URN AND TUGBOATS VISION OF A PROPULSION SYSTEM MANUFACTURER

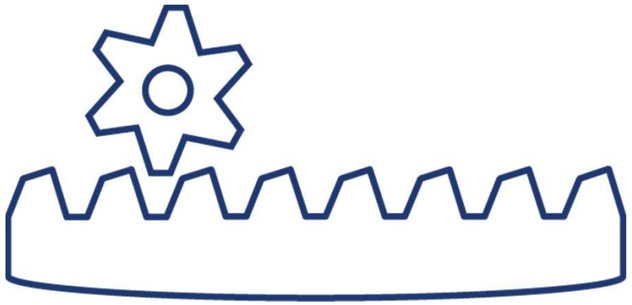
ROBITAILLE SYLVAIN | VICTORIA, BC | 30-06-2024

SCHOTTEL

SCHOTTEL

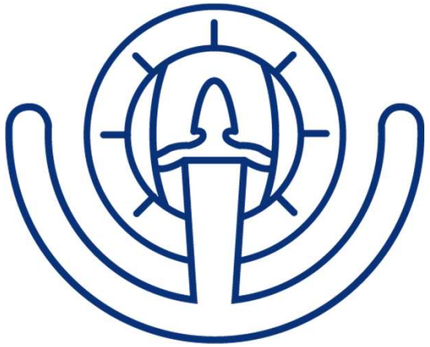
Competence in Customized Engineering

Mechanical design



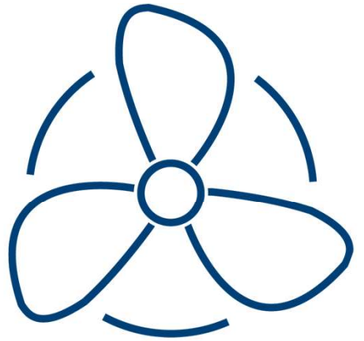
- Mechanical power transmission
- Structural mechanics
- Hydraulics & pneumatics
- Sealing technology

Electrical engineering



- Automation
- Condition monitoring
- Power electronics
- Assistance systems

Hydrodynamics



- Propeller design
- Model testing
- Computational fluid dynamics

SCHOTTEL
Worldwide

SCHOTTEL Canada
Québec
SYLVAIN ROBITAILLE
SROBITAILLE@SCHOTTEL.COM

Wismar
Spay
Dörth

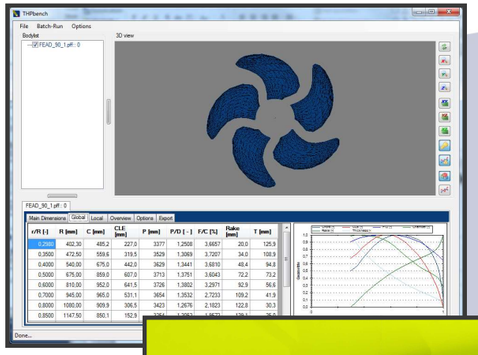
North America
Central America
South America
Europe
Africa
Asia
Australia/ Oceania

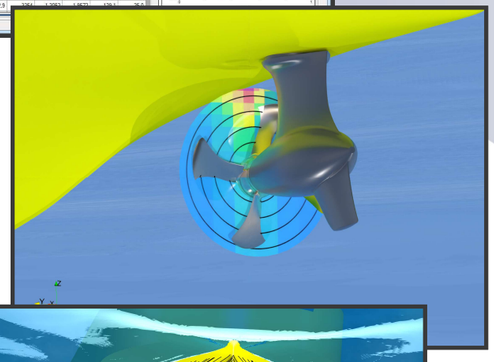
- SCHOTTEL Headquarters
- SCHOTTEL Production Site
- SCHOTTEL Subsidiary
- Sales Agency and/or Service Station

SCHOTTEL
Propeller Designs

Every SCHOTTEL propeller design is customized and unique

Optimization of propeller geometry

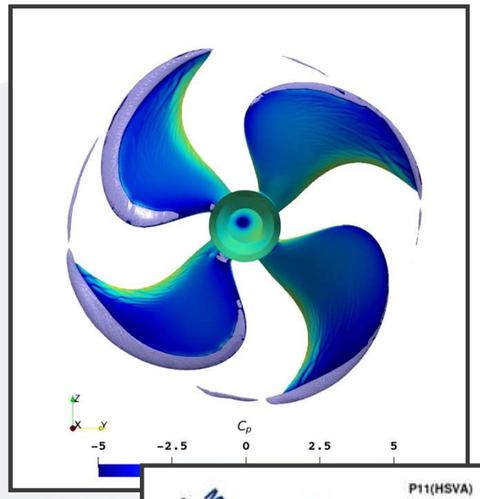




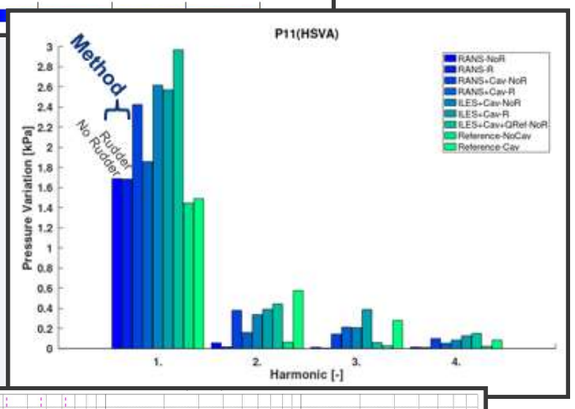
Propeller performance

Propulsion prognosis

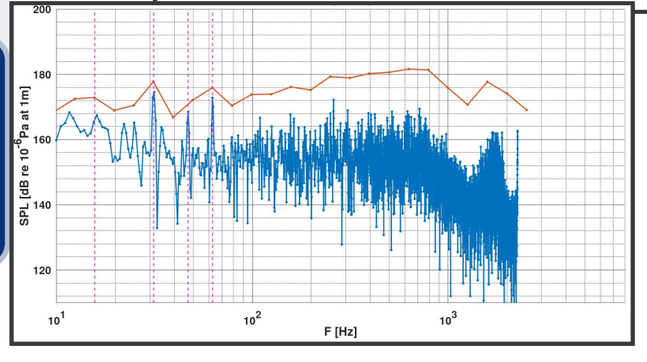
Cavitation prediction



Pressure pulse prediction



URN Signature

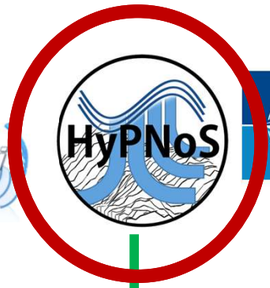


SCHOTTEL

Timeline of SCHOTTEL Underwater Noise Research Activities

Research projects

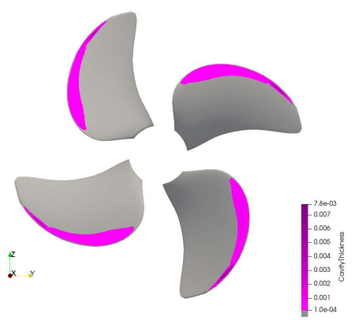
AVT-320



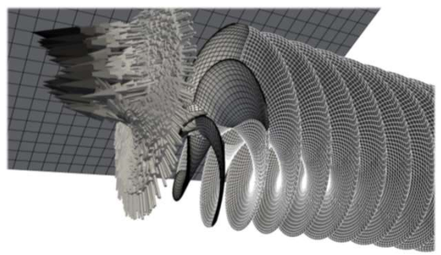
AVT-386

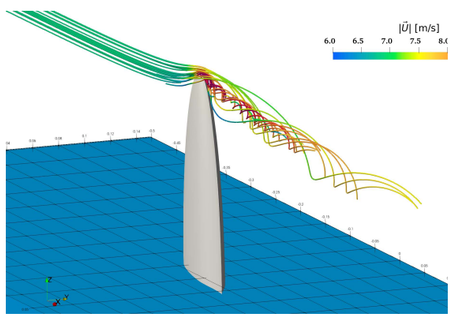
Methods

- Vortex-Lattice based propeller cavitation
- RANS single-phase cavitation
- Empirical pressure pulses
- Analytical pressure pulses at 1. harmonic
- Modal analysis

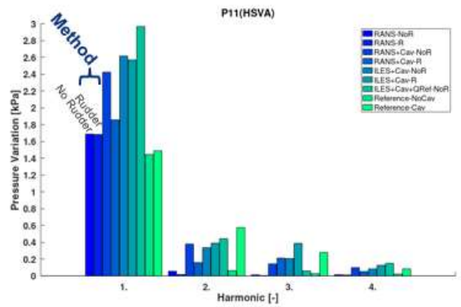


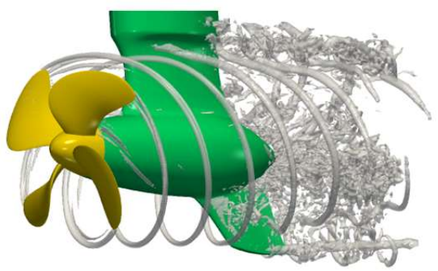
- BEM cavitation
- RANS two-phase cavitation
- LES



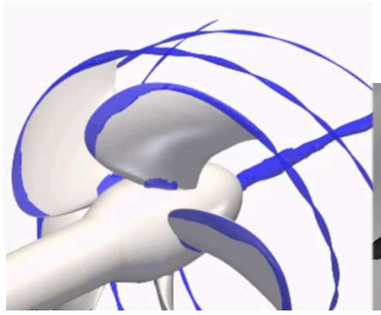


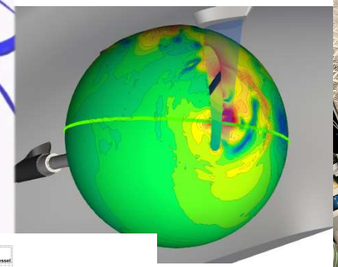
- CFD pressure pulse prediction
- BEM URN signatures
- Trailing vortex

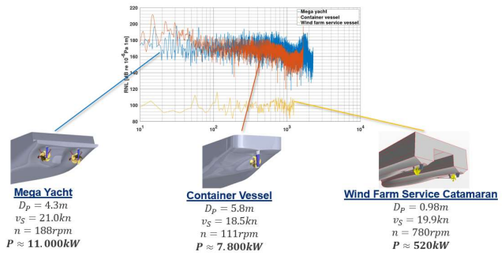




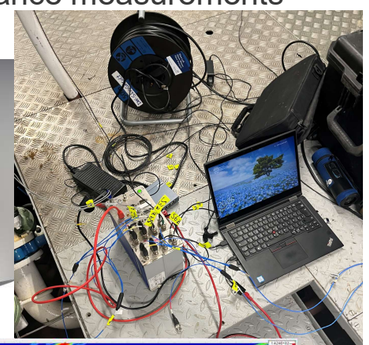
- LES trailing vortex cavitation
- CFD URN signatures
- Frequency Response Analysis

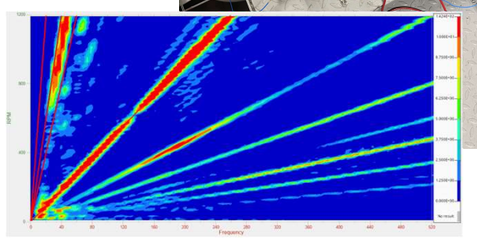






- CFD sound directivity
- Gear/Bearing noise
- Multi-Body simulation
- URN Measurements
- Vibration measurements
- Acoustic impedance measurements



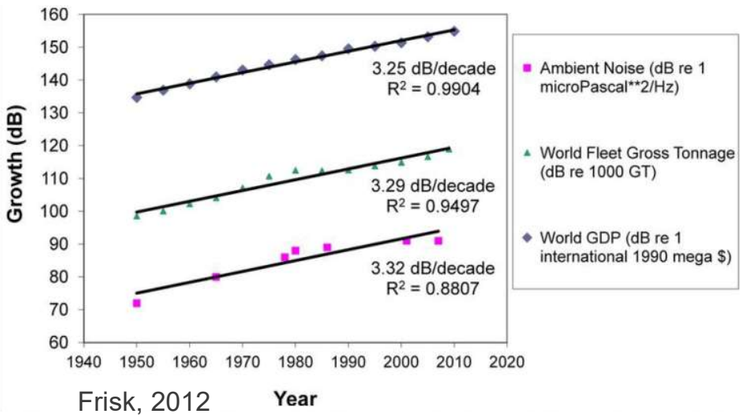


UNDERWATER RADIATED NOISE

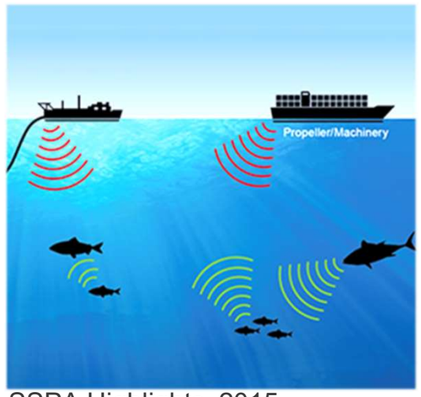
Underwater Radiated Noise

Motivation

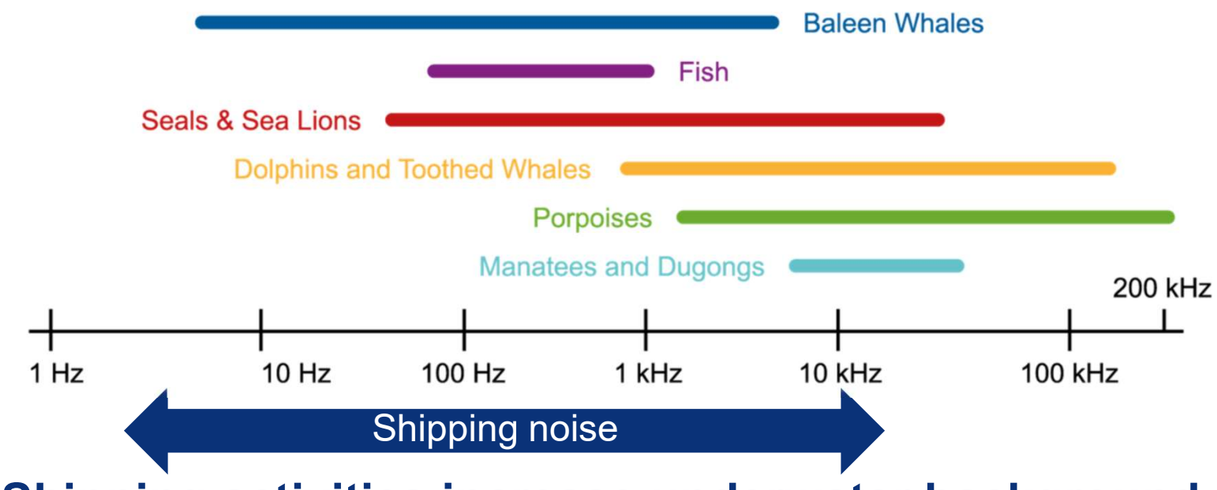
Protection of the Environment

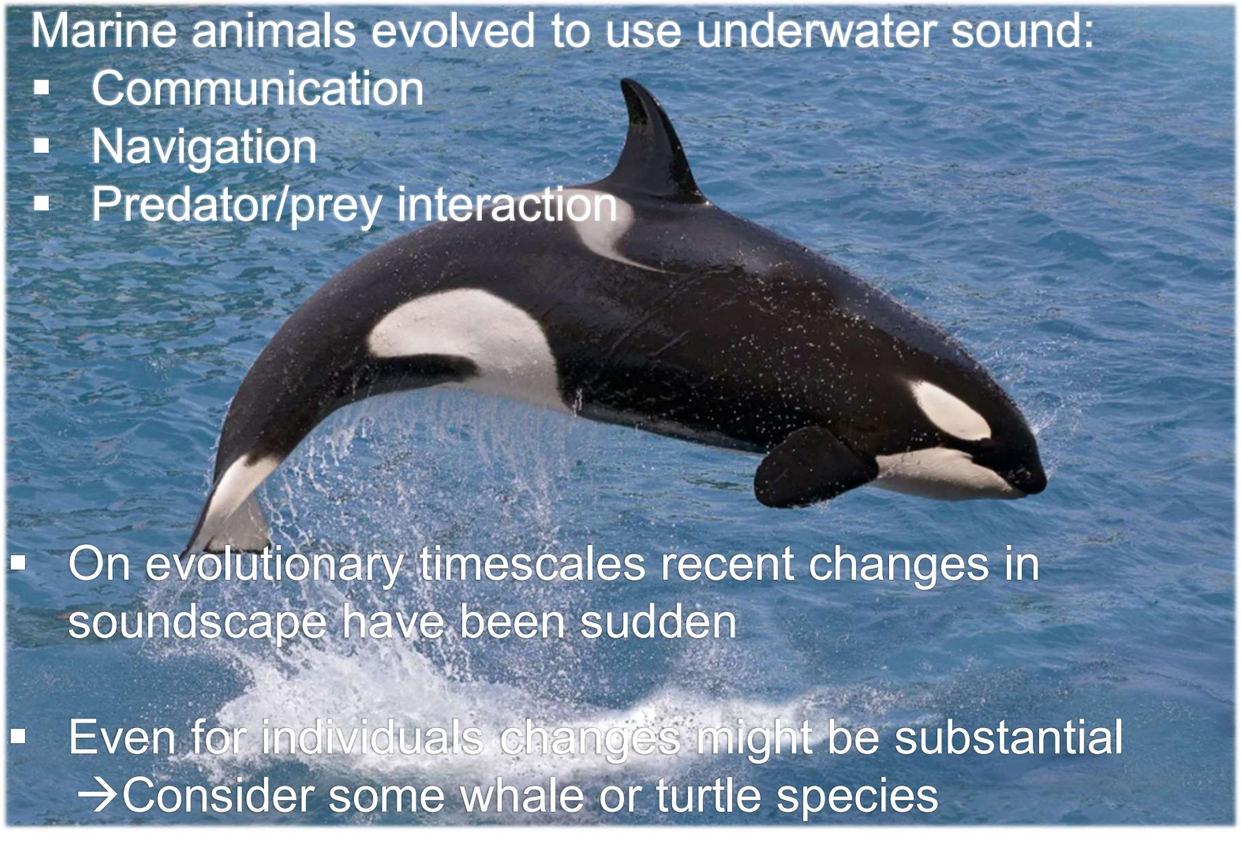


Frisk, 2012



SSPA Highlights, 2015





Shipping activities increase underwater background noise level by an estimated 20 to 30 dB (10 - 300Hz)

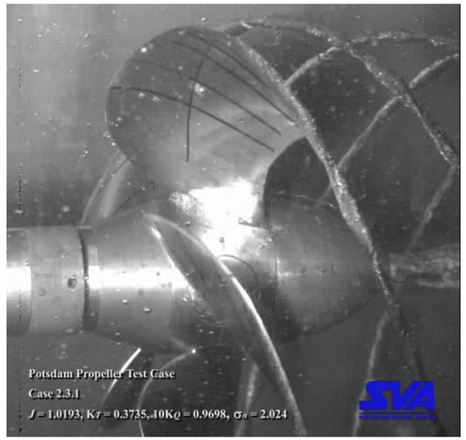
Underwater Radiated Noise

Noise Sources

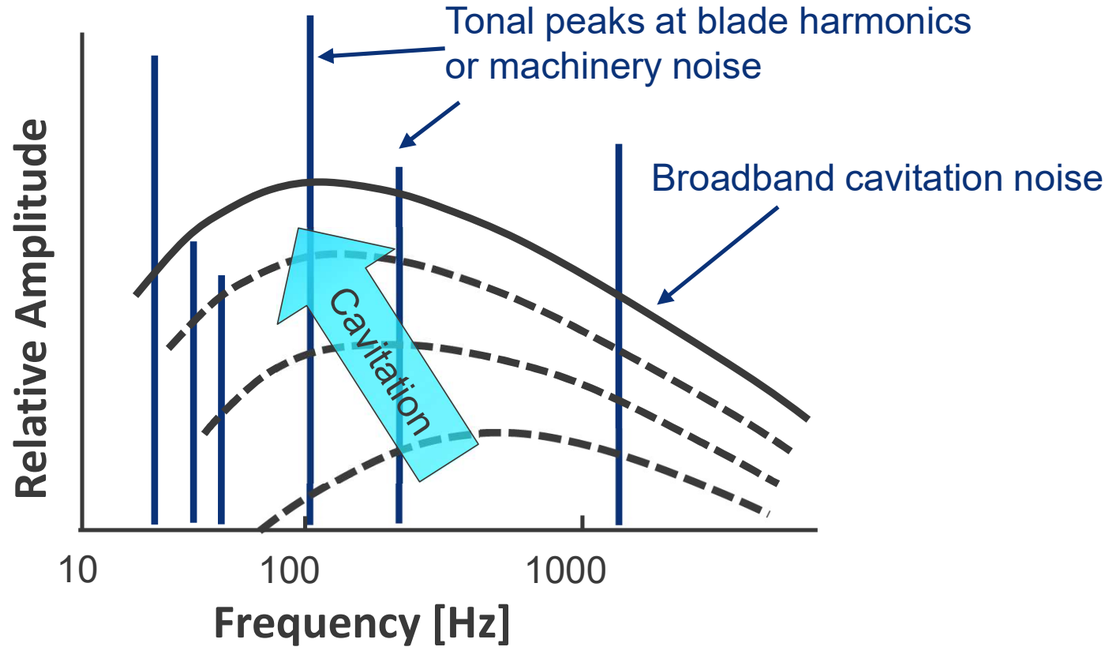
Severity

- Vessel moving through water
- Vessel wave pattern
- Turbulence in vessel wake
- Propeller displacement and thrust
- **Cavitation + cavitating vortices**
- Machinery: Gears, Bearings, Engines, …
- Electronics: VFD, E-Motor

Example propeller cavitation in model test



Theoretical ship noise spectrum

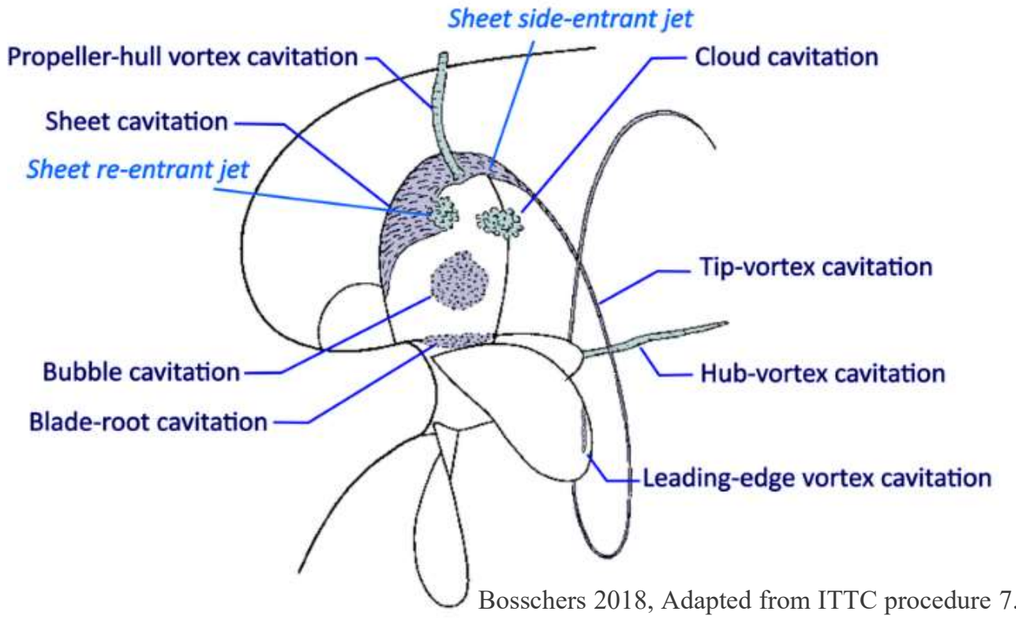


Underwater Radiated Noise

Cavitation

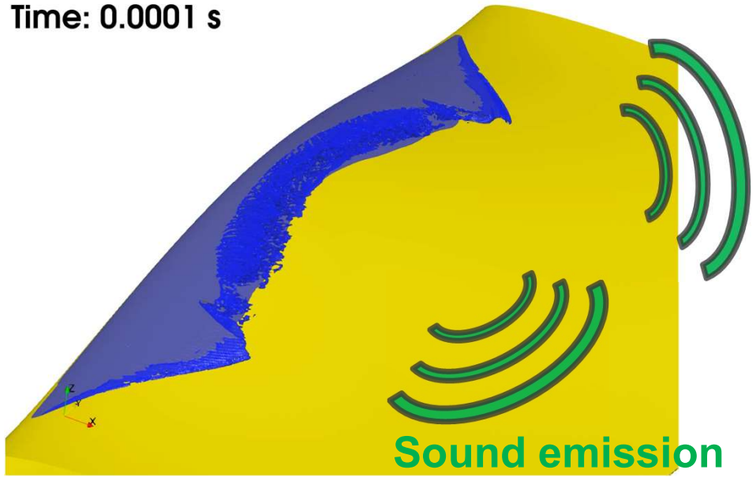
*"Most of URN is caused by **propeller cavitation**, but **onboard machinery** [is] also relevant"*

– IMO, Revised guidelines for the reduction of underwater noise from commercial shipping to address adverse impacts on marine life, 2023



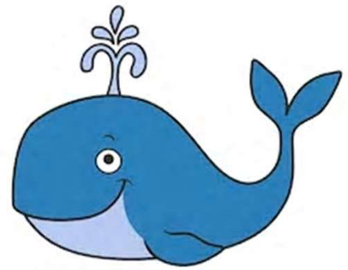
Bosschers 2018, Adapted from ITTC procedure 7.5-02-03-03.2

Fluctuating cavitation on hydrofoil



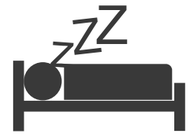
Sound emission onto structure

Sound emission into fluid

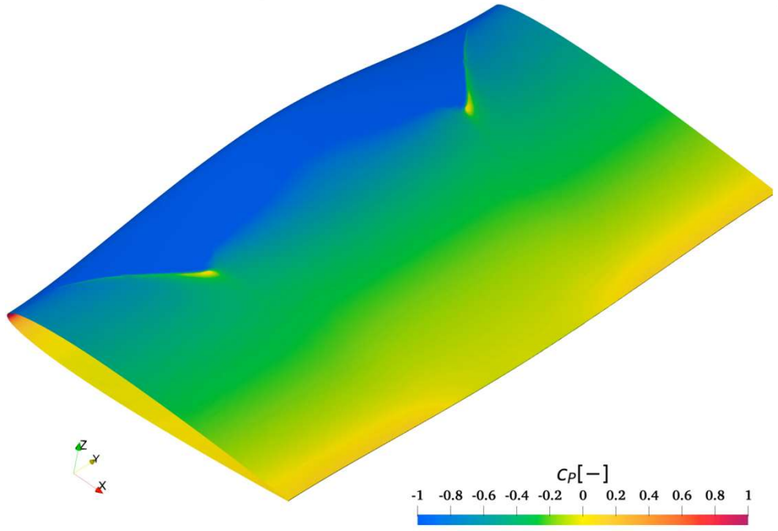


Structure Borne Noise

→Human comfort onboard ship



Corresponding Pressure on Hydrofoil



Underwater Radiated Noise

Upcoming Regulatory Framework

IMO 2023

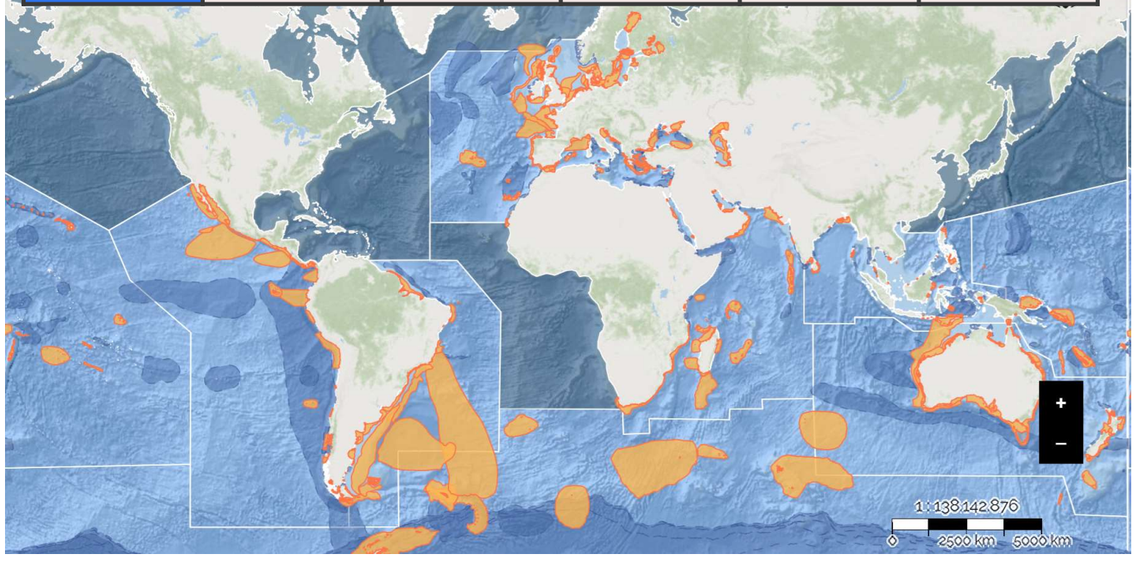
- Requirement of **baseline URN signature**
- Incentivization of **monitoring** along shipping lanes
- Implementation of **restricted zones**:
  - IMMAs (Important Marine Mammal Area)
  - PSSAs (Particularly Sensitive Sea Area)
  - Local restrictions by governments

Transport Canada

- Request for **on-board live monitoring**

→ Call for research proposals 2021

Class	ABS	BUREAU VERITAS	DNV	LR	RINA
Onboard Noise	COMF, HAB, MLC-ACCOM	COMF	COMF, VIBR	PAC, CAC, PCAC	COMF-NOISE, -VIB
(Underwater) Radiated Noise	AIRN, UWN, SUSTAIN	URN	SILENT	UWN	DOLPHIN

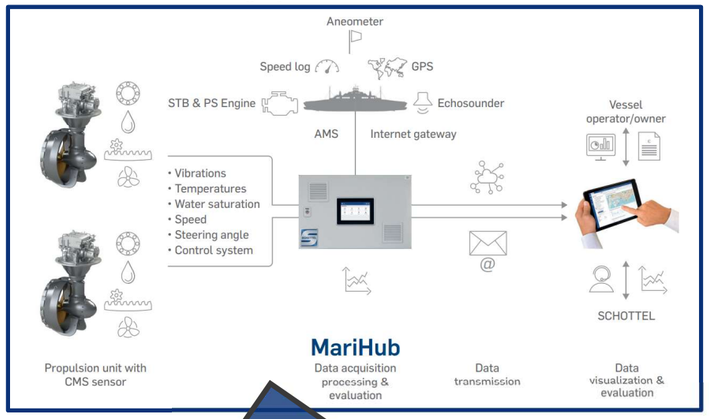


HYPNOS - CONCEPT

HYPNOS - CONCEPT

Theory

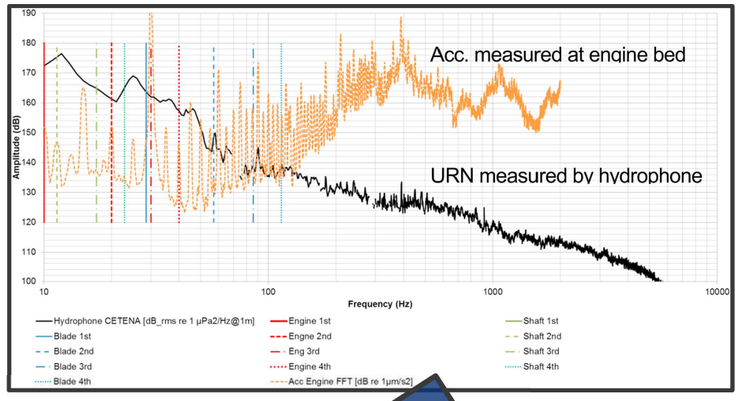
„SCHOTTEL MariHub, IoT & Monitoring system“, SCHOTTEL 2021



Hydrodynamic Propeller Noise Monitoring System

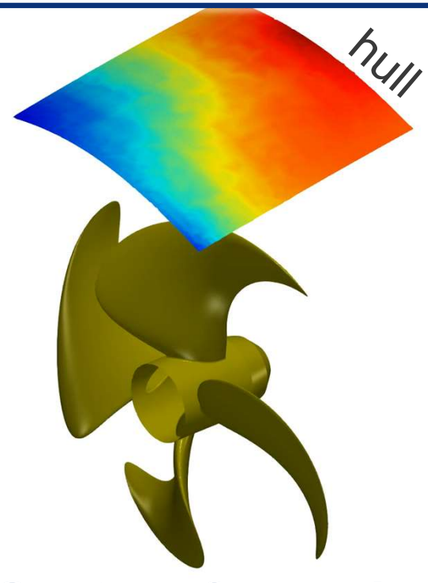
On-board vibrations for URN estimation

“On-board measurement techniques to quantify underwater radiated noise level”, Turkmen et Al., Ocean Engineering, 2017



Condition monitoring technology

Technology established in field



Correlation between structure-borne noise and URN

Known from experimental data

→ Functional Prototype System for on-board URN live monitoring

HYPNOS - CONCEPT

Input and Calibration

Estimation of URN

- Requires calibration for each vessel
- Accuracy depends on input parameters

Installed System

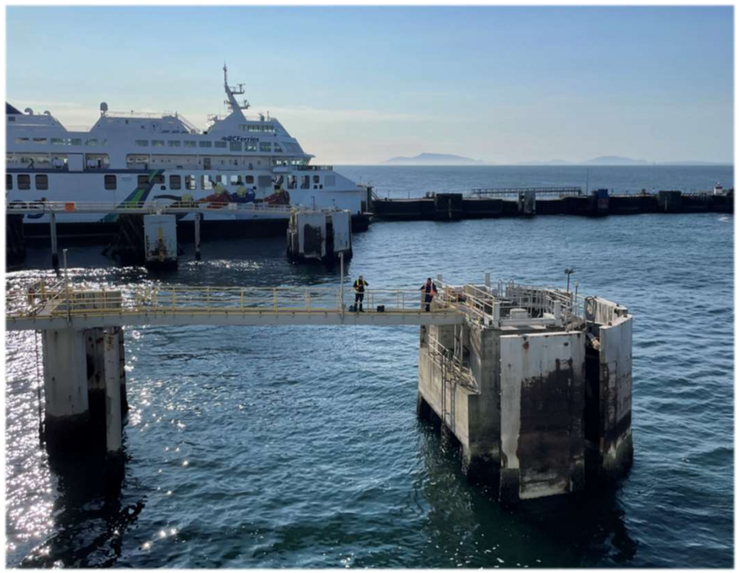
Calibration

Relevant operation:
- Vessel speeds
- Vessel draft
- Water depths
- Near structures
- …

Input

Improves prediction:
- **Vibration (min.)**
- **Internet**
- rpm
- Pitch
- Position
- Rudder angle
- Power
- Speed in water
- Draft
- Trim

Calibration at Berthing



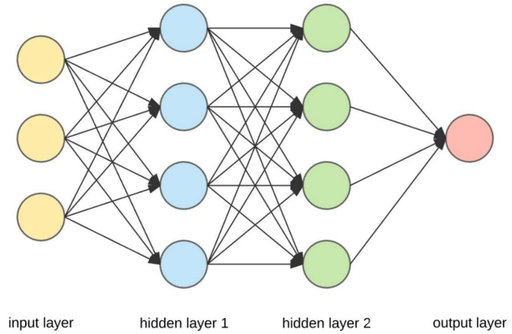
Calibration in Transit

HYPNOS - CONCEPT

Usability

Data Processing

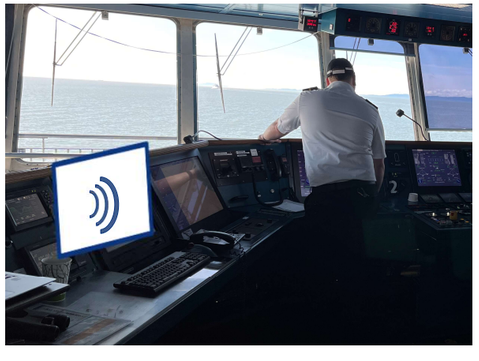
- On-board measurement and processing
- Cloud-based storage and evaluation
- AI-ready processing (depends on calibration data)
- Continuous improvements with over-the-air updates



Data Output

- Live Feedback to crew or operator
- Historic evaluation of vessel noise
- Fleet scale noise management

Option 1
Bridge Panel



Option 2
Bridge Computer

Option 3
Mobile Device

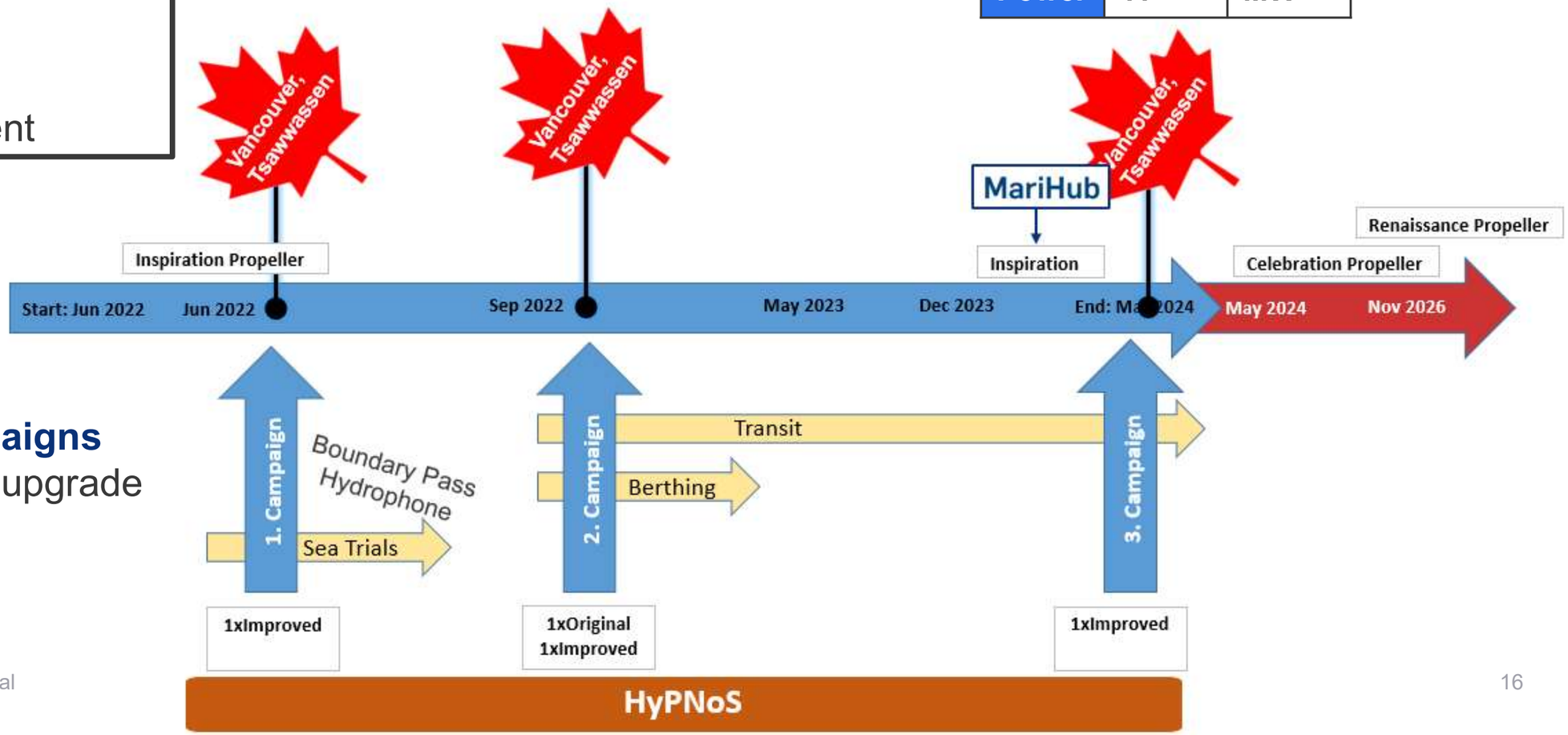
HYPNOS - CONCEPT

Timeline of Research Project

1. Simulations and measurements
2. Developing the algorithm
3. Installing prototype
4. Validation measurement

BCFerries

L_{OA}	159	m
Width	27.4	m
Draft	5.3	m
Power	11	MW



3 Measurement campaigns

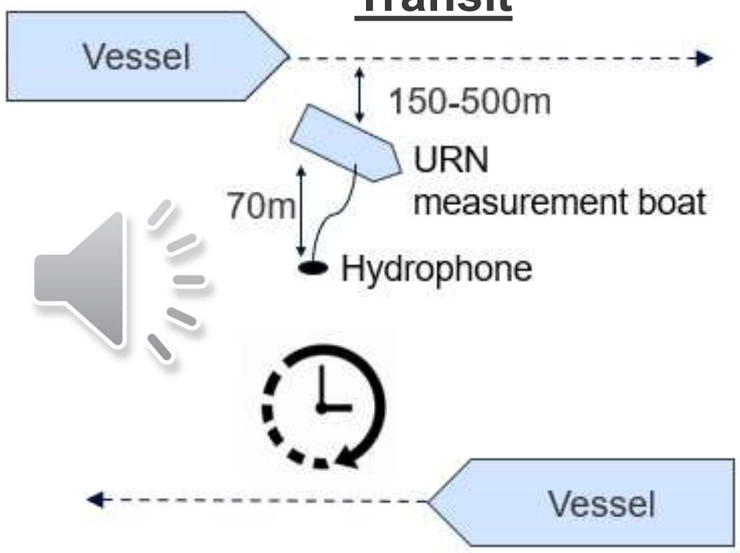
Connected to quarter life upgrade

HYPNOS - DEVELOPMENT

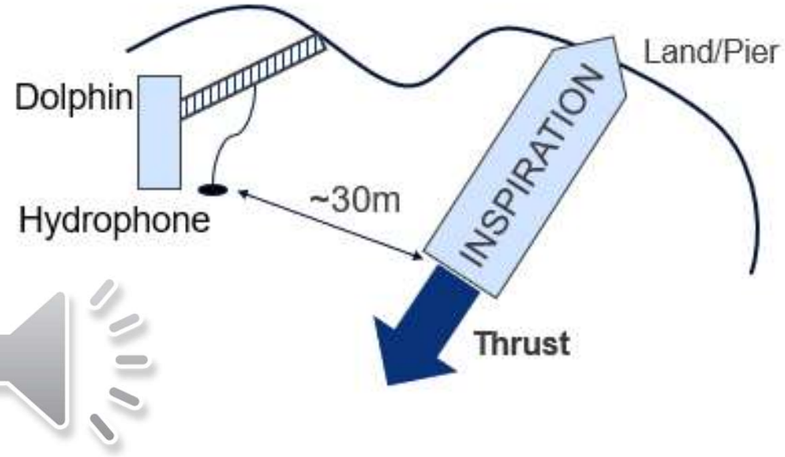
HYPNOS - Development

Measurements

Transit

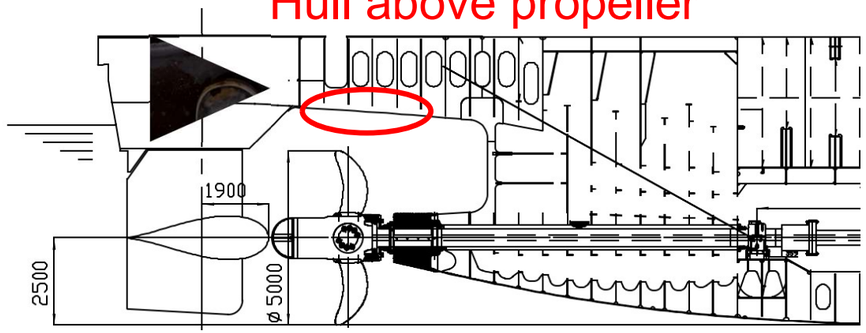


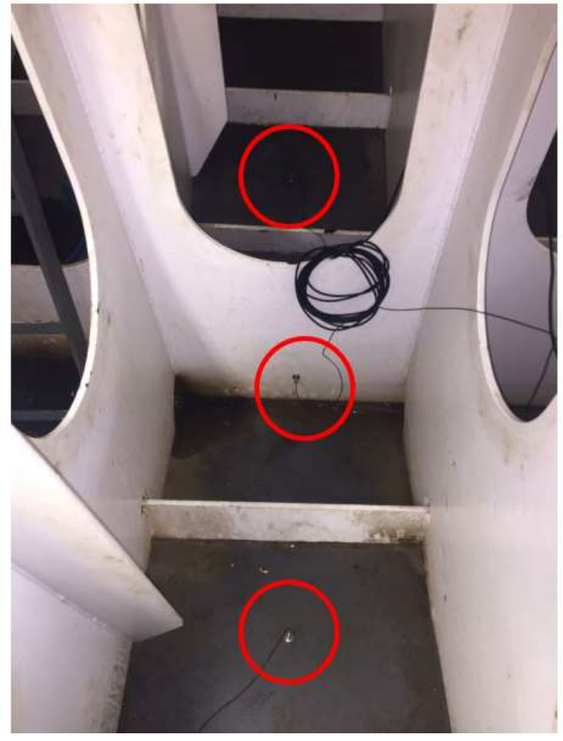
Berthing



On-Board

Hull above propeller





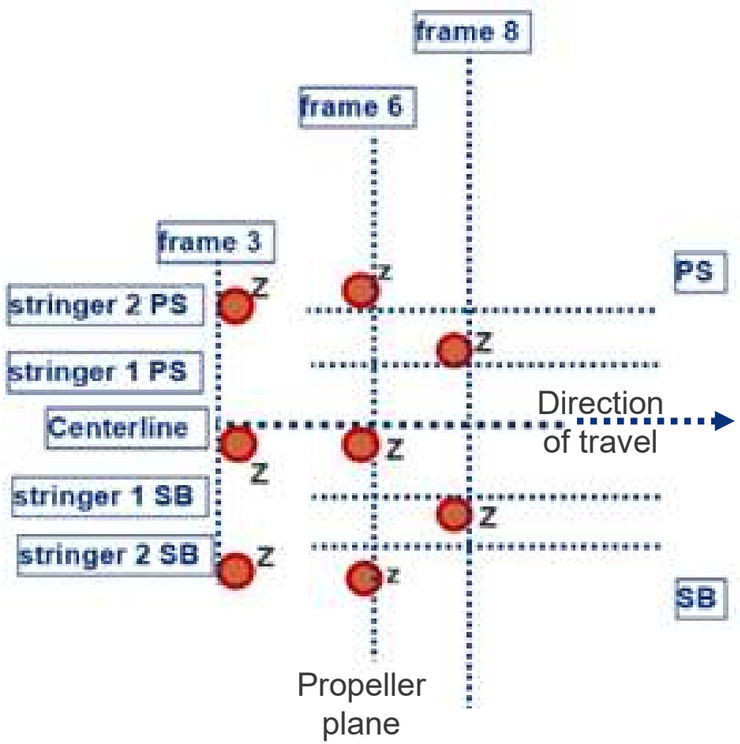
HYPNOS - Development

Vibration Data

Measurement Locations

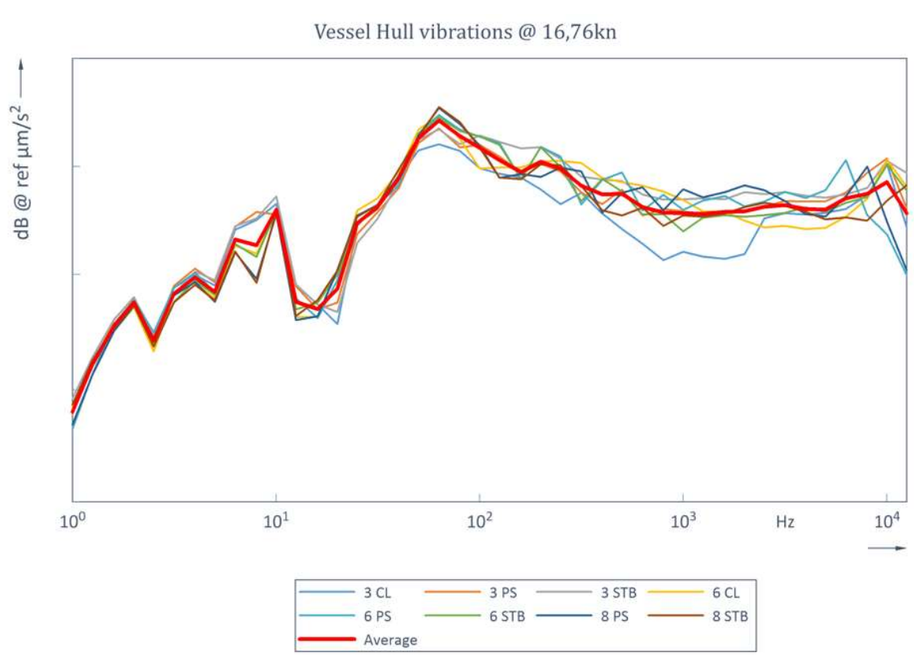
- Initial vibration measurements with 8 measuring locations and 12 sensors
- Reduced to 2 for final system

Map of vibration sensors above propeller

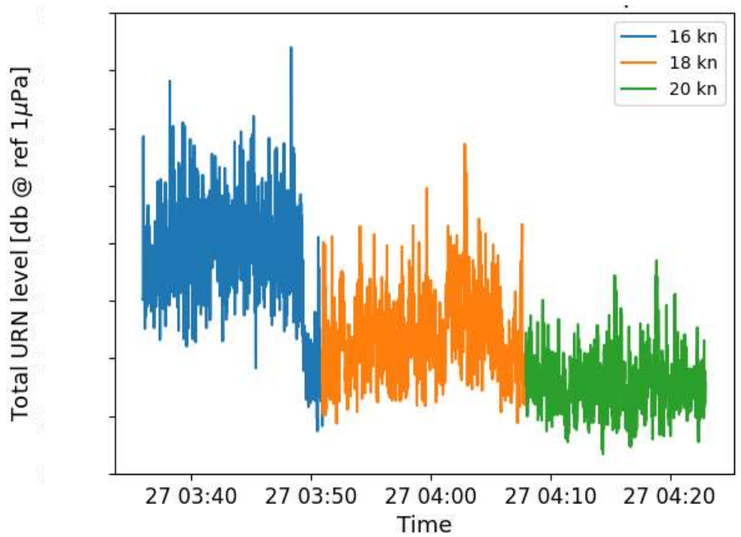


Very high correlation between sensors

→Only one sensor needed for final system



Change of vibration pattern with vessel speed



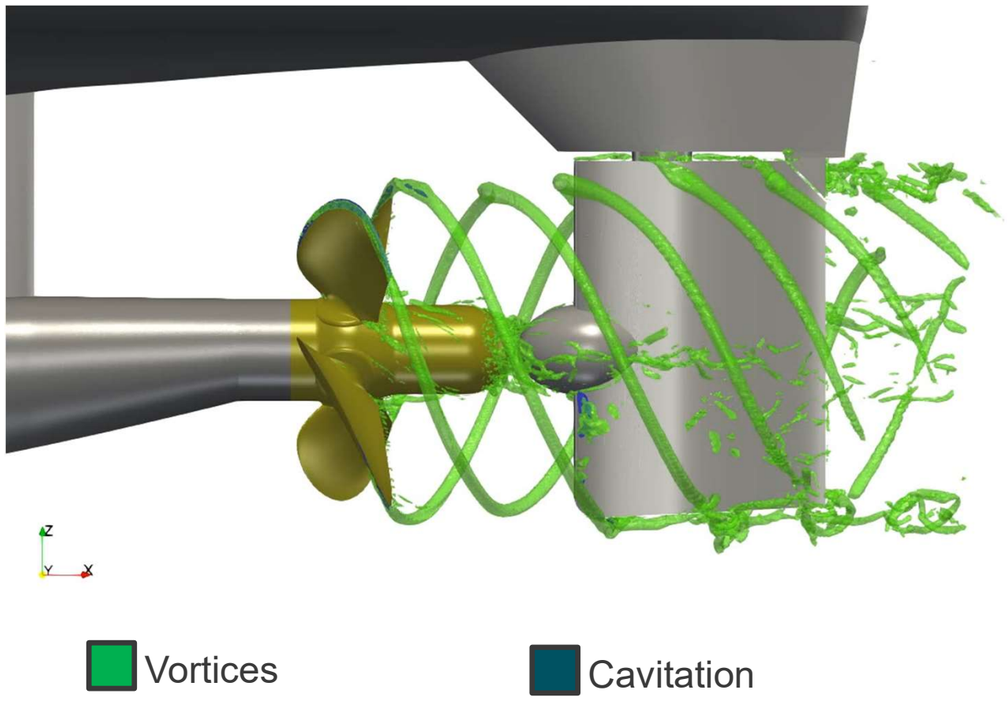
HYPNOS - Development

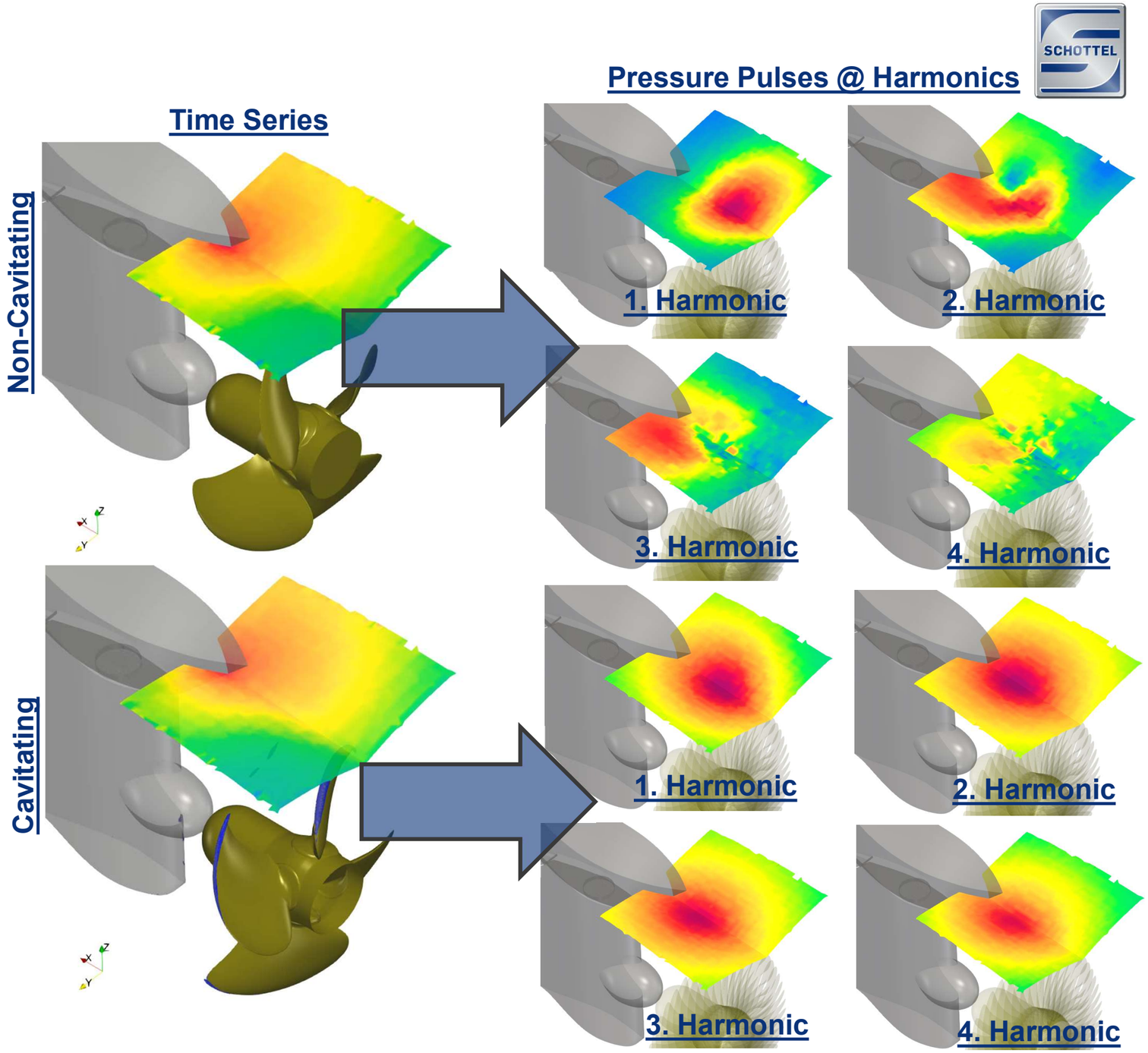
Hull Vibration Simulations

Pressure Pulses on Hull

→Hydrodynamic On-Board vibrations contain:

- Propeller
- Vessel
- Cavitation



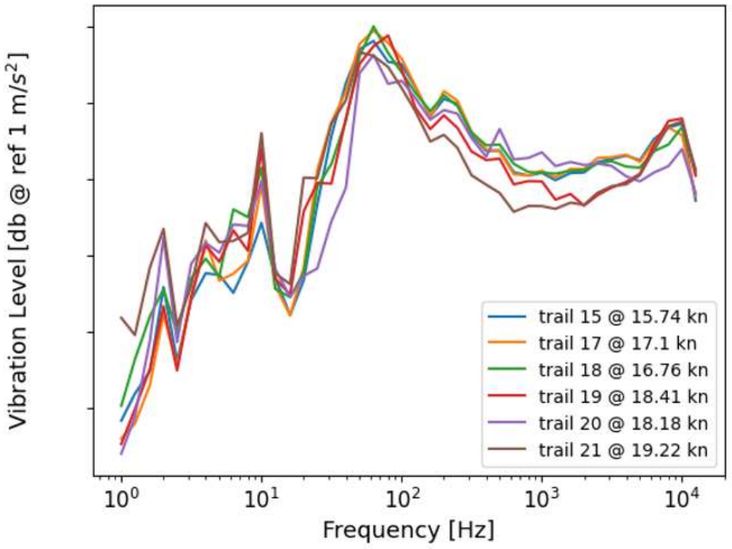


HYPNOS - Development

Prediction Algorithm

Vibration data

At different vessel speeds

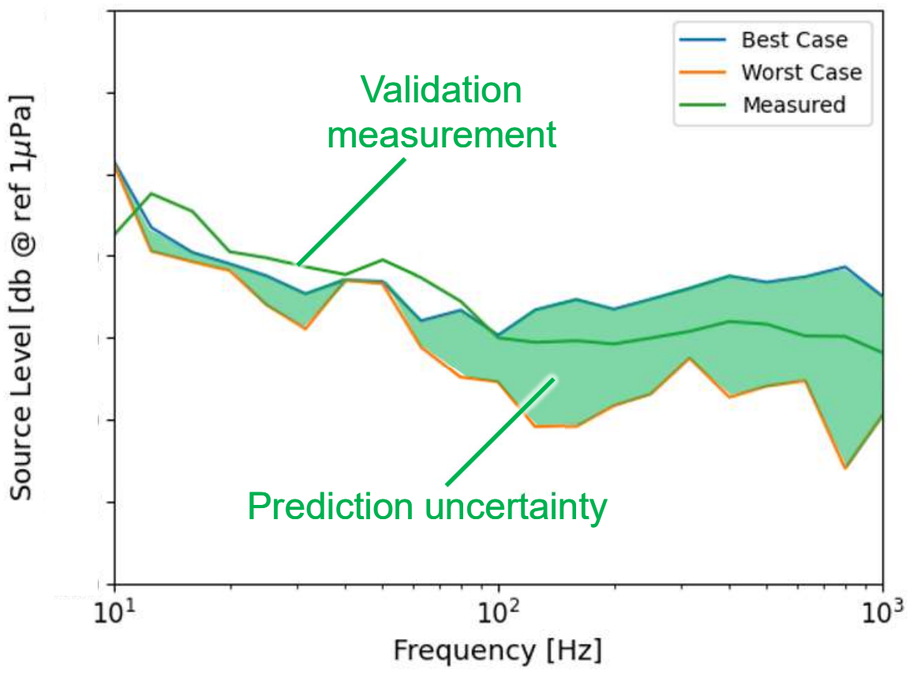


- Comparison of prediction with validation measurement
- at vessel design speed

Research with one input parameter: Vibration
Not ideal for real application

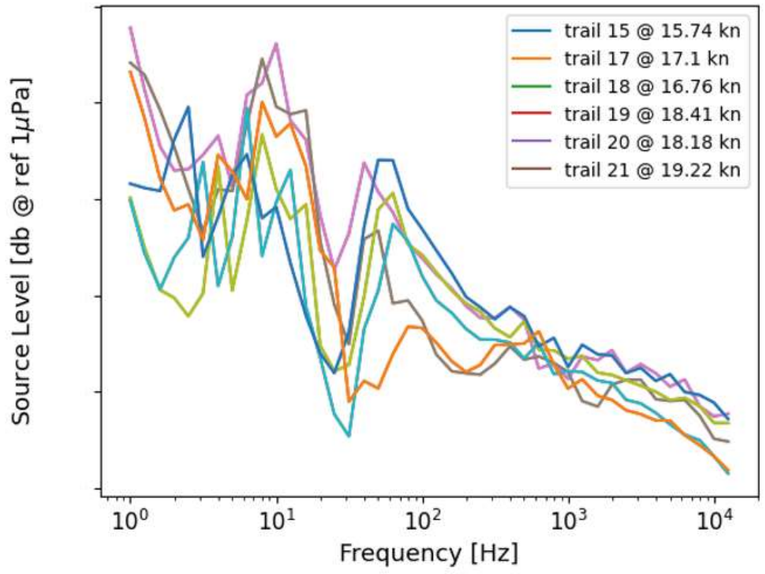
Correlation

Prediction



URN data

At different vessel speeds



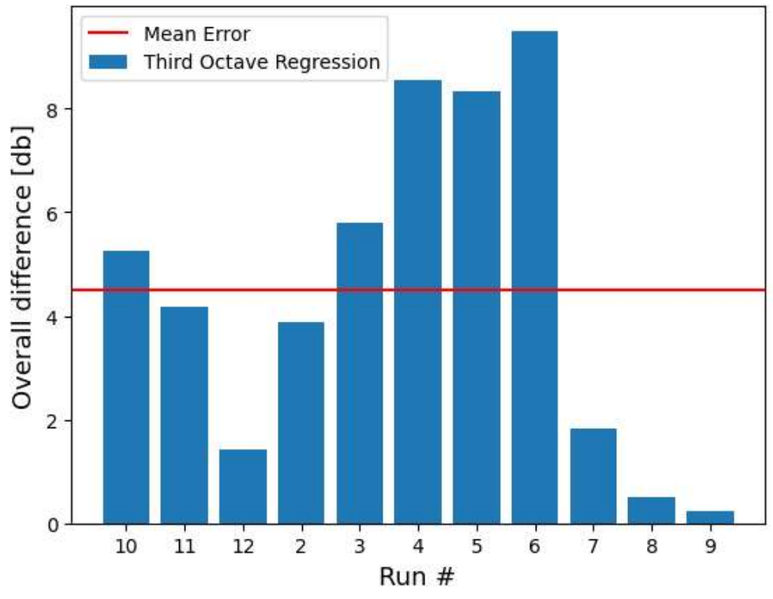
- Good agreement across complete frequency range
- Larger uncertainty at higher frequencies $f > 100Hz$

HYPNOS - Development

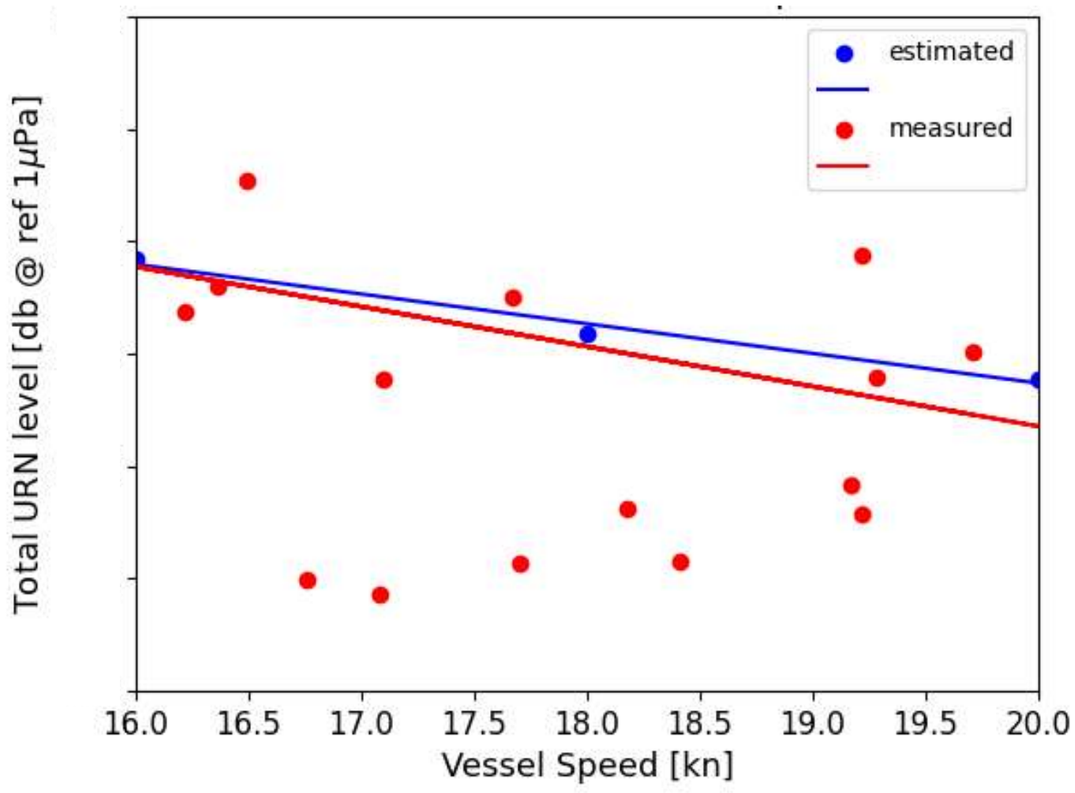
Accuracy

- System achieves mean error of <5dB
- Overall result depends on vessel speed
- Accuracy is vessel specific
- Accuracy increases with:
  - Input parameters
  - Calibration data

Error for different test runs



Accuracy over vessel speed



HYPNOS - APPLICATIONS

HYPNOS - Applications

Example Noise Sensitive Projects

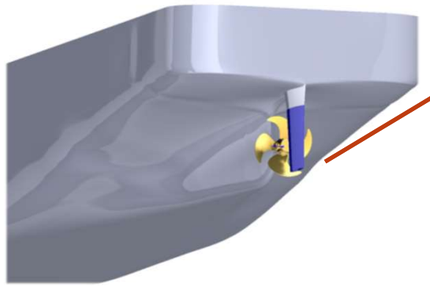
Container Vessel

$D_P = 5.8m$

$v_S = 18.5kn$

$n = 111rpm$

$\boldsymbol{P \approx 7.800kW}$



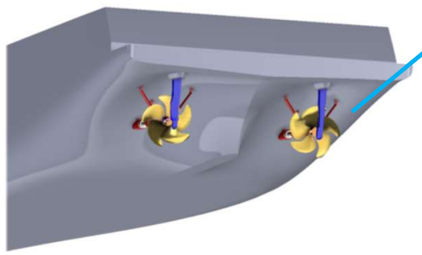
Mega Yacht

$D_P = 4.3m$

$v_S = 21.0kn$

$n = 188rpm$

$\boldsymbol{P \approx 11.000kW}$



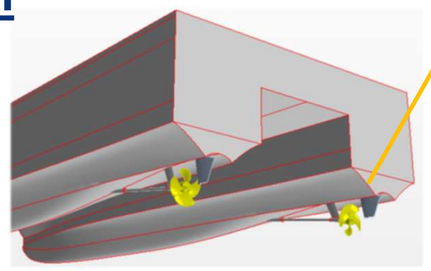
Wind Farm Service Catamaran

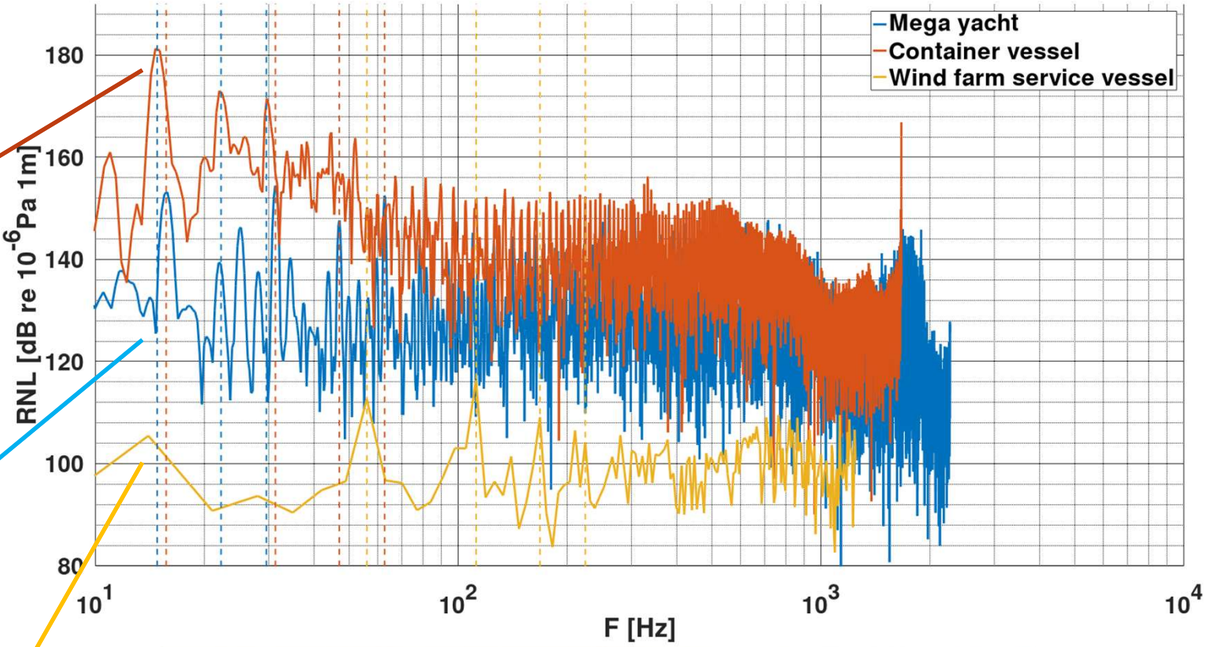
$D_P = 0.98m$

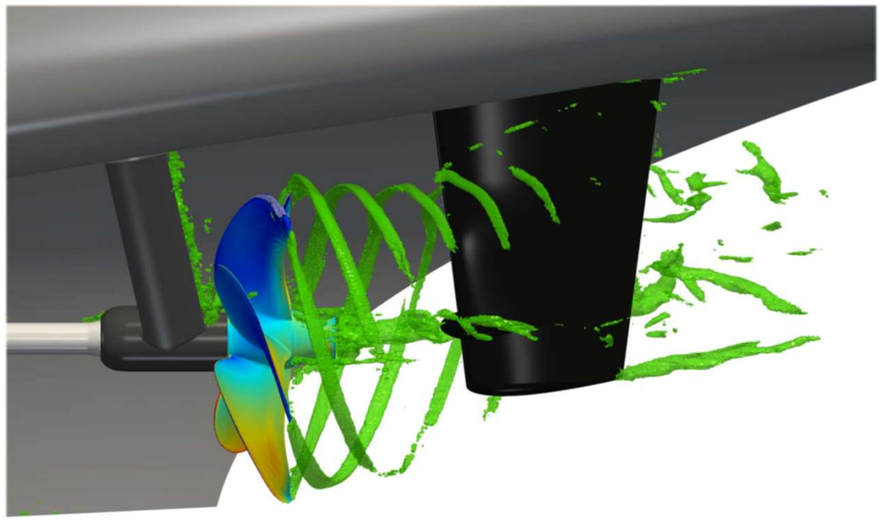
$v_S = 19.9kn$

$n = 840rpm$

$\boldsymbol{P \approx 520kW}$





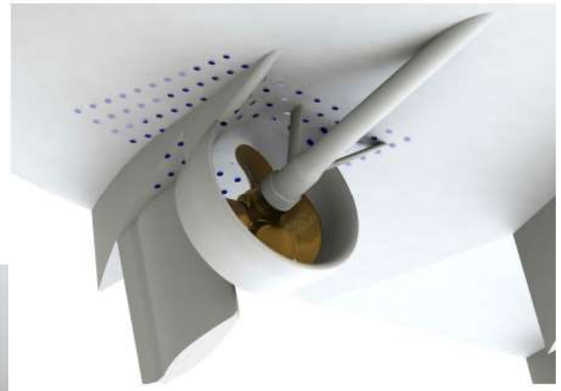


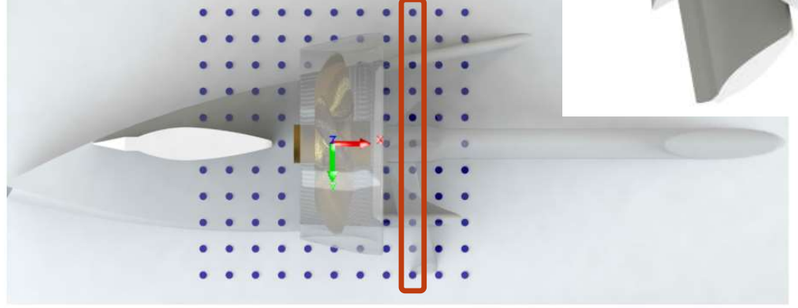
HYPNOS - Applications

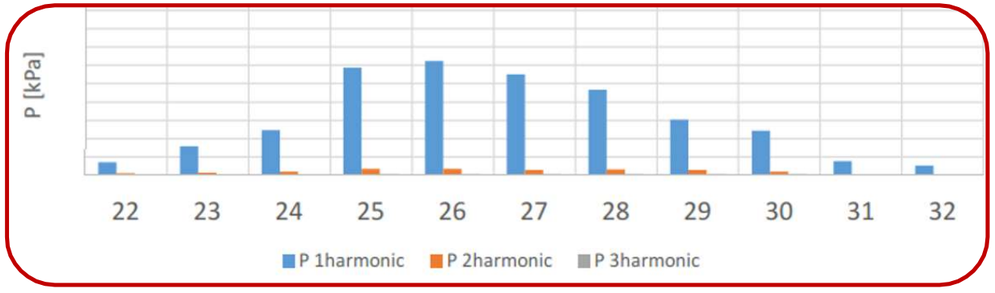
Example Noise Sensitive Projects

Dredger

- Twin screw conventional propeller, type SCP 65/4XG
- Integrated duct SDV45
- Rudder and headbox

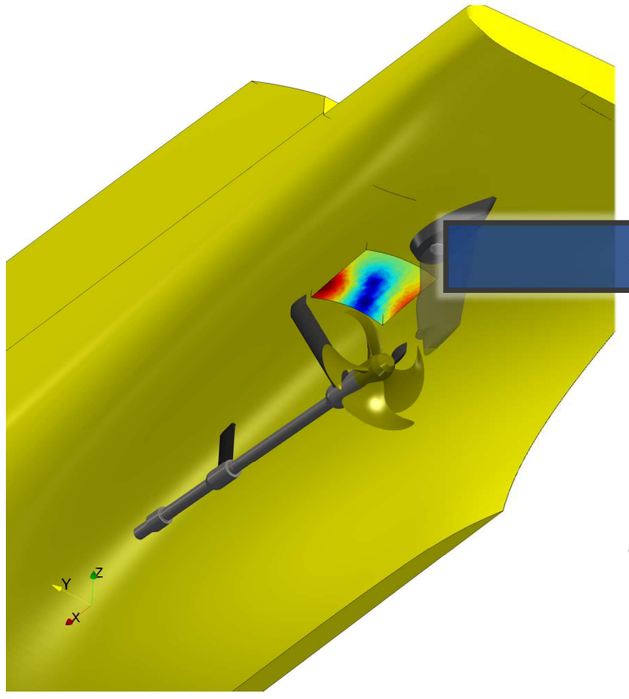


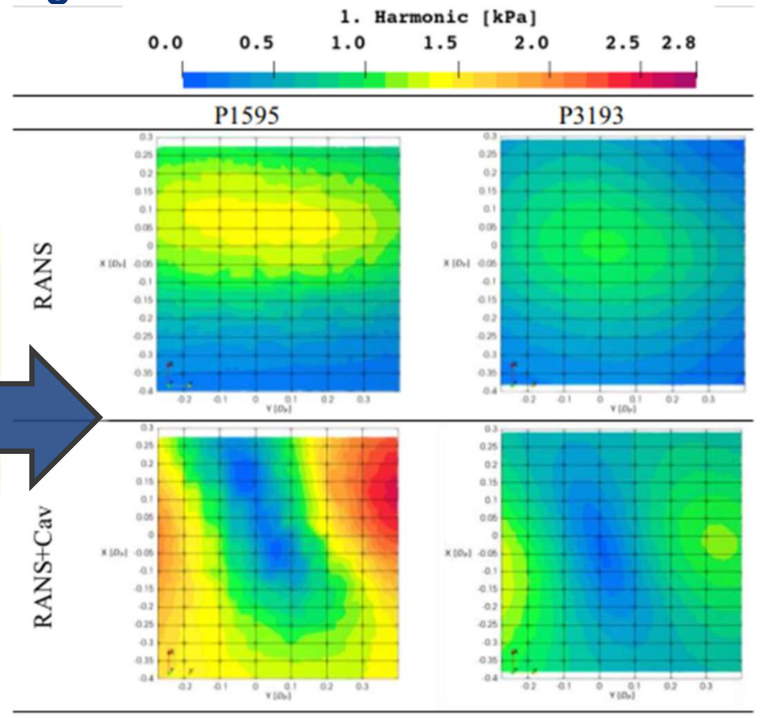


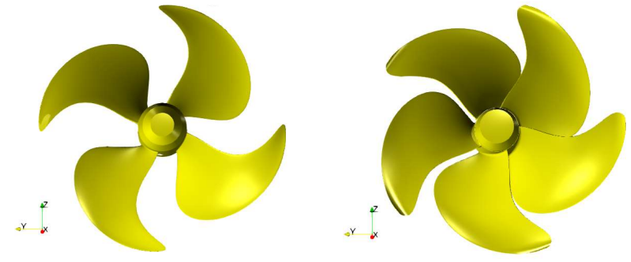


Mega Yacht

- Comparison of two propeller designs
- SCP without duct



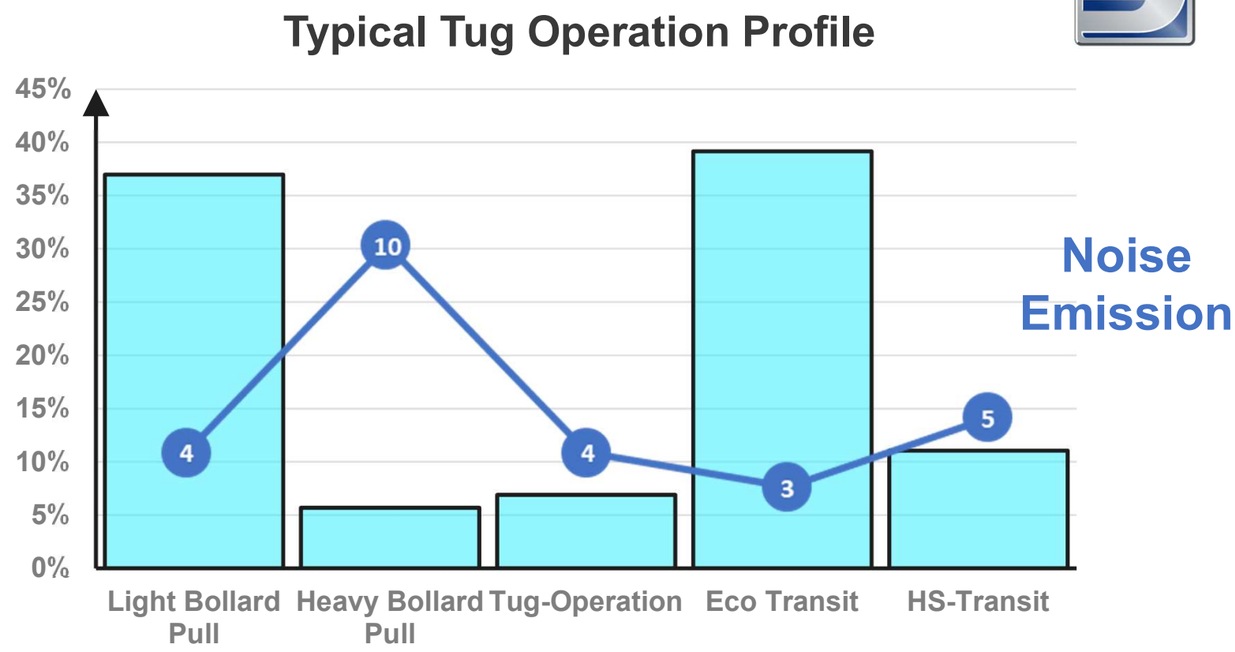




HYPNOS - Applications

On-Board Monitoring in Tug Applications

- Large installed power → Noise
- High variability in operation profile:
  - High noise at BP
  - Low noise in idling
- Highly localized noise emission events
- Short time noise events
- Operation near coastal waters: Habitat of marine mammals and fish



SUMMARY

Summary

HyPNoS – Research Project

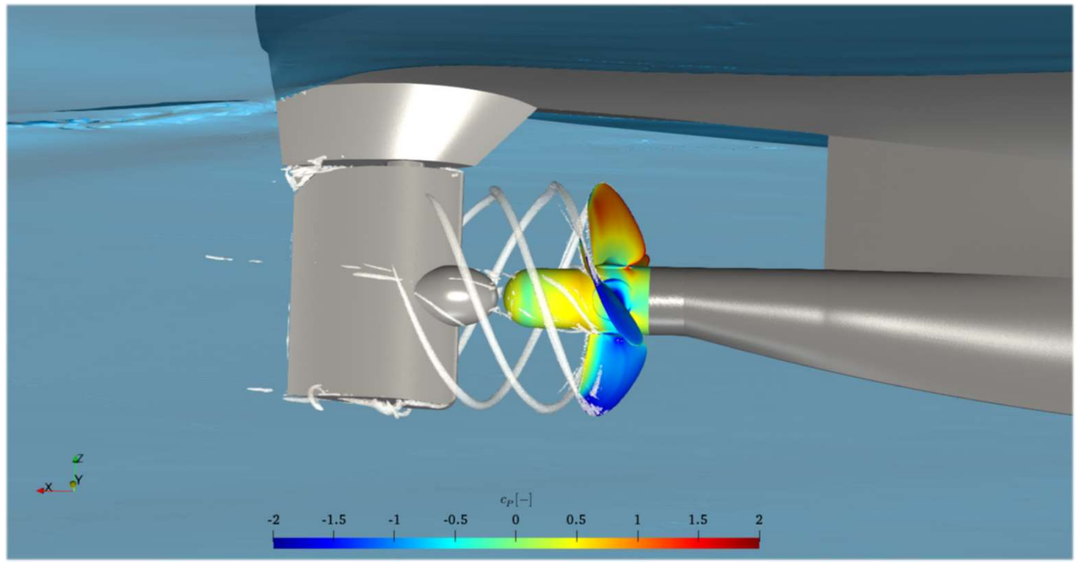
- Explores correlation of URN with vibration
- Prototype on-board live URN monitoring system
- Prediction based on one-time calibration measurements
- Calibration at relevant operation conditions
- Cloud based data evaluation
- AI-ready prediction algorithm

Find out more:

www.SCHOTTEL.com

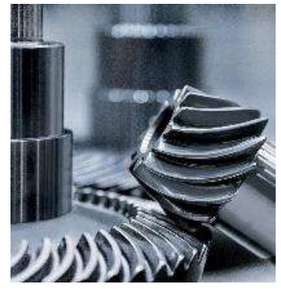
Special Thanks

- Funded by Transport Canada Quiet Vessel Initiative
- In cooperation with BCFerries




SCHOTTEL


SCHOTTEL




www.SCHOTTEL.com