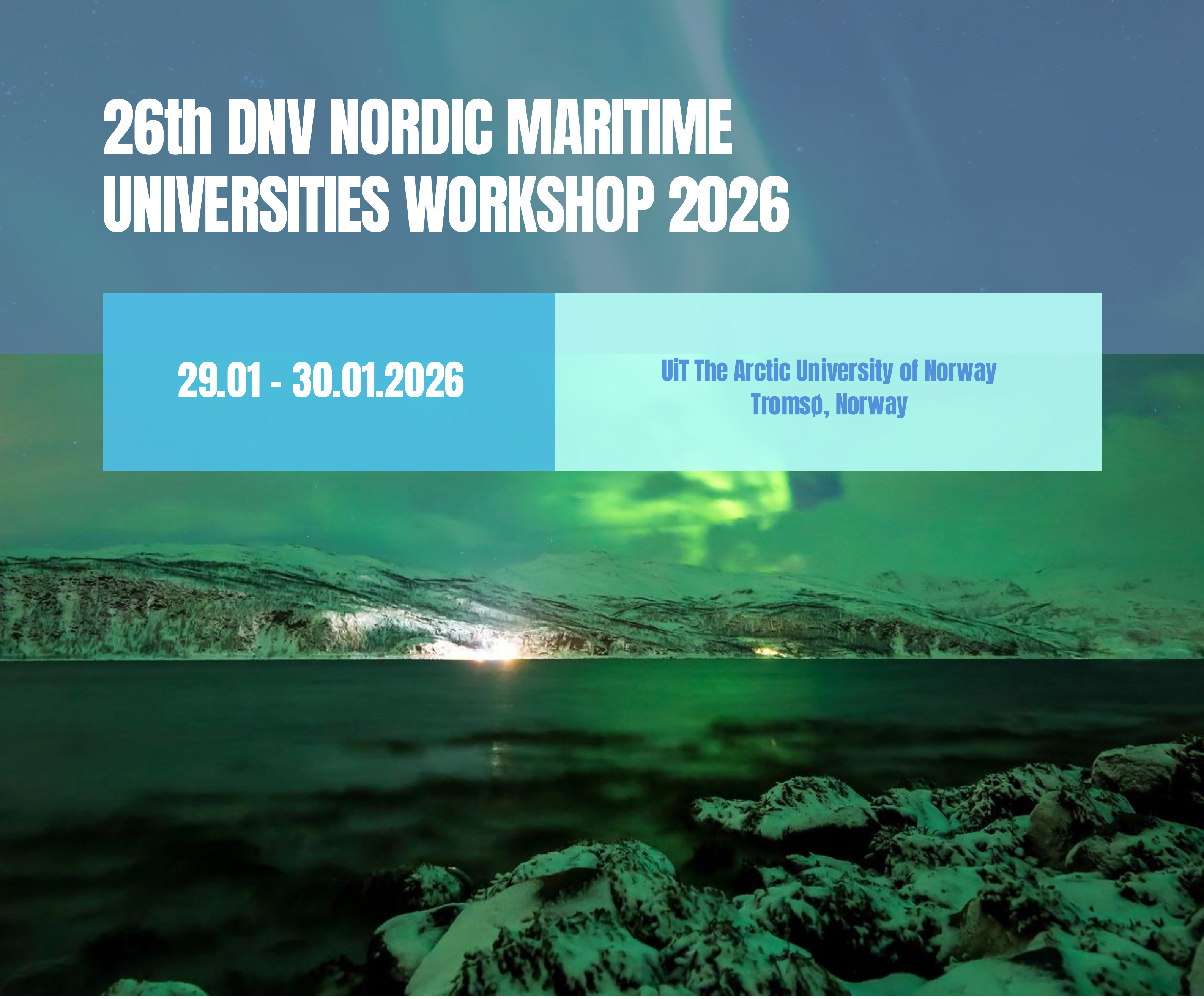
26th DNV NORDIC MARITIME UNIVERSITIES WORKSHOP 2026

29.01 - 30.01.2026

UiT The Arctic University of Norway
Tromsø, Norway



WORKSHOP GUIDE

SCIENTIFIC PROGRAM, PRACTICAL INFORMATION, PRESENTATION ABSTRACTS

Auditorium 2 (1.836)
UiT The Arctic University of Norway
Tromsø, Norway

WORKSHOP OBJECTIVES

The DNV Nordic Maritime Universities Workshop is a recurring academic workshop that brings together scholars from Nordic universities working in naval architecture, maritime engineering, and maritime transport. The workshop is organized in collaboration between DNV and Nordic universities with established activities in maritime education and research.

The main objectives of the workshop are to:

1. Provide a forum for academic presentation and discussion of ongoing research in naval architecture, maritime engineering and maritime transport
2. Facilitate intellectual exchange and academic collaboration among Nordic universities and research institutions
3. Promote exchange of results and innovation between academia and industry
4. Support the development of maritime education and research aligned with current and future industry needs
5. Encourage participation and visibility of early-career researchers and PhD students

A broad range of themes relevant to the evolving maritime domain is addressed. The workshop program features 52 speakers organized into 8 scientific sessions. Sessions 2 to 4 and 5 to 7 are conducted in parallel.

The 26th DNV Nordic Maritime Universities Workshop returns to Norway and is hosted in one of the country’s most iconic cities, Tromsø. We hope that this gathering will foster open scientific exchange, strengthen collaboration, and support the continued advancement of maritime research and education across the Nordic region.

HOST INSTITUTION AND VENUE

The workshop is hosted at UiT The Arctic University of Norway, northernmost university in the world. The Arctic is becoming increasingly important globally due to climate change, resource use, and environmental risks. UiT has a particular focus and strong profile on research and education within arctic areas.

Workshop Venue

The workshop will take place on UIT campus at:

Auditorium 2 (1.836)
Teorifaghus bygg 1
UiT Norges arktiske universitet
Universitetsvegen 31, 9019 Tromsø, Norway

The parallel rooms are close to auditorium 2.

When entering the Teorifagbygget, you will see a cafe directly in front of you. Use the stairs on the left-hand side to go down one level, where you will find the workshop venue.

The nearest bus stop is UiT, or UiT / Planetariet.

From Tromsø Airport to the City and Venue

Tromsø Airport is situated close to both the workshop venue and the city center. This makes travel to and from the workshop efficient and convenient.

By Taxi:
Taxi from Tromsø Airport to the city center or UiT campus takes approximately 10-15 minutes. Taxis are available outside the airport and throughout the city center. Several taxi apps are available, including TAXIFIX, Din Taxi, and Uber.

By Airport express bus:
The airport express bus runs between Tromsø Airport and the city center and takes about 15 minutes. It stops at several locations throughout the city.
Airport express schedule can be found here:
https://bestarctic.com/norway-airport-express-tromso-airport-bus-timetable/

By city bus:
You can use the SVIPPER app to check bus schedules and buy city bus tickets. City bus routes 24, 40, and 42 operate between Tromsø Airport and the city center. Routes 20 and 34 run between the city center and the UiT campus.

Further information on travel to Tromsø can be found here:
1. https://www.visittromso.no/plan-your-trip
2. https://www.visitnorway.com/places-to-go/northern-norway/tromso/plan-your-trip/

Norway uses the Norwegian Krone (NOK). Credit and debit cards (Visa and Mastercard) are widely accepted, and cash is rarely used.

ACCOMMODATION

A wide range of hotels and guest houses are available in the city center and near the UiT campus. Early booking is recommended, especially during peak tourist periods such as January.

Accommodation in Tromsø city center is often convenient, as it provides easy access to both the UiT campus and city amenities.

WEATHER AND CLOTHING

Participants are advised to be well prepared for Arctic winter conditions. January in Tromsø is typically cold, with the possibility of wind, snow, and icy surfaces.

Warm clothing and appropriate anti-slip winter footwear are strongly recommended.

Scientific Program

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

ROOM: AUDITORIUM 2, 1.836
08:30-09:00: REGISTRATION
09:00-09:10: OPENING REMARKS AND WELCOME FROM UIT THE ARCTIC UNIVERSITY OF NORWAY
BJØRN-MORTEN BATALDEN, DEAN, FACULTY OF SCIENCE AND TECHNOLOGY, UIT

09:10-09:25: DNV'S RESEARCH AND DEVELOPMENT
FRANK BØRRE PEDERSEN, VICE PRESIDENT AND MARITIME PROGRAMME DIRECTOR IN GROUP RESEARCH AND DEVELOPMENT, DNV

09:25-09:45: INDUSTRY KEYNOTE - WÄRTSILÄ - TOWARDS ZERO EMISSION MARITIME SECTOR – CHALLENGES AND SOLUTIONS
ANDERS ÖSTER, GENERAL MANAGER, RESEARCH COORDINATION & FUNDING, WÄRTSILÄ

09:45-10:00: COFFEE BREAK

SCIENTIFIC SESSION 1: SAFETY, RISK, AND RESILIENCE IN MARITIME SYSTEMS
SESSION CHAIR: DR. JORGE SANTOS, Dr. TAE EUN KIM, PROFESSOR, UIT

COMPARING THE SAFETY OF BUNKERING LNG, LH2, AND NH3 USING QUANTITATIVE RISK ASSESSMENT – A PHD THESIS SUMMARY
JØRGEN DEPKEN, GERMAN AEROSPACE CENTER DLR

HOLISTIC FULL-SCALE MEASUREMENTS FOR MITIGATING PROPELLER-INDUCED UNDERWATER NOISE
MAX STEDEN, EVERLLENCE, PRIMESERV DENMARK

AERATED GREEN WATER IMPACTS ON DECK STRUCTURES
PETER WELLENS, TU DELFT

INTEGRATING SOURCE AND PROPAGATION MODELING FOR ACOUSTIC EVALUATIONS
MARTA CIANFERRA, UNIVERSITY OF TRIESTE

DEVELOPING RESILIENCE STRATEGIES FOR PORTS AGAINST EXTREME WEATHER EVENTS
GABRIEL CHIKELU, AALTO UNIVERSITY

11:30-12:00 GROUP PHOTO, LUNCH AT TEORIFAGSKANTINA

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 2: ADVANCED MODELING AND ASSESSMENT TECHNIQUES FOR MARITIME APPLICATIONS
SESSION CHAIR: DR. TAE EUN KIM, PROFESSOR, UIT

ROOM: AUDITORIUM 2, 1.836

12:00-13:30

INTEGRATING PHYSICS- AND MACHINE LEARNING- BASED BATTERY DEGRADATION MODELS FOR MARITIME APPLICATIONS
VAIDEHI GOSALA, GERMAN AEROSPACE CENTER DLR

DEPTH EFFECTS ON THE DOPPLER SHIFT AND CONSEQUENCES IN SPECTRAL RESPONSE CALCULATIONS
RAPHAËL EMILE GILBERT MOUNET, TECHNICAL UNIVERSITY OF DENMARK

EARLY RESEARCH PLAN – ONBOARD ASSESSMENT OF UNDERWATER RADIATED NOISE FROM SHIPS
CHRISTOPHER HERREY, CHALMERS UNIVERSITY OF TECHNOLOGY

A HYBRID FRAMEWORK FOR INTEGRATING LARGE LANGUAGE MODELS AND OBJECT-ORIENTED BAYESIAN NETWORKS FOR SAFE ARCTIC SHIPPING
SIYUAN GU, CHALMERS UNIVERSITY OF TECHNOLOGY

RISKS AND ADAPTATION OF ONSHORE POWER SUPPLY IN IRELAND'S PORTS
ALINA KOVALENKO, NORD UNIVERSITY BUSINESS SCHOOL

MODELING THE OPERATION OF SAILING SHIPS: FROM VESSEL SCALE TO FLEET SCALE
AURORE WENDLING, NTNU

13:30-14:00: COFFEE BREAK

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 3: NUMERICAL METHODS, SIMULATION AND PERFORMANCE EVALUATION
SESSION CHAIR: DR. RATNABALI PAL, RESEARCHER, UIT

ROOM: 1.425

12:00-13:30

ARMS ADAPTIVE ROBUST MULTI-SENSOR FUSION FOR VESSEL STW ESTIMATION
YI EDWARD LIU, DNV

ADVANCING RELIABILITY OF MARITIME STRUCTURES THROUGH WELDED JOINT ANALYSIS: A DATA-DRIVEN APPROACH
MATHIS HARDER, GERMAN AEROSPACE CENTER DLR

NEUTRONIC ANALYSIS OF A HYBRID FUEL CYCLE BETWEEN MARITIME AND TERRESTRIAL FLUORIDE-SALT-COOLED HIGH-TEMPERATURE REACTORS
JOSEF HISANAWI, UNIVERSITY OF OSLO

TWO-ELEMENT WINGSAIL: STALL HYSTERESIS AND THE ROLE OF THE FLAP FOR THE AERODYNAMIC PERFORMANCE DURING OPERATION
ANTONIA HILLENBRAND, KTH ROYAL INSTITUTE OF TECHNOLOGY

NONLINEAR WAVES ATOP A VARYING BATHYMETRY
JUNBO WANG, UNIVERSITY OF BERGEN

NUMERICAL SIMULATIONS FOR A CAVITATING PROPELLER OPERATING IN SHIP WAKE
QAIS SHEHADEH KHRAISAT, CHALMERS UNIVERSITY OF TECHNOLOGY

13:30-14:00: COFFEE BREAK

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 4: RENEWABLE ENERGY AND GREEN PROPULSION

SESSION CHAIR: DR. CLARA GOOD, ASSOCIATE PROFESSOR, UIT

ROOM: 1.343

12:00-13:30

AN INTELLIGENT OPTIMIZATION STRATEGY FOR HOTEL LOAD MANAGEMENT IN PASSENGER SHIPS
ADANNA OKONKWO, AALTO UNIVERSITY

EVALUATION OF SHIPPING DECARBONIZATION PATHWAYS AND ALTERNATIVE FUELS USING AN INTEGRATED STRATEGIC TRAMP FLEET RENEWAL AND RETROFIT PROBLEM
ALBERTO TAMBURINI, TECHNICAL UNIVERSITY OF DENMARK

BLUE SYNERGIES: OFFSHORE WIND-SEAWEED CO-LOCATION FOR ENERGY, FOOD AND CLIMATE BENEFITS
JINGNAN ZHANG, KTH ROYAL INSTITUTE OF TECHNOLOGY

MULTI-WING TRIMMING AND CONTROL: HOW TO BEST USE WING SAILS FOR SHIP PROPULSION?
ULYSSE DHOMÉ, KTH ROYAL INSTITUTE OF TECHNOLOGY

TOWARDS A NOVEL IMPLEMENTATION OF THE SYROPE MODEL FOR POLYESTER MOORING ROPES IN MOORDYN
ZHILONG WEI, TECHNICAL UNIVERSITY OF DENMARK

A CRITICAL EVALUATION OF CONTROL-ORIENTED MODELING FOR WAVE ENERGY CONVERTERS: A SANITY CHECK ON THE DATA-DRIVEN PROMISE
ANTOINE DUPUIS, UPPSALA UNIVERSITY

13:30-14:00: COFFEE BREAK

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 5: SHIP DESIGN AND NAVAL ARCHITECTURE

SESSION CHAIR: DR. KARL GUNNAR AARSÆTHER, ASSOCIATE PROFESSOR, UIT

ROOM: AUDITORIUM 2, 1.836

14:00-15:30

DATA-DRIVEN CALM WATER POWER PREDICTION FOR CONTAINER VESSELS IN OPERATION
ELOÏSE CROONENBORGHS, NTNU

REGRESSION MODEL ANALYSIS FOR ALTERNATIVELY FUELLED SHIPS
BEN NOBLE, TU DELFT

DEFINE MISSIONS FOR MARINE VEHICLES
CHAMILA RANASINGHE, KTH ROYAL INSTITUTE OF TECHNOLOGY

FUTURE SHIP DESIGN FOR DECARBONIZATION – ESTABLISHING DIGITAL TWINS IN SHIP DESIGN
HAUWA YUNSA, KTH ROYAL INSTITUTE OF TECHNOLOGY

SHIP HULL FORM DATASET GENERATION
CHIARA GIOVANNINI, KTH ROYAL INSTITUTE OF TECHNOLOGY

AI IN SHIP DESIGN
IRIDA BOURNIA, NTNU

15:30-16:00: STEERING COMMITTEE MEETING

18:00: DINNER AT MASKINVERKSTEDET
NORDØSTPASSASJEN 39, 9008 TROMSØ
SPONSORED BY DNV

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 6: STRUCTURAL INTEGRITY AND MARINE STRUCTURES

SESSION CHAIR: KÅRE JOHANSEN, ASSOCIATE PROFESSOR, UIT

ROOM: 1.343

14:00-15:30

LINKING THE WELD GEOMETRY AND FATIGUE LIFE USING OPTICAL SCANNING AND COMPUTER VISION FOR RELIABLE MARITIME STRUCTURES
MARTIN LEONEL MELUCCI, GERMAN AEROSPACE CENTER DLR

EARLY-STAGE STRUCTURAL HEALTH MONITORING OF SHIP GEARBOXES
CASPER AASKOV DRANGSFELDT, UNIVERSITY OF SOUTHERN DENMARK

STRENGTHENING EUROPEAN SHIPBUILDING CAPABILITIES THROUGH ADVANCED AUTOMATION SOLUTIONS
CHRISTIAN BUUR KEJ, UNIVERSITY OF SOUTHERN DENMARK

A RELIABILITY STUDY OF NYLON MOORING LINES FOR FLOATING WIND TURBINES
KRISHNAJA BALACHANDRAN, NTNU

NUMERICAL REPRODUCTION OF AN EXTREME WAVE IMPACT ON FLEXIBLE PLATES
MARNIX BOCKSTAEL, TU DELFT

EFFECTS OF IRREGULAR SEAS GENERATION USING RANDOM VERSUS DETERMINISTIC AMPLITUDE IN PARAMETRIC ROLL PREDICTION
OGECHUKWU NWAFOR, KTH ROYAL INSTITUTE OF TECHNOLOGY

15:30-16:00: STEERING COMMITTEE MEETING

18:00: DINNER AT MASKINVERKSTEDET
NORDØSTPASSASJEN 39, 9008 TROMSØ
SPONSORED BY DNV

SCIENTIFIC PROGRAM DAY 1
THURSDAY, 29.01.2026

SCIENTIFIC SESSION 7: ADVANCED ENERGY SYSTEMS AND MODELING FOR MARITIME APPLICATIONS

SESSION CHAIR: DR. BENJAMIN LAGEMANN, ASSOCIATE PROFESSOR, NTNU

ROOM: 1.425
14:00-15:30

ENABLING BATTERY- & FUEL CELL-BASED HYBRID ENERGY SYSTEMS FOR ICE-CLASS RESEARCH VESSELS
DHEERAJ GOSALA, GERMAN AEROSPACE CENTER DLR

OPTIMAL BATTERY SIZING AND CHARGER LOCATION FOR INLAND WATERWAYS
TRAVIS TESKE, GERMAN AEROSPACE CENTER DLR

LIGNIN AS A CETANE IMPROVER FOR METHANOL COMBUSTION UNDER ENGINE-LIKE CONDITIONS
SAI KIRUTHEKA PERAM, NTNU

THE PHYSICS OF FLOATING SOLAR THROUGH A HYDROELASTIC DISPERSION RELATION ASSESSMENTS WITH A TABLE TOP EXPERIMENT
HANNA POT, TU DELFT

SYSTEM-BASED MODELLING OF A TWO-STROKE MARINE ENGINE FUEL EFFICIENCY AND ITS UNCERTAINTIES
SEYED AZIM HOSSEINI FARGHANI, CHALMERS UNIVERSITY OF TECHNOLOGY

SCALABILITY OF HEAT-PIPE COOLED REACTORS FOR REMOTE AND AUTONOMOUS APPLICATIONS
BALTASAR JOHANNES HEMMERLE, UNIVERSITY OF OSLO

15:30-16:00: STEERING COMMITTEE MEETING

18:00: DINNER AT MASKINVERKSTEDET
NORDØSTPASSASJEN 39, 9008 TROMSØ
SPONSORED BY DNV

SCIENTIFIC PROGRAM DAY 2
FRIDAY, 30.01.2026

ROOM: AUDITORIUM 2, 1.836

09:00-09:30: TECHNICAL KEYNOTE FROM DNV: THE MARITIME DIGITAL TRANSFORMATION AND REMOTE AUTONOMOUS INSPECTION
GEIR HAMRE, PRINCIPAL RESEARCHER, DNV

09:30-09:45: DTU'S OPEN-SOURCE AND FREE TOOLS FOR MARITIME APPLICATIONS
MOSTAFA AMINI-AFSHAR, TECHNICAL UNIVERSITY OF DENMARK

09:45-10:00: COFFEE BREAK

SCIENTIFIC SESSION 8: MARITIME HUMAN FACTORS, EDUCATION AND TRAINING
SESSION CHAIR: DR. ZIAUL HAQUE MUNIM, PROFESSOR, USN
10:00-11:30

NAVIGATING DECISIONS: BEHAVIORAL DESIGN FOR SUSTAINABLE WEATHER ROUTING
JØRGEN DALEN, OSLO SCHOOL OF ARCHITECTURE AND DESIGN

IMAGINING "TECHNOLOGY FOR TOMORROW": FUTURES OF TECHNOLOGY DESIGN IN THE FISHERIES SECTOR
MARIANNA OSOKINA, UIT THE ARCTIC UNIVERSITY OF NORWAY

USABILITY OF EYE TRACKING IN NAUTICAL SIMULATOR TRAINING
SAHIL BHAGAT, UIT THE ARCTIC UNIVERSITY OF NORWAY

ECONOMIC IMPACT ASSESSMENT OF MARINE AUTONOMOUS OPERATIONS: A REVIEW OF METHODOLOGIES
LAKSHIKA HASINI KAHANDA KANATHTHEGE, UIT THE ARCTIC UNIVERSITY OF NORWAY

MAPPING TEAMWORK COMPETENCE GAPS IN MARITIME SIMULATOR TRAINING: A COMPARATIVE IMPORTANCE-IMPROVEMENT ANALYSIS FOR THE IMPLICATION OF LEARNING ANALYTICS DASHBOARDS DESIGN
FANG ZHENG, UNIVERSITY OF SOUTH-EASTERN NORWAY

PROBABILISTIC PREDICTION OF MOTION SICKNESS SYMPTOMS BASED ON VESSEL MOTION CHARACTERISTICS
ELMA RAMIC, UNIVERSITY OF SOUTHERN DENMARK

11:30-13:00 LUNCH AT TEORIFAGSKANTINA
CONCLUSION OF THE WORKSHOP

PRESENTATION ABSTRACTS

All presentation abstracts submitted by the authors are attached.

Scientific session 1:
Safety, Risk, and Resilience in Maritime Systems

Comparing the Safety of Bunkering LNG, LH_2 and NH_3 Using Quantitative Risk Assessment – A PhD Thesis Summary

Jorgen Depken[1]

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Abstract

The shipping industry, responsible for approximately 3% of global greenhouse gas emissions, is under increasing pressure to transition to low-carbon fuel sources. Hydrogen, along with methanol and ammonia, has emerged as a promising alternative to conventional fossil fuels. While liquified hydrogen (LH_2) boasts superior gravimetric storage densities, its extremely low temperature of 20 K presents significant technical challenges. In comparison, liquified natural gas (LNG), already widely adopted for maritime use, operates at a significantly higher temperature, approximately 90 K above LH_2. Even higher temperatures of 240 K or a pressure of approx. 10 bar at ambient temperature are employed for the storage of ammonia (NH_3). Besides the ignition hazards present between all three fuels, ammonia is toxic as well.

A critical aspect of implementing hydrogen-based fuels involves the safe and efficient bunkering process, which includes transferring LH_2 via flexible pipelines or loading arms, necessitating rigorous safety protocols to mitigate associated risks. The thesis employed a quantitative risk assessment to compare the safety of bunkering LNG, as a state-of-the-art benchmark to the safety of bunkering LH_2 and NH_3.

Initially, the frequencies of the hazardous events “pool fire”, “flash fire”, “vapor cloud explosion” and “toxicity/asphyxiation” are obtained by means of an event tree. Subsequently, the consequences of each event are modeled and translated into a required safety distance. A comparison is made between the frequencies and safety distances of two distinct systems. The initial system exhibits uniform pipe diameter for all three fuels, consequently yielding substantially divergent bunkering durations for each fuel type. In the second system, the pipe diameter is adapted in a manner that yields the same bunkering duration for all three fuels.

The findings indicate, that the pipe diameter of the system and the duration of bunkering have a substantial influence on the frequencies of the hazardous events. Conversely, the pipe diameter has no influence on the consequences for a leak of the same size. An observable influence is only evident in the context of a full rupture. The dispersion cases, flash fire and toxicity/asphyxiation, require for all fuels the largest safety distances, thereby dictating the overall safety distance.

Holistic Full-Scale Measurements for Mitigating Propeller Induced Underwater Noise

Max Steden, Joseph Praful Tomy

Propeller & Aft Ship Department, Everllence SE, Denmark

Abstract

Underwater radiated noise (URN) from marine propellers is a growing environmental concern, affecting marine life and driving stricter regulatory requirements. Addressing this challenge is essential for sustainable propeller design and requires both accurate prediction tools and a deep understanding of noise-generating mechanisms. To tackle this, we conducted a comprehensive full-scale measurement campaign on a controllable pitch propeller (CPP) to isolate cavitation-induced noise from other sources such as engine and gearbox noise.

The holistic approach integrated far-field hydrophones, hull-mounted pressure sensors, onboard accelerometers, and visual cavitation observations, complemented by filtering techniques to isolate machinery and flow noise. By carefully choosing appropriate propeller operating conditions, we were able to trigger different cavitation types: leading edge, sheet, and tip vortex. Their influence on radiated noise is analyzed through measurements on the near-field pressure sensors and far-field hydrophones.

Insights from this campaign form the basis for validating our numerical URN prediction tools based on the Ffowcs Williams–Hawkings acoustic analogy. The measurement campaign also provided an in-depth understanding about the noise signature of the ship, which will eventually be translated into a low-noise engine operation curve for the ship. The holistic approach to URN measurements enhances scientific understanding of cavitation noise and aids in evaluating the feasibility of efficient prediction tools, paving the way for quieter, environmentally responsible propeller design

Aerated Green Water Impacts on Deck Structures

Peter Wellens[1] and Marnix Bockstael[1,2]
[1] Delft University of Technology, Ship Hydromechanics Laboratory
p.r.wellens@tudelft.nl, m.m.bockstael@tudelft.nl
[2] MARIN, Defence department

Abstract

Green water is a wave-structure interaction phenomenon that can lead to impacts on deck structures of ships (Greco et al., 2005; Boon and Wellens, 2022). In heavy seas, the white crests of the waves are an indication of the fact that the ship is sailing through a mixture of air and water. We call that mixture aerated water and, some part of a typical wave period after breaking of the wave, a typical percentage of air in water is between 1% and 2% by volume. During a green water event, an amount of aerated water flows on deck and undergoes impulsive interaction with deck structures in the path of the flow. The maximum pressure during an impact with 1% air in water can be 20% lower than an impact with water that has no entrained air (Eijk and Wellens, 2024a).

A novel set of experiments was devised in which controlled impacts on a plate with varying configurations of the water front were studied. The plate could take on different angles with respect to the flow direction of the water front. The water front could have different velocities and, also, different angles of the front, so that a relative angle between water front and plate could be defined. The tests were conducted without aeration and with 4 different percentages of air in water.

The impacts were measured by means of force gauges and pressure gauges, the water front was registered by means of resistive free surface gauges and a set of high-speed cameras. Impacts following from the same starting configuration were repeated so that variations could be studied.

The tests in the experiment were also simulated by means of a dedicated numerical solver of our own design (Eijk and Wellens, 2023, 2024a). The numerical solver is based on the Navier-Stokes equations and the free surface is transported by means of a Volume-of-Fluid method. A BLIC (bilinear interface reconstruction, Eijk and Wellens, 2024b) algorithm was devised in combination with an unsplit advection algorithm to achieve high accuracy in representing the free surface configuration upon impact.

The differences between experiments and simulations are small and can be interpreted so that new insight into the reality of aerated wave-structure interaction has been obtained, which we are keen to share at the workshop.

References

Greco M, Faltinsen, O.M. and Landrini M. (2005). Shipping of water on a two-dimensional structure. *Journal of Fluid Mechanics*. 2005;525:309-332. doi:10.1017/S0022112004002691.

Boon, A.D., Wellens, P.R., (2022). Probability and distribution of green water events and pressures. Ocean Eng. http://dx.doi.org/10.1016/j.oceaneng.2022.112429.

van der Eijk, M., & Wellens, P. (2023). Two-phase free-surface flow interaction with moving bodies using a consistent, momentum preserving method. *Journal of Computational Physics*, *474*, 111796. https://doi.org/10.1016/j.jcp.2022.111796

van der Eijk, M., & Wellens, P. (2024a). An efficient pressure-based multiphase finite volume method for interaction between compressible aerated water and moving bodies. *Journal of Computational Physics*, *514,* 113167. https://doi.org/10.1016/j.jcp.2024.113167

van der Eijk, M., & Wellens, P. (2024b). An efficient bilinear interface reconstruction algorithm and consistent multidimensional unsplit advection scheme for accurate capturing of highly-curved interfacial shapes on structured grids. *Journal of Computational Physics*, *498*(September 2023), 112656. https://doi.org/10.1016/j.jcp.2023.11265

Integrating Source and Propagation Modeling for Acoustic Evaluations

Marta Cianferra[1] and Rickard Bensow[2]

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[2] Chalmers University of Technology, Department of Mechanics and Maritime Sciences
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Abstract

Regulatory frameworks, such as the Marine Strategy Framework Directive and international standards, have recently emphasized the need for robust tools to characterize the acoustic state of the marine environment and assess anthropogenic impacts. Translating these regulatory goals into operational modeling approaches remains challenging: defining the acoustic state through noise maps or reliably evaluating mitigation measures requires versatile and accurate modeling of both source characteristics and sound propagation processes.

Over the past decade, basin-scale noise mapping has become a standard approach for assessing underwater sound, typically using omnidirectional source models based

on semi-empirical formulations, combined with computationally efficient 2D or pseudo-3D propagation schemes, such as parabolic-equation or ray-tracing solvers. While robust and well established for large-scale assessments, these methods often overlook the detailed physics of individual sources and the complex variability of propagation conditions. In parallel, a growing research community focuses on high- fidelity modeling of specific noise mechanisms, such as propeller cavitation, wake noise, and hull vibration, offering insights rarely integrated into basin-scale frameworks.

The proposed approach maintains a balanced level of complexity, allowing both source characterization and propagation modeling to be treated consistently within a

unified computational framework. A case study is presented for a benchmark vessel operating in a shallow-water channel, where complex boundary interactions and bathymetric effects strongly influence sound propagation. This workflow demonstrates the potential to enhance understanding of source-path coupling mechanisms and to support the development of effective strategies for assessing and mitigating underwater shipping noise.

Developing Resilience Strategies for Ports against Extreme Weather Events

Gabriel Chikelu[1], Osiris Valdez Banda[1]

[1] Aalto University, Department of Energy and Mechanical Engineering
Gabriel.chikelu@aalto.fi, osiris.valdez.banda@aalto.fi

Abstract

Ports are critical hubs for global trade and economic stability, yet they face increasing challenges due to extreme weather events such as hurricanes, storm surges, drought, high wind, and rising sea levels. My research focuses on developing resilience strategies to enhance port preparedness, ensuring operational continuity, and minimizing infrastructure damage during severe weather conditions. The study is structured into three key phases, each addressing a crucial aspect of port resilience.

The first phase will involve a vulnerability assessment to identify the hazards as well as the critical port infrastructure and logistics systems at risk. This assessment will integrate historical data, and geospatial analysis to determine the susceptibility of port operations to extreme weather events. The outcome will be a detailed vulnerability profile that forms the basis for targeted resilience interventions.

The second phase involves a comparative analysis of climate governance frameworks to assess whether scientifically recommended mitigation and adaptation measures are reflected in port policies. This analysis will examine existing regulations, international climate policies, and port management strategies to identify areas where policies align with or deviate from best practices in climate resilience.

The third phase focuses on simulating port operations under extreme weather conditions to quantify their impact on port infrastructure and operational capacity. The objective is to model disruptions caused by adverse weather and test recovery strategies aimed at maintaining at least 80% operational efficiency during extreme weather events. This simulation will help port authorities understand bottlenecks, vulnerabilities, and the effectiveness of emergency response measures, leading to better preparedness and strategic decision-making in real-world scenarios.

My study aims to provide comprehensive insights for policymakers, port operators, and maritime stakeholders to enhance port safety, reduce economic losses, and improve climate adaptation strategies.

Keywords: Port Resilience, Port Operations, Extreme Weather Impact, Maritime Risk Assessment, Climate Adaptation

Scientific session 2:
Advanced Modeling and Assessment Techniques for Maritime Applications

Integrating Physics- and Machine Learning- Based Battery Degradation Models for Maritime Applications

Vaidehi Gosala[1], Kishan Patel[1], Dheeraj Gosala[1], Jan Oberhagemann[1], Moritz Braun[1], and Sören Ehlers[1]

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Abstract

Against the backdrop of climate change and the increasingly stringent emissions regulations from the EU and IMO, batteries are emerging as a key technology for maritime transport systems. Accurate prediction of battery degradation is essential both during design and operation for sizing, maintenance and safe operation. Traditionally physics-based models, empirical and semi-empirical models have been used for such prediction. While physics-based models are more accurate, they are also computationally intensive. Empirical and semi-empirical models are fast but lack accuracy. Among them, specifically, machine learning (ML) approaches have shown success in predicting battery degradation but need large datasets covering variety of operational conditions to learn therefore may struggle with generalization and interpretability. During this presentation, an approach to integrate the physics- and machine learning-based modeling techniques will be presented. Reduced-order models are used to describe the Solid-Electrolyte Interface (SEI) layer formation and Active Material (AM) loss at the graphite anode, and combined with the Long-short term memory (LSTM) model. The approach is demonstrated using an open-source degradation dataset for Lithium Ferrous Phosphate (LFP) cells. This model is expected to be more understandable and real-time implementable, making it suitable for real-time monitoring and prognostics for maintenance scheduling, which are of critical importance for maritime applications.

Depth-effects on the Doppler Shift and Consequences in Spectral Response Calculations

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Abstract

All ships operate at intermediate water depth, at times. A particular application revolves around ship operations associated with crew transportation to (installation, inspection, and maintenance of), e.g., offshore wind and aqua farms. In this connection, decision support systems may help the ship master in navigating the ship with respect to speed and course, relative to the waves, for preventing a high MSI (motion sickness incidence). At *intermediate* water depths, the exact dispersion relation must be considered in seakeeping assessments, stressing that the dispersion relation represents a transcendental equation in wave number and wave frequency. Consequently, the Doppler shift needs careful attention (compared to its deep-water version) to correctly relate the absolute and the observed "encountered" frequencies, and this must be included in response calculations aimed at predicting *encountered* response spectra and not only response statistics. In this study, we perform spectral response calculations using the modified and the deep-water versions of the Doppler shift, and the resulting deviations are studied; noticing that we also introduce a depth-corrected version of the wave spectrum (Bouws et al., 1985). To make the assessment as "clean" as possible, the response of a perfect wave sensor responding to waves with a 1-to-1 relationship, via an "identity transfer function", is studied; in other words, we are computing the encountered wave spectrum. We assume *long-crested* waves, without restrictions on the wave-encounter angle, emphasising that the spectral algorithm (Nielsen et al., 2025), applicable for arbitrary speed and wave-encounter angle combinations in short-crested waves, cannot be used as it assumes deep-water conditions.

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Early Research Plan – Onboard Assessment of Underwater Radiated Noise from Ships

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Abstract

Average underwater noise levels have increased by approximately 3 dB per decade since 1950, primarily due to commercial shipping. Noise from vessels interferes with marine fauna's ability to communicate, navigate, reproduce and forage which may cause displacement and disruption of various marine populations. Managing underwater noise is therefore an integral part in the goal of conserving and sustainably using the oceans, seas and marine resources. This research project is on developing a noise monitoring system for onboard assessment of radiated underwater noise. The monitoring system will enable ship crew to assess their vessel's underwater noise levels in real time, supporting navigation with minimized noise impact on the marine environment.

The monitoring system will be based on measured pressure pulses on the ship hull from propeller and cavitation, correlated with the propagated underwater noise through a transfer function. Part of the research is to develop this transfer function and identify its accuracy. In developing the transfer function machine learning methods will be used incorporating synthetic data from STAR CCM+ and measurement data from sea trails. In a later stage of the project the system will be related to a controllable pitch propeller, with the plan on exploring any trade-of between fuel consumption and radiated noise by the adjustment of the propeller pitch. To assess the adoption of new technology on board ships, the research plan also includes a qualitative phase focusing on the shipping crew's perspective. This qualitative phase will examine the shipping crew's awareness of underwater radiated noise and their willingness to engage with new technology. The study will explore motivations and potential conflicts of interest onboard, as well as preferences for data presentation. The intended result of the research project will contribute to both theoretical understanding of ship underwater radiated noise as well as the practical conditions required for managing it in everyday operations.

A Hybrid Framework for Integrating Large Language Models and Object-oriented Bayesian Networks for Safe Arctic Shipping

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Abstract

With the accelerating commercialization of Arctic Sea Routes and the growing intensity of maritime activities, the safety of navigation in ice-covered waters faces increasingly complex uncertainties and multi-hazard coupling risks. This study aims to establish an integrated framework for risk identification, mechanism analysis, risk evaluation, and intelligent risk treatment for ships operating in the Arctic. First, an accident knowledge extraction workflow based on large language models (LLMs) was developed to systematically mine and structure multi-source textual data, forming a comprehensive knowledge base of environmental, ship-related, and human risk factors. Second, the reasoning capability of LLMs was employed to analyze the coupling and propagation mechanisms of multi-hazard risks, identifying causal dependencies and key vulnerability nodes in the evolution of systemic risks. Third, a knowledge and data dual-driven risk assessment model based on an object-oriented Bayesian network was constructed to quantitatively model and dynamically evaluate the coupling relationships among environmental, ship, and human factors. Finally, LLMs were utilized to generate risk control measures and governance strategies corresponding to key risk factors, establishing an intelligent risk governance framework for Arctic ship navigation. The proposed research framework provides a scalable and verifiable technical approach to enhance risk perception, control, and safety management capabilities for ship navigation in Arctic waters.

Risks and Adaptation of Onshore Power Supply in Ireland's Ports

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Abstract

This study evaluates the economic viability and implementation risks of onshore power Supply (OPS) deployment in Ireland under the Alternative Fuels Infrastructure Regulation (AFIR), which mandates OPS availability for container and passenger ships at berth from 2030 onwards, unless zero-emission technologies are employed. A mixed-methods approach was adopted, combining 29 semi-structured interviews with key stakeholders, including shipping companies, port authorities, and energy providers, with quantitative estimations of auxiliary engine costs while at berth for different vessel types. The results reveal three main categories of risks associated with OPS deployment: (1) demand risks, including uncertainty over shipping companies' adoption of OPS versus alternative fuels, variability in call durations, and hybrid-electric vessel strategies; (2) supply risks driven by grid capacity constraints and competing priorities for network upgrades; and (3) financing risks. Insights from a comparative case study of a Norwegian port are further provided to illustrate alternative business models and governance arrangements that could mitigate such risks.

Modeling the Operation of Sailing Ships: from Vessel Scale to Fleet Scale

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Abstract

The goal of the research is to evaluate the feasibility and emission-reduction potential of primary wind propulsion. The characteristics of sailing ships, and in particular their dependency on weather, might require adaptations of existing shipping practices to sustain effective transport services when changing winds are the main propulsion source. To identify such viable sail shipping patterns, we seek to tackle the problem from a fleet operations perspective.

A first component for a sailing fleet model has been developed in the form of a weather routing tool designed to represent the operation of a single wind-propelled vessel. The next stage consists in integrating it into a wider fleet model. However, selecting a suitable fleet operation strategy rises a number of questions:

- Are any shipping segments particularly favourable for primary wind propulsion?
- What are the current trends for sail cargo companies? In which segments do they operate?
- Maritime operations problems are known to be hard to solve, how can we deal with the increased complexity due to including wind propulsion?

Outcomes from the work on weather routing will be briefly presented, before discussing the aforementioned questions and describing the methods selected for fleet modeling.

Scientific session 3:
Numerical Methods, Simulation and Performance Evaluation

ARMS - Adaptive Robust Multi-Sensor Fusion for Vessel STW Estimation

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Abstract

We propose ARMS (Adaptive Robust Multi-Sensor Fusion), an unsupervised algorithm for temporal signal estimation from multiple sensors subject to systematic deviations. Unlike existing methods that assume Gaussian noise or require ground truth, ARMS automatically detects and mitigates sensor-specific biases through adaptive robust estimation within a factor graph framework. ARMS formulates the fusion problem as sparse factor graph optimization, providing computational advantages: $O(K \cdot N \cdot M)$ complexity, batch processing of all measurements for robust parameter learning, and scalable sparse linear algebra. The algorithm employs three adaptive mechanisms: (1) Huber loss functions with robustness parameters learned from residual statistics via Median Absolute Deviation ($\delta\ j$ = 1.4826 · MAD), (2) sensor reliability weights updated iteratively based on precision and bias metrics ($w\ j$ ∝ [1 + MAD](−1) · [1 + |$bias$|/2](−1)), enabling automatic identification of deviant sensors, and (3) consensus-based outlier detection leveraging cross-sensor agreement to flag systematic deviations without ground truth. Evaluated on synthetic sensor data, ARMS significantly outperforms Kalman variants in accuracy and efficiency. On real maritime speed-through-water (STW) measurement data, ARMS achieves R^2 = 0.995 vs. Hindcast (0.993) and DVL (0.984), demonstrating robust performance without manual tuning.

Keywords: Multi-sensor fusion, robust estimation, factor graphs, adaptive algorithms, unsupervised learning

Advancing Reliability of Maritime Structures Through Welded Joint Analysis: A Data-Driven Approach

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Abstract

Welded joints are a critical component in the construction of maritime structures, accounting for a significant portion of the total structural weight and stress concentration. However, their complex geometry and variability in manufacturing processes make them a significant source of uncertainty in structural reliability assessments. As a result, there is a need to develop accurate and efficient methods for analyzing welded joints, particularly in the context of butt welds.

In this presentation, we will discuss our ongoing research on the analysis of weld geometry data from 2D-slices, leveraging parameterized geometry models to automate the process of building finite element simulations. By integrating a functional description of the weld geometry into the simulation process, we are able to generate accurate stress concentration factors, which are essential for assessing the structural reliability of welded joints. Our approach has the potential to significantly improve the efficiency and accuracy of welded joint analysis, enabling the development of more reliable and resilient maritime structures.

Neutronic Analysis of a Hybrid Fuel Cycle Between Maritime and Terrestrial Fluoride-salt-cooled High-temperature Reactors

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Abstract

This study computationally evaluates a hybrid nuclear fuel cycle in which partially depleted fuel pebbles from a compact maritime Fluoride-salt-cooled High-temperature Reactor (FHR) are transferred to a larger terrestrial FHR for continued utilization. Neutronic behavior is analyzed using a high-fidelity Monte Carlo framework: the Hyper-Fidelity (HxF) tool models detailed depletion in the maritime reactor, while the Search Equilibrium tool determines the equilibrium steady-state fuel composition in the terrestrial core. Results indicate that the hybrid approach significantly enhances total energy extraction per unit mass of heavy metal compared to independent single-reactor operation. **While a conventional once-through cycle achieves an average burnup of 148 MWd/kgHM**, **transferring pebbles at burnup of 47.5 MWd/kgHM enables a subsequent burnup of 110 MWd/kgHM in the terrestrial core, yielding a total of 157.5 MWd/kgHM, a 6.4% increase**. Additionally, performance improves further at lower transfer burnups, with 35 MWd/kgHM transfers achieving total burnups up to 163 MWd/kgHM. These results demonstrate that sequential burning of pebbles in spectrally different reactor environments can outperform the energy extraction limit of single-core operation, providing a potential path toward improved fuel utilization and reduced waste generation for advanced FHR fleets, and potentially other TRISO fueled reactors.

Two-element Wingsail: Stall Hysteresis and the Role of the Flap for the Aerodynamic Performance During Operation

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Abstract

The relevance of wind propulsion in maritime decarbonization has been confirmed by regulatory developments over the past years, highlighting significant retrofit potential across a broad range of vessel types. Despite geopolitical delays introducing uncertainty, early adopters continue to drive demand for wind-assist technologies, reinforcing the need for targeted research and development.
Various technologies are currently under development and testing, one of them being rigid wingsails. Research efforts span performance prediction, route optimization, and numerical studies of the performance regarding crucial details such as atmospheric boundary layer modelling and aerodynamic interaction effects. However, few studies address the trimming of wingsails during operation.

This talk presents a compilation of aerodynamic investigations into trimming, based on wind tunnel campaigns conducted in two Göttingen-type wind tunnels – one with a closed and one with an open test section – and complementary CFD analyses of a model-scale two-element wingsail. The investigated wingsail consists of two wing elements with symmetric profiles separated by a streamwise gap. The wind tunnel model is equipped with an in-wind actuation system. Several geometric variations were explored including different hinging arrangements between upstream and downstream element and gap sealing. As a base, the aerodynamic performance was characterized using a six-component load balance. Further, the boundary layer flow regime and surface flow characteristics have been studied using tuft visualization and passive acoustic monitoring. Particle image velocimetry (PIV) was used for qualitative flow field analysis and to support validation of numerical simulations.
The results demonstrate the beneficial impact of the flap's presence on the aerodynamic performance of the wingsail. Having a separate degree of freedom independent of the global angle of attack increases the potential for active trimming strategies.

Nonlinear Waves Atop a Varying Bathymetry

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Abstract

Near-shore areas exhibit complex bathymetry with abrupt depth transitions (ADTs) that have been found to play an important role in the formation of rogue waves in laboratory observations, numerical simulations, and theoretical studies (see, Li & Chabchoub, 2023; Li *et al.* (2021), Trulsen et al., 2020 among others), where rogue waves are referred to as the waves *which suddenly appear out of nowhere with an amplitude much larger than their ambient waves*. Motivated by the possible formation of rogue waves in coastal regions, a part of the PhD topic is to deepen our understanding of the main features of surface waves experiencing ADTs. A special focus is on how wind waves and swells affect the properties of each other in water regions with ADTs. The main method is to develop a new theoretical framework using potential flow theory, which is accurate to the second order in wave steepness. Validation of the novel theoretical results will be made through comparisons with the existing nonlinear numerical solver by Liang *et al.* (2015). The results would lead to a deeper understanding of the formation of rogue waves in more realistic sea states and novel physical insights into waves in complex coastal environments.

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Numerical Simulations for a Cavitating Propeller Operating in Ship Wake

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Abstract

Researchers and engineers within the maritime community are heavily reliant on the outputs of numerical simulations and experimental investigations to make informed decisions on ship design and operation. One of the main factors considered during these stages is cavitation, i.e. the formation of vapor structures inside the fluid. These cavities appear on marine propellers in several forms, such as sheet and tip vortex cavitation. They induce intense pressure fluctuations, vibrations and material erosion as well as radiate in the form of underwater noise. Therefore, understanding of the cavitation phenomena on propellers is crucial for the early-stage design and ship operation.

With the growing capabilities of Computational Fluid Dynamics (CFD) in the past decades, engineers and researchers are becoming more reliant on these numerical tools to investigate cavitation. There are many methodologies and approaches that have been developed with varying cost and reliability. Typically, more reliable approaches are more computationally expensive. Therefore, in this work, we investigate and compare numerical results from two approaches. The first is the Reynolds Averaged Navier-Stokes (RANS) method, while the second is Detached Eddy Simulation (DES), a hybrid RANS and Large Eddy Simulation (LES) approach. The objective is to compare the results of both methodologies and assess their capabilities in predictions related to cavitating propellers.

Simulations are performed on a chemical tanker equipped with a controllable pitch 4-bladed propeller using the commercial software package Simcenter STAR-CCM+. Cavitation is modelled with the Schnerr-Saur mass transfer model which treats the liquid and vapor phases as a homogeneous mixture. Analysis will include predictions of far field underwater radiated noise. This investigation will provide details on the capabilities of the RANS and the hybrid approaches and their influence on cavitation induced pressure fluctuations and far field underwater radiated noise.

Scientific session 4: Renewable Energy and Green Propulsion

An Intelligent Optimization Strategy for Hotel Load Management in Passenger Ships

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Abstract

Passenger ships consume a substantial amount of energy for hotel services such as ventilation, lighting, galley operations, and other onboard systems. As energy efficiency becomes a growing priority in maritime operations, optimizing hotel loads is critical for reducing overall ship energy demand and operational costs. This study proposes an intelligent optimization strategy for managing hotel energy consumption on board passenger ships, with a focus on the ventilation system, a major contributor to hotel load demand.

Using high-resolution operational data collected from a Roll-on/off passenger ship, machine learning models were developed to predict energy consumption and airflow rates based on key influencing factors, including passenger occupancy and weather conditions. The prediction models were integrated into a metaheuristic optimization framework that adjusts ventilation setpoint temperatures to minimize energy use while maintaining indoor air quality. Comparative analyses were conducted using Chimp Optimization Algorithm (CHOA), Particle Swarm Optimization (PSO), and Genetic Algorithm (GA).

Results demonstrate that the proposed approach achieves significant energy savings, with CHOA offering the best trade-off between convergence speed and solution quality. The strategy is scalable and adaptable to other hotel subsystems, offering a pathway towards intelligent, energy-aware hotel load management for passenger ships

Evaluation of Shipping Decarbonization Pathways and Alternative Fuels Using an Integrated Strategic Tramp Fleet Renewal and Retrofit Problem

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Abstract

This paper evaluates the efficacy and efficiency of shipping decarbonization pathways. We compare three different regulatory approaches: the most recent International Maritime Organization (IMO) Net-Zero Framework, where a two-tier time-dependent soft-constraint mechanism is used to incentivize low-emission fuels; a hard-constraint scheme, where for each period, a hard cap on the emission is fixed; finally, a global constraint scheme, where a hard cap on the emission during the entire planning period is fixed.
To find the best solution for each pathway, we use a Strategic Tramp Fleet Renewal and Retrofit Problem (STFRRP) with emission reduction integrated with tactical and operations decisions. The strategic decisions interest the fleet lifetime and power system selection. The tactical and operations variables concern the fleet deployment and the transportation demand satisfaction. The integrated model effectively measure the fleet emission and the operations profit.
We analyze a case study based on historical data from a concrete tramp operator and the demand is examined under a constant and an increasing assumption starting from the historical baseline. The available engines are diesel, LNG, ammonia, LPG, and methanol. We conclude by discussing the different trajectories cost-efficiencies and the marginal contribution of the most relevant fuels.

Keywords—Shipping; Strategic Planning; IMO Net-Zero Framework; Alternative Fuels.

Blue Synergies: Offshore Wind–Seaweed Co-Location for Energy, Food, and Climate Benefits

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Abstract

The transition toward carbon-neutral societies requires both renewable energy expansion and sustainable food production. Offshore wind and seaweed aquaculture, which are two rapidly developing blue industries, offer complementary opportunities yet often compete for limited marine space. This project aims to explore their co-location as a strategy to enhance marine resource efficiency, generate climate and nutritional co-benefits, and strengthen the blue economy.

Using Sweden's planned floating offshore wind farms as a model system, we combine spatial modeling, production simulation, life cycle assessment (LCA), and stakeholder co-creation to evaluate technical, economic, and environmental outcomes. Geospatial analysis identifies feasible co-location zones considering wind infrastructure, depth, and hydrodynamic constraints. Production modeling estimates both energy generation and seaweed biomass yields, enabling assessment of their joint contributions to renewable energy and sustainable food targets.

Nutritional translation and LCA are applied to quantify dietary benefits and carbon savings, while collaboration with Nordic SeaFarm AB and energy stakeholders explores value creation pathways linking the food and energy sectors.

The project introduces a new framework for multi-use ocean systems, positioning offshore wind and aquaculture as equal actors in a shared spatial and sustainability agenda. By integrating engineering, environmental, and food perspectives, it aims to deliver the first evidence-based roadmap for realizing energy–food symbiosis offshore domain.

Multi-wing Trimming and Control: How to Best Use Wing Sails for Ship Propulsion?

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Abstract

The sailing research at KTH Centre for Naval Architecture has focused on several aspects linked to the control of wing sails: their aerodynamic interactions (with the hull and between each other), the wind resource, and methods to control them efficiently.

Recently, the L2000 wind tunnel was modified to accommodate ships and a generic model equipped with wings and interchangeable hull was developed. The ship model is a car-carrier designed specifically for wind propulsion as the principal source of propulsion. The ship is meant to be about 200 m long, carry 7000 cars and is equipped with four single element rigid wing sails of 80 m span and 23 m average chord, with a NACA0015 profile.

The wind tunnel model is 1.5 m long, with a wingspan of 0.57 m. Each wing is equipped with its own rotation mechanism, and a 6-components force balance. The hull of the ship is also mounted on a 6-components balance, and is isolated from the wing mechanisms, to ensure that the hull forces only are measured. Finally, the whole model is fixed on another 6-component balance measuring the overall forces. This balance is mounted on an actuated turntable capable of rotating the model to any apparent wind angle in a static or dynamic way, thus giving the ability to mimic wind variations.

An important aspect that was investigated before using this model is the scale effects and the flow characteristics to replicate best full-scale. This was performed on a single wing at the scale of the ship model (1:140) and at a larger scale from a past experiment at a scale of approximately 1:57.

Using the ship model, a preliminary study focussing on different trimming strategies was performed with varying apparent wind angles, combinations of sheeting angles and different flow conditions.

The presentation shows results from these different experiments and how they can (and will) be used to define control strategies and algorithms for wind powered vessels.

Towards a Novel Implementation of the Syrope Model for Polyester Mooring Ropes in MoorDyn

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Abstract

Polyester ropes are attractive for reducing the costs of mooring systems for floating offshore wind turbines. Their tension-strain response, however, is nonlinear, path-dependent, and sensitive to loading rate and duration. The Syrope Joint Industry Project proposed a visco-elasto-plastic framework that captures these complex stiffness characteristics. In this model, the dynamic stiffness under fast cyclic loading varies linearly with mean tension, which is applicable to both wave-frequency (WF) and low-frequency (LF) loads, while slow effects are represented by the so-called working curves. Conventional practice of implementing the Syrope model [1] performs a quasi-static analysis along the working curves to obtain mean tension, followed by a dynamic analysis at this working point using the corresponding dynamic stiffness.

As part of the ESOMOOR project (www.esomoor.eu) co-funded by EU's CETPartnership, we introduce a fully dynamic, time-domain implementation of the Syrope model that eliminates this split, in which the mean tension is estimated without switching between static and dynamic solvers. In the Syrope model, the total stretch is decomposed into permanent and elastic parts. Permanent stretch is tracked by the preceding highest mean tension, which defines the current working curve. Whenever a higher mean tension is detected, the preceding highest mean tension as well as the active working curve is updated. Elastic stretch is represented by a fast spring in series with a Kelvin–Voigt element (dashpot and slow spring in parallel). The fast spring responds instantly to both fast and slow loading, whereas the Kelvin–Voigt branch is inactive at high rates because the dashpot locks the slow spring. Dashpot damping can be tuned to separate WF/LF loads from other slow loads. The implementation has been verified against DNV Syrope data by comparing the tension-strain path across a series of several different sea states. The integration into the open-source MoorDyn [2] codebase is in progress.

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A Critical Evaluation of Control-Oriented Modeling for Wave Energy Converters: A Sanity Check on the Data-Driven Promise

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Abstract

Nowadays, ocean wave energy still represents a large, untapped, renewable energy source. To bring this potential to reality, the levelized cost of energy harvested by wave energy converters (WECs) must be reduced, to reach a viable commercialization of wave energy. This can be achieved by two means: by increasing the survivability and durability of WECs, and by improving their efficiency. The energy capture of WECs can be improved by using control, where controlled WECs can absorb significantly more power than uncontrolled, passive WECs. A large number of the available control approaches are model-based, meaning that the performance of such control relies heavily on their modeling accuracy. Paradoxically, control-oriented models must be computationally fast, which often comes at the cost of prediction accuracy. The so-called linear potential flow approach is based on strong assumptions that limit the models to small wave amplitudes and displacement around the equilibrium position, greatly affecting the performance of the controllers based on such models. Data-driven approaches emerged as a promising solution to these drawbacks, combining both accuracy and computational speed. However, related literature and recent research struggle to show this evidence, at least in an objective and robust manner.

In this work, we aim to bring a more complete, critical comparison where the main criteria of control-oriented models, namely computational speed, robustness, and accuracy, are studied in close to real conditions. Accordingly, the wave elevation, a critical component in the Froude-Krylov force estimation scheme, is not assumed to be known but is instead estimated. This study considers both linear and data-driven models of a point-absorber WEC, and objectively evaluate their performance in various realistic irregular sea states. In particular, data requirement, range of operation, computational speed, accuracy and noise robustness are used to assess the different models with the intention to inspect the added value from data-driven approaches. The data required for both training and testing, as well as wave profile generation will be generated from a high-fidelity computational fluid dynamics scheme, using the mesh- less method Smooth Particle Hydrodynamics (SPH).

Scientific session 5:
Ship Design and Naval Architecture

Data-Driven Calm Water Power Prediction for Container Vessels in Operation

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Abstract

Shipping companies aim at reducing costs in terms of fuel and greenhouse gas (GHG) emission taxes. Tools that can predict power requirements under different operational conditions can be used by vessel owners and operators to make informed operational decisions that will reduce such costs. DNV's Vessel Technical Index (VTI) measures vessels' in-service performance relative to their expected performance as new-built. The accuracy of the VTI relies on accurate predictions of the expected performance. However, traditional empirical methods can lack accuracy due to outdated hull designs and limited applicability beyond design conditions, making them unsuitable for predicting modern vessel performance across their entire operational range.

We are introducing a data-driven methodology to predict calm water power requirement for slender hulls, such as container vessels. The approach consists of two stages using state-of-the-art machine learning (ML) regression techniques. First, a general thrust prediction model is trained on a database of self-propulsion CFD simulations from approximately 80 existing vessels. Second, a vessel-specific power prediction model is developed by combining the general thrust prediction model with the vessel's sea trial report and operational data.

This presentation outlines the data preparation process and the model derivation approaches used in both stages. The proposed methodology aims to improve power prediction accuracy for modern vessels across a broad range of operational conditions, supporting better decision-making in the shipping industry.

Keywords: calm water performance, power prediction, machine learning, data-driven model, CFD simulations, operational data, container vessel, vessel technical index

Regression Model Analysis for Alternatively Fuelled Ships

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Abstract

The maritime industry is facing increasing pressure to develop ship designs that are powered by alternative marine fuels. Early-stage ship design typically relies on empirical formulae to determine initial dimensions and predict key performance indicators (KPIs) of new designs. However, these models are predominantly derived from conventionally fuelled ships. Alternative fuels such as liquefied natural gas (LNG), methanol, hydrogen, and ammonia have significantly different energy densities compared to conventional fuels, necessitating substantially larger storage volumes.

This shift impacts the relationship between ship dimensions, cargo capacity, and performance, potentially reducing the accuracy of existing empirical models when applied to alternatively fuelled ships. This study evaluates the predictive performance of traditional empirical formulae, linear and non-linear regression models, and random forest regression models trained on conventional ship datasets for estimating the dimensions and KPIs of alternatively fuelled vessels. It also investigates whether models trained exclusively on the limited dataset of existing alternatively fuelled ships can achieve comparable accuracy. Results indicate that regression models trained on data from conventional bulk carriers, container ships, RO-Pax vessels, and tankers remain effective in predicting the dimensions of their alternatively fuelled counterparts. Whilst these results suggest that existing empirical methods are sufficient for early- stage design of alternatively fuelled ships, further research is required to identify the KPIs most affected by alternative ship design choices. This may require additional data alongside more sophisticated data analysis techniques.

Define Missions for Marine Vehicles

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Abstract

The maritime industry faces increasingly complex challenges due to evolving operational demands, stringent regulations, and rapid technological advancements. Consequently, the process of selecting or designing a suitable marine vehicle has become a critical task. However, existing assessment methods for vehicle selection and design primarily focus on basic requirements such as speed, cargo capacity, and fuel consumption, overlooking broader factors, such as environmental impact, economic viability, social considerations, and human factors. There is a clear need fora systematic approach that enables vessel selection and design based on a comprehensive set of factors, including all these dimensions.

To address this gap, a research project has been initiated as a collaborative effort between RISE – Research Institutes of Sweden and KTH Royal Institute of Technology, to develop a Mission Suitability Assessment Framework. The first phase of the project involves identifying the missions of the marine vehicles and their specific requirements. To achieve this, a mission definition model (MDM) is developed to systematically define the missions of marine vehicles.

The MDM consists of a comprehensive set of structured questions, whereby answering these questions, one can systematically define the intended mission, ensuring that all relevant factors, including safety considerations, regulatory requirements, and industry best practices. The questions are initially generated in collaboration with a consensus panel, based on the content domain of marine vehicle missions. They are then refined across six subdomains: application, vehicle, human, environment, economy, and society. Then the questions are validated for relevance and simplicity with an expert panel over three consecutive rounds. After each round, the questions are revised by the consensus panel.

The presentation will provide an overview of the development and validation of the Mission Definition Model (MDM).

Future Ship Design for Decarbonization – Establishing Digital Twins in Ship Design

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Abstract

The maritime sector is under strong pressure to decarbonize, driven by the International Maritime Organization's revised greenhouse gas strategy (DNV, 2024). At the same time, it is undergoing a technological shift (Lv. et al., 2023), with digital innovations reshaping how ships are designed, built and operated. According to DNV's Maritime Forecast to 2050, decarbonization and digitalization are highlighted as key drivers expected to significantly transform the shipping industry (DNV, 2024).
At the design stage, these drivers become particularly relevant, as it is the phase that determines a ship's future performance and emissions profile, making it an ideal stage for integrating digital technologies with decarbonization objectives. One such technology is the concept of Digital Twin (DT), which has the potential to enhance the design process and support the maritime sector's transition toward smarter and more sustainable ships.

The concept of DTs in ship design remains limited despite their growing success in ship operation (Lv et al., 2023; Mauro and Kana, 2022). This limitation largely stems from the absence of a physical asset during the design phase. Therefore, the ongoing research aims to establish a structured approach to address the gap. The key research question guiding this research is:

"How can Digital Twins be established in ship design, and what challenges are associated with their implementation?"

Building on the earlier presentation at the DNV workshop, the current phase of the research focuses on developing and refining a DT architecture and step-by-step framework tailored to ship design. This progress represents an important step toward integrating DT technology into ship design to improve design accuracy and support data-driven decision-making for future ship design.

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Ship Hull Form Dataset Generation

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Abstract

The increasing demand for sustainability in the maritime industry has driven shipowners and designers to adopt innovative and accelerated design methodologies. Recent developments, particularly in hull optimization, have leveraged digital technologies such as machine learning (ML) and generative artificial intelligence (AI).

While ML and AI have transformed many engineering disciplines, their application in the maritime sector remains constrained by the limited availability of structured, high-quality datasets.

To address this challenge, we propose a methodology for building a flexible dataset of ship hull geometries using the open-source Python library PyGeM. By applying Free Form Deformation techniques, our approach generates diverse hull variants suitable for training data-driven models.

This generalizable framework can be applied to a broad range of hull forms, providing a foundation for ML-based prediction of hydrodynamic performance and design optimization. Ultimately, it aims to accelerate innovation in ship design, promote sustainable practices, and support compliance with the International Maritime Organization's (IMO) revised greenhouse gas reduction targets.

AI in Ship Design

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Abstract

The use of artificial intelligence (AI) in our lives has increased significantly since OpenAI introduced ChatGPT in 2022. Many industries are already using AI or attempting to integrate it into their processes. The maritime industry is no exception. People are trying to figure out ways to use AI in this industry. In my PhD, my main motivation is to better understand the steps in the ship design process and how AI can be integrated into it. Having a "theoretical model" of the design process makes it easier to identify steps where AI can be helpful. Building on that, it is important to evaluate whether integrating AI into working processes actually improves them or if it is just an add-on because of its popularity. Within the project Design Re-Engineering and Automation for Marine Systems (DREAMS), the main goal of this research is to determine how a ship design firm can be modernized by integrating AI into its procedures to make them faster, cheaper, and more efficient. While exploring how to make this happen, I tested two different cases. The first was an AI agent with knowledge of SOLAS regulations, however, it ended up more like a chatbot rather than an agent that can answer specific questions. The second was an automated general arrangement of a containership based on its main dimensions, but the results were a sketch level quality that could not be used for further design. These were preliminary approaches, and more effort should be put into them in order to be more useful for design. However, they demonstrate how the ship design process could be sped up. Ongoing developments of the research project will be presented.

Scientific session 6: Structural Integrity and Marine Structures

Linking the Weld Geometry and Fatigue Life Using Optical Scanning and Computer Vision for Reliable Maritime Structures

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Abstract

Welded joints are critical to the safety and reliability of maritime structures, where fatigue failure is a major concern affecting the design of engineer structures. This study examines the correlation between weld geometry quality (classified by standards such as ISO 5817 or Volvo STD 181-0004) and fatigue life using a data-driven approach. Optical scanning is used to capture the local weld geometry which then are linked to fatigue test results. Additionally, convolutional neural networks are applied to identified crack initiation sites on fatigue fracture surfaces. The aim is to identify which local geometric features act as the most relevant stress concentrators which would enable the prioritization of inspection points and potential repairs as post-processing after manufacturing. Preliminary results and recent literature indicate that current quality levels do not reflect the fatigue behavior supporting the need of new quality definitions.

Early-stage Structural Health Monitoring of ship Gearboxes

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Abstract

In many real-world applications, particularly within the maritime domain [1], developing data-driven models is challenged by the limited availability of representative data. Traditional machine learning methods often require large, labelled datasets before a model can be deployed, which is rarely feasible for complex systems operating under time-varying conditions. One example is health monitoring systems, where such models must be trained on data that capture the full range of environmental and operational variability. Due to seasonal changes and other operational parameters, this often requires sampling data for years before deployment [2].

Health monitoring systems are fundamentally based on baseline comparison to infer structural integrity. Any deviations—particularly persistent ones—are typically interpreted as indicators of damage [3]. Therefore, it is crucial that the baseline model captures the full range of variability. However, many systems operate across discrete regimes, each characterized by distinct dynamic behaviour, challenging the use of a single baseline. This challenge is not limited to health monitoring but extends to other reference-based analyses, such as the energy efficiency of ships [4], [5].

In this work, a Bayesian Multi-Model framework for Structural Health Monitoring of the gearboxes on a working vessel is presented as a practical solution that enables model deployment from the very beginning of operation and continuous improvement as new data becomes available. The framework is based upon a Bayesian Vector AutoRegressive formulation, in which the model parameters are treated as random variables whose distributions represent our current belief about the system's dynamic behaviour. As new observations are collected, these beliefs are updated on the fly—without the need for retraining on large data batches. Each operating regime of the system is represented by its own posterior distribution, forming a global reference of the system. Incoming data obtained under an unknown regime are compared against these references to identify the most likely regime and detect deviations that may indicate structural changes. The study demonstrates how Bayesian updating and a multi-model formulation can advance health monitoring and potentially other reference-based analyses in complex, evolving systems.

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Strengthening European Shipbuilding Capabilities through Advanced Automation Solutions

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Abstract

The ship hull assembly process is widely regarded as one of the most labour intensive processes in the construction of a ship. Due to high labour costs, ship production has been outsourced to countries with lower wages throughout the past decades, leading to a significant reduction in European shipbuilding capacity.
The competitiveness of European shipyards is further challenged by labour shortages, as it is becoming increasingly difficult to secure the required skilled workforce for building a ship.
Revitalisation of European shipbuilding capacities requires both political incentives and technological advancements. The aforementioned challenges must be addressed in order to ensure the competitiveness of future European shipbuilding activities.

The present project is part of the SDU Center for Large Structure Production (LSP), which aims to mitigate the challenges faced by the European shipbuilding industry by advancing the level of automation in shipbuilding activities. A novel, multi-purpose robotic work cell is being developed, which will be able to handle various shipbuilding operations within the same multi-robot workspace, thus addressing the challenges faced by the industry.
The presentation at the DNV NMU workshop will provide a general overview of the development of the robotic work cell. Furthermore, state-of-the-art technologies for robotic manipulation, alignment and assembly of panels used in ship construction will be presented based on a literature survey. This knowledge will provide a foundation for future work, with the goal of enabling automatic assembly of ship modules in the robotic work cell. Additionally, various robotic welding technologies applicable to shipbuilding will be discussed, highlighting their strengths and weaknesses.
Plans for future work will be presented, where steps towards achieving robotic assembly of ship panels will be highlighted, including the application of “design for manufacture” approaches to naval architecture and “early outfitting” of pipes, cables, etc.

A Reliability Study of Nylon Mooring Lines for Floating Wind Turbines

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Abstract

The ship hull assembly process is widely regarded as one of the most labour intensive processes in the construction of a ship. Due to high labour costs, ship production has been outsourced to countries with lower wages throughout the past decades, leading This study presents a comparative analysis of structural reliability methods for estimating the failure probability of nylon mooring lines in floating wind turbines, utilizing case study data for the extreme tension load on **a floating wind turbine in the Gulf of Maine** and **experimental test data for the tensile strength of nylon yarn**. The First-Order Reliability Method (FORM), standard Monte Carlo simulation (in both X- and U-space), and Importance Sampling are evaluated. A low-uncertainty case (Resistance CoV = 2%, Load CoV = 4%) and a higher-uncertainty case (Resistance CoV = 5%, Load CoV = 10%) are considered for this analysis. Results show strong agreement among all the different methods, validating their applicability in relation to mooring line reliability assessment. However, computational analysis highlights the comparative inefficiency of crude Monte Carlo simulations compared with the other reliability methods. This research work which was conducted as part of the **NYMOOR project**, demonstrates that advanced methods such as FORM and Importance Sampling provide computationally efficient and practical alternatives for reliability-based design of floating wind turbine mooring systems at the individual line level.

Numerical Reproduction of an Extreme Wave Impact on Flexible Plates

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Abstract

Extreme wave impacts can exert high loads on maritime structures, which can lead to damage or failure. In literature, commonly mentioned categories of wave impact are slamming (Kapsenberg, 2011) and green water (Buchner, 2002). The occurrence of the most extreme wave impacts is rare, which makes it hard to obtain converged statistics of extreme values (van Essen and Seyffert, 2023; Boon and Wellens, 2022). Besides the stochastic process of ocean-ship dynamics, the final excitation of structural responses is also stochastic and sensitive to small variations. Controlled, artificially generated wave impacts are therefore important tools for the study of the expected value and variability of these events.

This study concerns the repeatable generation of an extreme wave impact using numerics and physical model test at scale. The dynamics of extreme wave impacts involve large variations of the interfaces and large responses of the impacted structure. The hydrodynamic loads and structural response depend on their coupled interaction (hydroelasticity), which should be taken into account during wave impacts (Faltinsen, 2000). The experimental setup used in this study was designed to include all of these phenomena (Bromlewe et al., 2025). It consists of a rectangular tank that undergoes an oscillating motion to produce a sloshing wave impact against a flexible, overhanging, cantilever plate.

In both the design and analysis of the physical setup, numerical tools are extensively used; first for dimensioning the system, and later for the interpretation of measurements. Their main advantage is that changes in the setup are significantly faster than in the physical setup. Numerical tools also help identify relevant scaling parameters of problems in multiphysics, which may be impossible using physical materials (Dias and Ghidaglia, 2018).

The numerical reproduction of the physical experiment is performed using a hydrostructural model. The hydrodynamic part of the model consists of a two-phase finite-volume Navier-Stokes solver, which was developed specifically for modelling extreme wave impacts (van der Eijk and Wellens, 2024). The novel structural part consists of a finite-element discretisation of a beam, which is monolithically coupled to the hydrodynamic model.

Comparing physical and numerical results often serves the validation of the numerical model. In this study, the reverse is also true: The numerical simulations are used to validate, or interpret, the physical test results. Results for varying plate stiffness and impact severity form the basis for developing scaling relations for this type of fluid-structure interaction. Besides the presentation of the reproducible wave impact setup, the effects of

hydroelasticity on the (numerical) analysis of the physical measurements will be the main point of discussion.

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Effects of Irregular Seas Generation Using Random versus Deterministic Amplitudes in Parametric Roll Prediction

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Abstract

Parametric roll prediction in irregular seas relies on generating spatiotemporal wave surfaces that preserve the statistical properties of a Gaussian Sea. While attention has been given to frequency discretization methods to avoid self-repetition, the approach used to assign wave component amplitudes—typically either random or deterministic—has received less attention. Deterministic amplitude schemes, though commonly used, artificially suppress variability in spectral moments and may distort the assessment of nonlinear responses such as parametric roll. This study investigates how deterministic amplitude scheme (DAS) and random amplitude scheme (RAS) influence rare event prediction using a GPU-accelerated 3DOF time-domain simulation model. The study highlights the importance of wave generation choices for accurate parametric roll prediction.

Scientific session 7:
Advanced Energy Systems and Modeling for Maritime applications

Enabling Battery- & Fuel Cell- based Hybrid Energy Systems for Ice-Class Research Vessels

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Abstract

Hybrid energy systems are investigated as a viable alternative to conventional energy systems typically consisting of multiple diesel engines, on ice class vessels. Vessels bearing ice class notation experience significant disparities in load profiles between typical voyages and those involving occasional icy conditions. Ice class rules mandate considerably higher installed power than necessary for regular service, which can reduce the average operating efficiency of a conventional energy system. This paper demonstrates the performance of two hybrid energy system configurations on a 50-meter research vessel operating mainly in the Baltic Sea with ice class 1A. Ship resistance is calculated in open water and ice and characteristic time-based load profiles are generated for a selected route over three voyage conditions. The peak propulsion loads even in mild winter conditions with ice are observed to be over 4 times as high as open water operation in summer.

Various hybrid energy system configurations including diesel gensets, fuel cells, and batteries are analyzed over three voyage conditions. Results indicate that a fuel cell-based energy system can yield up to 24.2% energy savings. Upto 13.7% energy savings can be achieved by modularizing the onboard genset installation, while battery hybridization enables optimal energy system operation over a wider range of voyages. Finally, it is shown that ice class capable energy system can perform as efficiently as a comparable downsized energy system when the genset installation is modularized, and even enable further fuel savings in the presence of fuel cells.

Optimal Battery Sizing and Charger Location for Enabling Electrification of Inland Waterways

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Abstract

Battery electric propulsion represents a highly promising avenue for the defossilisation of inland waterway (IWW) transport. However, to electrify the sector, substantial investments in new propulsion systems and also the charging infrastructure are necessary. It is therefore vital to guide investment decisions during the initial build up phase to ensure optimal use of resources. This work thus develops a holistic approach for planning a charging network for a fleet of IWW vessels using both a multi criteria decision making approach in a geographical information system (GIS) and mixed integer programming. A case study is performed using AIS data to calculate energy demands of a fleet of 1800 IWW vessels travelling on a subsection of the IWW network in North-Rhine Westphalia. The developed methods are employed to optimise a charging network for the study area. Moreover, a multi-objective optimisation is conducted to analyse the effect of onboard battery sizes on the charging network. A Pareto front is calculated to illustrate the trade-offs between increasing the vessels battery capacity and expanding charging network density, supporting balanced decision-making by revealing optimal solutions that align with differing strategic priorities.

Lignin as a Cetane Improver for Methanol Combustion Under Engine-Like Conditions

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Abstract

Approximately 3% of the annual Greenhouse Gas (GHG) emissions come from the shipping industry, which is predicted to increase as global trade expands. There is a need to develop low-carbon fuels to meet the International Maritime Organization's (IMO) target of net-zero greenhouse gas emissions by 2050. This study investigates the combustion characteristics of methanol-lignin blends as a possible alternative to conventional marine fuels. Lignin is an alcohol-soluble biomass-derived product, which acts as a cetane improver, enhancing ignition properties while contributing to fuel sustainability. Experiments will be carried out in a Constant Volume Combustion Chamber (CVCC), using a Design of Experiments (DoE) methodology to systematically evaluate Ignition Delay Time (IDT), cylinder pressure and heat release. Preliminary tests suggest that the methanol-lignin blends will improve the combustion stability and reduce the IDT when as little as 10% lignin is added, as compared to neat methanol.

The Physics of Floating Solar Through a Hydroelastic Dispersion Relation Assessments with a Table Top Experiment

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Abstract

Offshore floating solar designs are extensive in area rather than volume, such as ships. Their diameter is typically larger than a wave length to produce as much energy as possible, and their rigidity is ideally low to save construction cost (Zhang & Schreier, 2022). The solution of the characteristic equation, the hydroelastic dispersion relation, provides the main insights into the physical behaviour of the structure.

Large parameter spaces (including for instance wave frequencies and models with various thicknesses or stiffness) as well as a large structure length (L) over wave length (λ) ratio are required for the proposed investigation. Both the large L/λ (demanding large models) as the large parameter space poses challenges for common facilities such as wave tanks, due to limited wave frequencies, and blocking due to large surface coverage (Tassin et al., 2024).

This study demonstrates that a large parameter space can be explored using an accessible laboratory-scale approach. A Faraday experiment is used to generate standing waves in a 13 cm diameter basin via a vertically driven shaker. Floating membranes of various thicknesses are placed on the fluid surface, and their dynamic response is recorded using a full-field Synthetic Schlieren technique. The setup allows for continuous frequency variation over a wide range as well as rapid replacement of membrane models, so that hydroelastic behaviour can be systematically studied in the complete parameter space within a reasonable time frame.

The results of this study show clear correspondence between the thinnest membrane and the case without membrane and only water, indicating the correspondence between the effect of the membrane and the effect of surface tension, and the suitability of the method. In contrast, the thicker membrane exhibits a wavelength increase beyond initial theoretical expectations, indicating that a linear hydroelastic dispersion relation may not include the relevant physics for all cases. Interpretation of these differences will be the main point of discussion.

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System-Based Modelling of a Two-Stroke Marine Engine Fuel Efficiency and Its Uncertainties

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Abstract

This study develops a high-fidelity zero-dimensional thermodynamic model of a large two-stroke marine diesel engine, utilizing an advanced molding environment. To bridge the gap between computational speed and physical fidelity, the study incorporates a phenomenological Dual Flame Model. This approach resolves in-cylinder processes on a crank angle basis, explicitly differentiating between premixed and diffusion combustion phases to generate predictive thermodynamic states. Specific calibration strategies are considered to parameterize engine subsystems, including heat transfer, mechanical friction, and turbocharger performance, using limited standard engine shop test data. Simulation demonstrated good agreement with physical measurements, successfully capturing the characteristic non-linear efficiency trends across the operational envelope. Crucially, when applied to scenarios simulating added resistance from adverse weather, the model identifies the operational states characterized by increased thermal and mechanical loads and quantifies the resulting specific fuel consumption penalty relative to baseline conditions, which are often missed by quasi-steady estimation methods. The shift toward rigorous decolonization standards exposes the limitation of conventional steady-state polynomial fuel consumption maps, which often fail to account for the complex, non-linear engine responses essential for accurate efficiency prediction under dynamic environmental loads. This system-level simulation is capable of being integrated with other models, serving as a comprehensive decision-support tool for optimizing propulsion system interactions and evaluating the operational viability of energy-saving technologies in real-world conditions.

Scalability of Heat-Pipe cooled Reactors for Remote and Autonomous Applications

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Abstract

Heat-Pipe cooled Reactors (HPRs), which were originally intended for space applications, are of particular interest for remote/autonomous operations as they are simple, compact, and transportable. Historically most HPR designs have produced limited thermal power and/or utilize highly enriched fuel. This work investigated how reactor design principles can be used to scale up HPRs to higher nominal powers without exceeding material limits and while using less-enriched fuel. The effective core height, diameter-to-height ratio, and heat-pipe operating temperature were used to constrain the scope of the work. A variety of HPR fuel assemblies were modeled; the open-source particle transport code OpenMC was used to determine the axial power distribution of an average fuel pin, which was coupled with an iterative finite-difference scheme to determine local temperature distributions in the reactor core. Fuel assemblies were modified until a HPR core was obtained that could produce between 10 and 100 MWth without exceeding thermal material limits. The final up-scaled core was modeled neutronically in OpenMC to determine key properties relating to power distribution, reactivity feedback mechanisms, and operation capabilities.

Scientific session 8:
Maritime Human Factors, Education, and Training

Navigating Decisions: Behavioral Design for Sustainable Weather Routing

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Abstract

Decision-making in a maritime context is complex. The crew must balance multiple and often conflicting goals—such as safety, timeliness, fuel consumption, and other operational constraints—when planning a route.

For vessels using *wind propulsion*, one particularly critical decision concerns *weather routing*, as wind speed and direction directly affects fuel consumption. Weather routing applications typically present the crew with several alternative routes, each with distinct characteristics such as estimated consumption, wind speed, distance, and wave height. The choice of route significantly impacts not only fuel use but also arrival time, crew comfort, and potentially safety. Currently, the weather routing and the wind propulsion systems act independently. The latter does not "suggest" a change of route itself, even if it has real-time data on actual wind speed and direction.

This presentation will provide an overview of a field trip on a hybrid vessel using wind propulsion, highlight findings from the observing the crew, and suggest some ways forward to help crews choosing the right route.

Design and research questions

Several questions were raised before the field study. How is the decision made when choosing a route? What is the role of habits when doing so? How can interface design influence the decision-making process? What types of "choice architecture" most effectively nudge users toward selecting the route with the lowest consumption—while staying within safety limits? How can design support the resolution of goal conflicts, such as between minimizing consumption and maintaining schedule reliability? What happens if the weather changes in a way that was not predicted? Are there barriers when it comes to using wind propulsion?

The field study

To explore these questions, a field study was conducted at the wind-assisted cargo ship *Canopée* on a voyage between Rotterdam and Bremen. Canopée is a special purpose vessel built to carry parts for the Ariane 6 rocket from European ports to a space centre at the other side of the Atlantic (Guiana). The vessel does the Atlantic crossing in 10-14 days, and usually has some "slack", which is a benefit when choosing the most fuel-effective route. The field work focused on observations of the crew's interaction with the weather routing and wind propulsion applications.

The weather routing system (D-ICE) provides the crew with weather data from several vendors to choose from and the possibility to set constraints on the suggestions, like maximum duration of the voyage. Usually, ca 5 different routes are set up for the Atlantic crossing. This is done by one of the cadets, while the captain is taking the final decision on what route to take. The weather routing is done every 12 hour (this was the update frequency of most of the weather models). When a route is chosen, it is loaded onto a USB stick and plugged into the ECDIS for validation, to confirm that there are no other obstacles that stops them from following this route.

The wind propulsion system (OceanWings) consists of 4 sails that can be raised or lowered, or set to neutral position when raised (close to zero effect). When the sails are raised, the system runs on auto-pilot where the angle of the sail is adjusted automatically. Like other sails, it is best when the wind comes from one of the sides. Headwind up to 45 degrees on each side give little to no effect, and the same with tailwind straight from the back. The crew raise and lower the sails with a physical button. The interface itself is not much used during the voyage. The sails are lowered automatically if the wing is too strong.

Main findings

We followed a crew over two days, both day and night, on the leg between Rotterdam and Bremen. The sails were used most of the time. Weather conditions were very good “wind-wise”, with wind speeds in the range of 10-14 meters per second. The crew were autonomous when it came to weather routing and decisions related to wind propulsion, in contrast to other companies where these decisions might be taken in other parts of the organization or by external service providers.

Here are the most important findings:

- There are barriers to perform frequent weather routing
    - weather forecast updated only twice a day, and the crew performed weather routing at the same frequency
    - no notification to the crew when the weather changed
    - cumbersome transfer of suggested route from weather routing app to ECDIS for validation (load route onto a USB stick and transfer manually to ECDIS for validation)
- The choice of route seems to be based on habits/rules of thumb to some degree
    - in this field study, the captain´s trust in the reliability of the different weather models/forecasts for the specific area was most important when choosing route
- Little to no help in the interface to do trade-offs between different goals when choosing route
    - many different variables are shown (wave height, ETA, wind speed, estimated consumption…)
    - easy to see what route is “best” related to one variable, but little support to find the best trade-off between different goals

- Little or no feedback to the crew after the voyage related to the choice of route
  - what could be learned from how to handle risk/unpredictable weather?
  - the captain did his own, private logging to understand the impact of different actions
  - lower emissions can be attributed to a lot of different factors. Will feedback be precise enough?

- No interaction between different systems
  - the wind propulsion interface doesn´t give feedback that the current route is not optimal
  - no feedback from the wind propulsion to the captain about added drift and reduction of main engine power. Before raising the sails, the captain is not quite sure how the vessel will be affected.

Discussion

The wind propulsion system estimated the fuel savings for this voyage to be close to 23%. Based on our observations, we think there is an "untapped potential" for saving even more. Here are hypotheses on where the potential for further reduction in emissions lie:

- Create awareness of habits and decision-making styles of the crew when choosing a route.
  - Research generally supports the idea that greater awareness of your own decision-making style can lead to better decisions, especially over time and in complex or uncertain situations
  - Research suggest that people tend to make more accurate judgments and are better at adjusting their strategies when faced with new information (like change in the weather)

- Show what kind of impact the use of wind propulsion (sails) will have on the vessel – before raising them
  - The crew hesitates to raise the sails in heavy traffic/tight areas because they create drift/added speed
  - If the interface inform them of these effects *before* they raise the sails, they would maybe be less hesitant

- Give continuous feedback to the crew whether the route they follow is optimal
  - Today, the crew decides on the route every 12 hour, and then switch on the auto-pilot
  - The wind propulsion system will know at all times if this direction/route is the best for maximum utilization of wind
  - The wind propulsion system should inform the crew if a slight change of course could improve the efficiency

Imagining "Technology for Tomorrow": Futures of Technology Design in the Fisheries Sector

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Abstract

The presentation introduces **ongoing PhD project**, which explores how fisheries may be transformed if emerging digital trends such as artificial intelligence (AI), robotics, the Internet of Things (IoT), and autonomous systems (Rowan, 2023; Vanhée et al., 2018) are integrated into vessel and gear design, and how (or if) it could be done to support sustainable, ethical, and inclusive futures for fisheries.

Small-scale fisheries (SSF) in Norway were selected as a case study because the actors engaged in this socially and culturally important economic activity face increasing uncertainty, where either adoption and resistance to emerging technologies may have complex implications for fishing efficiency, safety, sustainability, as well as for people's identity, autonomy, and livelihoods.

The research employs **a multi-layered theoretical framework conceptualized as a phoropter** - a combination of lenses from fisheries science, science and technology studies (STS), futures studies, and design anthropology. These lenses enable analysis of fisheries as socio-eco-technological systems (SETS) (Charles, 2023; Markolf et al., 2018), exploration of sociotechnical imaginaries (STI) (Jasanoff, 2016) that influence design strategies and technology trajectories, and examination of how human-technology interaction onboard and co-design practices may shape future vessel and gear design.

By accessing the relevant context, an extended understanding of design integrating both technology development and use is gradually developed and **the following questions are critically examined**: *What sociotechnical constructions comprised of attitudes, future visions, and lived experiences of actors in the fishery sector exist; How emerging digital trends might influence the future form and functionality of fishing technology (vessels and gear), as seen in these constructions;* and finally, *How can engaging with sociotechnical constructions developed by technology users and developers help establish "good design practice" in the fishery sector?*

Methodologically, the research integrates ethnography, phenomenology, and futures studies. Data are collected in multi-site fieldwork among technology users and developers and include observations of everyday practices (onboard and on land) and in-depth interviews with 5 small-scale fishers; observations and interviews with 10 engineers/naval architects in organizational settings of Norwegian company working with marine design; >30 rapid interviews with technology producers during relevant fishing and maritime technology events (e.g. Nor-Fishing 2024, Nor-Shipping 2025, Autonomous ship).

Findings revealed that, despite the constraints set by material and immaterial infrastructure, reflected in participants' *attitudes* (i.e. skepticism, concerns, and

Usability of Eye Tracking in Nautical Simulator Training

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Abstract

Traditional maritime training assessment relies heavily on subjective observation. Our research proposes a multimodal AI framework to automate and objectify this process by fusing eye-tracking metrics with simulator telemetry. We demonstrate that visual attention metrics correlate with situational awareness and cognitive workload. Technically, the study leverages a hybrid machine learning architecture by utilising an Explainable AI (XAI) approach. We combine an XGBoost model (on simulator tabular data) and Convolutional Neural Network (CNNs) (on eye-tracking based heatmaps), both interpreted via SHAP values, to predict performance and identify key decision-making features. Furthermore, we deployed a Retrieval-Augmented Generation (RAG) system to generate interactive, natural language feedback for trainees. Results demonstrate that our multimodal AI approach provides a foundation for future, objective maritime training systems.

Economic Impact Assessment of Marine Autonomous Operations: A Review of Methodologies

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Abstract

The emergence of Autonomous Technologies (AT) is transforming the marine industries. However, the economic impacts of adopting AT in marine operations remain underexplored in mainstream literature, despite their critical importance. A lack of consensus on Economic Impact Assessment (EIA) methods has led to fragmented approaches and limited understanding of the economic trade-offs involved. This study addresses these gaps by identifying the existing methods, techniques, and tools used for the EIA of marine autonomous operations and proposing a comprehensive methodological framework for future assessments. Using a Systematic Literature Review (SLR) approach, 17 publications were carefully selected for in-depth analysis. The selected literature covers three key application domains of AT: shipping, port operations, and offshore windmill infrastructure inspection. The findings reveal that the existing studies primarily focus on cost assessment, while often assuming constant revenues and overlooking indirect economic effects and broader macroeconomic concerns. Cost-benefit analysis emerges as the most commonly used approach, while qualitative methods and modelling and simulation approaches remain underutilized. Based on these results, this study introduces a generalized methodological framework for conducting EIAs of AT. This framework consists of twelve procedural steps, including conceptualizing the technology, recognizing technology maturity level, planning scenarios, identifying technical parameters, formulating objectives, defining the scope of assessment, selecting variables and data assessment, choosing the right tools, performing assessment, validation and reporting. The proposed framework provides tools for stakeholders, including marine companies, technology developers, policymakers, and investors, seeking to assess the economic implications of new technologies, thereby supporting informed decision-making.

Keywords: Autonomous operations, economic evaluation, economic feasibility, impact analysis

Mapping Teamwork Competence Gaps in Maritime Simulator Training: a Comparative Importance-improvement Analysis for the Implication of Learning Analytics Dashboards Design

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Abstract

Maritime education and training (MET) shape the competencies of future seafarers, directly influencing the safety of ship operations. Effective bridge teamwork relies on shared behaviors (such as closed-loop communication, the use of multiple communication channels), shared attitudes (including mutual support and inclusion), and shared cognition. This study examined the teamwork training needs based on full-mission bridge simulator exercises conducted at a Norwegian maritime institution, involving two instructors and 22 students organized into 8 teams navigating in the inner Oslo Fjord. After the exercise, both instructors and students were invited to evaluate the importance and improvement needs of the five teamwork dimensions, allowing us to map perception gaps between the two groups. Results revealed that for students, shared attitudes were consistently underestimated by both lower and higher performing teams. When instructors' evaluation was added into the picture, for lower-performing teams, the shared cognition and shared behavior of using multiple communication channels emerged as key priorities, as instructors rated them higher in both importance and need for development. Meanwhile, for higher-performing teams, the shared attitude of inclusion was particularly emphasized as a critical area where more attention is needed. This study highlights the need to align behavioral, cognitive and attitudinal dimensions in MET bridge teamwork training. The results further provide practical implications for designing Learning Analytics Dashboards that visualize students-instructors perception gaps on teamwork competencies, enabling more targeted feedback and adaptive instructional interventions in future simulator-based training.

Probabilistic Prediction of Motion Sickness Symptoms Based on Vessel Motion Characteristics

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Abstract

The daily tasks of offshore wind technicians are both mentally and physically demanding. Despite strict physical and mental fitness requirements, one critical factor that may compromise their ready-to-work level is motion sickness, a prevalent issue among offshore wind workers. This is particularly relevant upon arrival at the wind farm but may also affect well-being and performance throughout the day due to the persistence of symptoms.

While the widely employed Motion Sickness Incidence (MSI) metric remains the standard for quantifying motion sickness, its focus on vertical motion alone and emesis limits its applicability to smaller working vessels used in the offshore wind context. This study addresses these limitations by developing a probabilistic prediction model for motion sickness symptom severity among offshore wind technicians. Using data collected over a one-year period from an operating crew transfer vessel, the model combines measured vessel motion across four degrees of freedom (sway, heave, roll, and pitch) with self-reported symptoms of headache, fatigue, and nausea. Motion signals were transformed into frequency-domain features and used as predictors in a Bayesian logistic regression framework, where motion sickness was represented as a latent variable driving observed symptoms.

The study found that heave contributes most strongly to predicted sickness severity, followed by pitch, which shows broader sensitivity between 0.2 and 0.4 Hz. Roll exhibits a local peak near 0.2 Hz with higher uncertainty, while sway shows smaller but more stable effects. Across all DOFs, coefficients approach zero at low (<0.1 Hz) and high (>0.8 Hz) frequencies, indicating limited influence. There were both modeling limitations, primarily due to data imbalance, and practical challenges, such as missing individual details about the technicians that could affect motion sickness susceptibility. Despite these limitations, this preliminary study demonstrates potential for further development and integration into a more comprehensive prediction system.

caution about possible changes) and *future visions* (i.e. difficulty, inability, or reluctance to envision certain options), both users-fishers and developers-engineers also expressed curiosity, adaptability, and creativity within certain limits. These were observed and interpreted, for example, as *bricoleur innovativeness* in user practices (e.g. combining/modifying equipment onboard for new, unintended by design uses) or as *creative problem-solving* in design strategies (e.g. vessel design with wider hull to comply with length restrictions for certain operations).

The research contributes to ongoing debates on the possibilities and concerns around emerging technologies that may significantly transform the fishing industry (e.g. by enabling autonomous fishing operations) and demonstrates the **methodological usefulness** of combining futures studies methods and STS lenses to expand the design space and enable more ethical and inclusive pathways for sociotechnical innovation in fisheries and beyond.