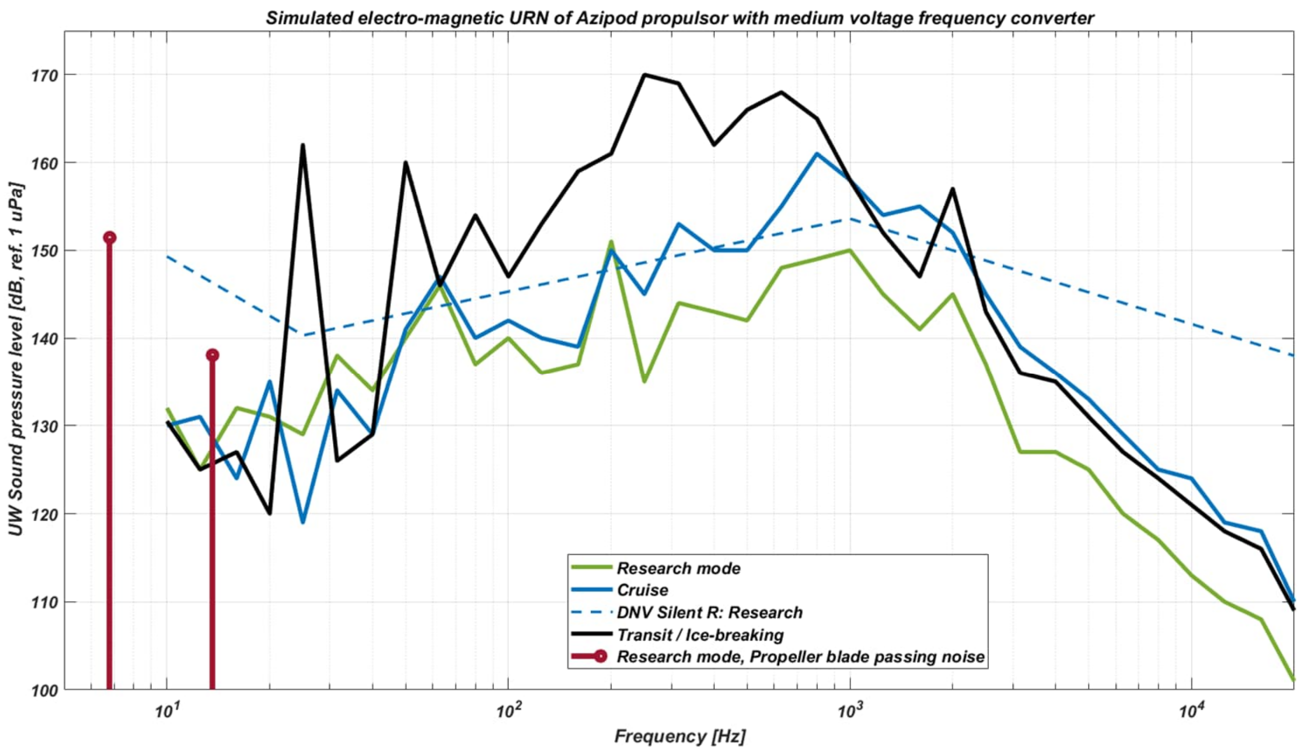
# Silent designs for research vessels

Research vessel with low voltage propulsor



# Silent designs for research vessels

Research vessel with medium voltage propulsor



# Takeaways

1. In order to estimate Azipod propulsor electro-magetic URN reliably, fully coupled approaches should be used in the simulations
2. Fully coupled simulations require more memory and processor power than uncoupled cases, but this is not an issue with modern computer platforms
3. Project CLUE serves the following goals:
   - ✓ Developing the near-field methdologies further by improving the URN sensing accuracy for Azipod propulsors
   - ✓ Advanced condition monitoring methods for propeller cavitation, propeller singing, etc…
   - ✓ On-line URN monitoring system could be useful for research vessels also
4. ABB has made intensive research on URN of Azipod propulsors already for more than a decade and developed the product to fulfill the tightest underwater noise requirements.