



THE 26th SYMPOSIUM ON THEORY
AND PRACTICE OF SHIPBUILDING

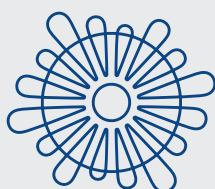
2024

SORTA 2024

Book of Abstracts



2 - 5 October 2024, Zadar – Croatia



Sveučilište u Zadru
University of Zadar



UNIVERSITÀ
DEGLI STUDI
DI TRIESTE

The 26th Symposium on Theory and Practice of Shipbuilding

2 - 5 October 2024, Zadar – Croatia

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Luca Braidotti

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Preface

Dear participants of the SORTA 2024 symposium,

In the name of the Standing Committee, it is my pleasure to announce the XXVI Symposium Theory and Practice of Shipbuilding in memoriam prof. Leopold Sorta that will take place in Zadar – Croatia, from October 2-5, 2024, jointly organized by the University of Zadar (Croatia) and University of Trieste (Italy). Traditionally, the Symposium is under the auspicious of the Croatian Academy of Sciences and Arts which obliges the symposium to maintain a high scientific and professional level of presentations during technical sessions.

This year's Symposium has for the first time status of an international scientific conference, as it is co-organized by the recognized international research institution i.e. University of Trieste (Italy) and has established International Scientific Board and International Editorial Board. The contributions to the Symposium are in the form of abstracts or as full papers. The latter, after passing international peer-review, will be published in the proceedings of full papers, cited in SCOPUS. This flexible format of contributions was chosen to accommodate needs of the industry participants without a time resources to draft full papers, from one side, and of the academic participants from the other side, who are interested to have their research highly visible and recognized. This reflects continuous efforts of the Standing and International Scientific Committees in analysing Symposiums' trends, aiming to find optimal format that would maintain the interest of the professional and academic shipbuilding and marine technology communities.

About seventy presentations will be presented at this XXVI Symposium, which is similar number as in previous symposia. The present booklet contains abstracts of all presented papers, while around thirty full papers, accepted after peer-review by at least two international reviewers will be published in Proceedings of Full Papers. The Standing Committee highly appreciates the effort of the International Editorial Board, chaired by Prof. dr. sc. Nastia Degiuli, in reviewing papers and editing this Book of Abstracts.

Three plenary lectures will be presented at the opening session of the Symposium. The Standing Committee acknowledges the efforts of Mr. Oskar Levander, Vice President Strategy & Business Development Integration & Energy Kongsberg Maritime, Mr. Sander Klaasse, Product Sales Manager Wärtsilä Voyage, Europe, and Mr. Zoran Kunkera, managing director at Leaera Ltd., business advisory services Zagreb, Croatia for their willingness to provide plenary lectures, contributing thus to the success of the Symposium.

The panel discussion "Maritime Decarbonization – From Vision to Reality" will be organized within the Symposium. The Standing Committee is grateful to the moderator and panellists for their participation and contribution in understanding the industry needs in the present challenging circumstances of strictening the international maritime regulations because of the global warming.

The Organizing Committee of this XXVI Symposium SORTA, chaired by Assoc. Prof. Marko Valčić, University of Zadar, has been working hard for the past two years and carried the work for this Symposium, which is gratefully acknowledged by the Standing Committee.

Finally, the Standing Committee expresses sincere gratitude to all sponsors, as the organization of the Symposium would be impossible without their kind support.

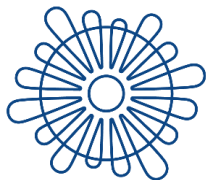
Zagreb, September 26, 2024

Prof. dr. sc. Joško Parunov

Chair of the Standing Committee of the Symposium SORTA

SORTA 2024

SORTA 2024 is the 26th Symposium on the Theory and Practice of Shipbuilding in memoriam prof. Leopold Sorta jointly organized by the University of Zadar, Maritime Department, Zadar, Croatia, and the University of Trieste, Faculty of Engineering and Architecture, Trieste, Italy, with support of the Digital Innovation HUB Innovamare, Šibenik, Croatia. Such a significant tradition of the Symposium proves the importance of shipbuilding science and practice for both the economic and scientific development of the Republic of Croatia. Relying on such a significant tradition, the SORTA 2024 Symposium will contribute to the integration of the existing knowledge and experience in the context of modern scientific and professional achievements in the field of shipbuilding, offshore engineering, maritime and inland navigation, through invited lectures, scientific and professional papers, panel discussions and round tables.



University of Zadar
Universitas Studiorum
Jadertina | 1396 | 2002 |



**UNIVERSITÀ
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Under auspices of Croatian Academy of Sciences and Arts



Symposium Topics

- ✿ Construction, strength and vibration of vessels and offshore structures
- ✿ Design of vessels and offshore structures, safety and offshore engineering
- ✿ Hydromechanics of vessels and offshore structures
- ✿ Production and maintenance of vessels and offshore structures
- ✿ Maritime transportation, environmentally friendly shipping, safety of navigation
- ✿ Autonomous surface vessels, underwater systems and marine engineering
- ✿ Applications of artificial intelligence in shipbuilding and maritime industry
- ✿ Education and training in shipbuilding and maritime industry
- ✿ Maritime economics, logistics and law
- ✿ Projects Dissemination




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2 - 5 October 2024, Zadar, Croatia


FINAL PROGRAMME

Wednesday, 2 October 2024		
Time	Event	Venue
14:00 – 17:00	<i>Croatia Yacht Show (Yacht Viewings)</i>	Zadar Cruise Port (Gaženica)
19:00 – 21:00	<i>Welcome Gathering with Cocktail Dinner</i>	Museum of Ancient Glass Zadar

Thursday, 3 October 2024		
Time	Event	Venue
08:00 – 09:00	<i>Registrations</i>	
09:00 – 09:30	<i>Opening Ceremony with Welcome Speeches</i>	
09:30 – 10:00	<i>Invited Lecture (1)</i> Oskar Levander (Kongsberg Maritime) How to Navigate the Upcoming Fuel Transition	
10:00 – 10:30	<i>Invited Lecture (2)</i> Sander Klaasse (Wärtsilä Voyage, Europe) Fleet Optimization Solutions and Marine Decarbonisation	University of Zadar The Old Campus The Great Hall
10:30 – 11:00	<i>Invited Lecture (3)</i> Zoran Kunkera (Leaera Ltd) Smart Strategies for the Improvement of the (European) Shipbuilding Industry Competitiveness	
11:00 – 11:30	<i>Coffee Break</i>	 Obala kraljica Petra Krešimira IV. 2, Zadar
11:30 – 12:45	<i>Panel Discussion</i> MARITIME DECARBONIZATION – FROM VISION TO REALITY Moderator: Siniša Reljić (Founder and ex-CEO of Navis Consult) Panellists: Oskar Levander (Kongsberg Maritime), Sander Klaasse (Wärtsilä Voyage, Europe), Joško Markov (Tankerska plovidba), Mladen Matak (Thome Croatia), Roko Vuletić (ISKRA Shipyard)	
13:00 – 14:00	<i>Lunch Break</i>	

Thursday, 3 October 2024		Event		Venue	
14:30 – 15:00		Registrations			
		Parallel Sessions (1-3)			
15:00 – 16:40	Construction, Strength and Vibration of Vessels and Offshore Structures Room: 01, Chairs: S. Bertagna & N. Momčilović	Design of Vessels and Offshore Structures, Safety and Offshore Engineering (1) Room: 03, Chairs: L. Braidotti & B. Zima	Hydromechanics of Vessels and Offshore Structures (1) Room: 04, Chairs: J. Prpić-Oršić & A. Turk	University of Zadar SEP Building Ground Floor Rooms 01-04	
15:00 – 15:20	<i>Comparative Analysis of the VVBM for Hull Girder Fatigue Assessment according to IACS Rec. No. 34 Rev 1 and 2</i> A. Mikulić, M. Čorak, J. Parunov	<i>Improving Survivability of Twin-screw Propeller Passenger Ship by Setting Central Bulkhead in Engine Room Compartment</i> D. Ban, S.E. Blašković	<i>A Numerical Investigation of the Wind and Air Resistance of the Containership for Different Loading Conditions and Speeds</i> C.G. Grlj, N. Degiuli, Ž. Tulković, I. Martić		
15:20 – 15:40	<i>Finite Element Analysis of an Unconventional Hull Designed for Aquafarming</i> N. Momčilović, M. Kalajdžić, D. Antić	<i>Concept Design of an Electric 100-passenger Ship</i> V. Ostrovska, V. Slapničar, J. Andrišić, I. Lalović	<i>Direct Calculation Approach for Marine Structures – Nonlinear Loads</i> A. Bakica		
15:40 – 16:00	<i>Efficiency Evaluation of Reduction Gearbox for Diesel Electric Ship Propulsion</i> D. Pastorčić, I. Poljak, V. Mrzljak, V. Knežević	<i>Updated Steel Weight Estimation for Cruise Ship Concept Design</i> S. Utzeri, L. Braidotti, N. Norcia, A. Marinò	<i>Scale Resolving Simulation of Unsteady Bow Thruster Hydrodynamics</i> M. Kazemi, N. Kornev		
16:00 – 16:20	<i>Structural Design of Lifiable Car Carrier Deck Structure made of Steel and Aluminium</i> J. Andrić, M. Petrak, M. Tomićić	<i>Towards Cleaner Oceans and Ports: Developing an Eco-friendly Waste Collection Vessel</i> A. Karczewski, M. Reichel, H. Prusko, E. Marcinkiewicz	<i>A Numerical Study on the Effect of Trim on the Total Resistance of a Container Ship Model in Confined Water</i> I. Martić, B. Anušić, N. Degiuli, C.G. Grlj		
16:20 – 16:40	<i>On the Structural Response of Innovative Plastic Materials for Boatbuilding Applications</i> S. Bertagna, N. Taucer Marchesi, V. Bucci, A. Marinò	<i>Structural Design of Composite Passenger Catamaran</i> T. Dolšak, J. Andrić, T. Uroda, M. Tomićić	<i>Marine Applications of Floating Solar Photovoltaic Systems</i> I. Čatipović, N. Alujević, I. Gatini, M. Matijević, A. Mikulić, D. Smoljan, K. Trontl		
16:40 – 17:10	Coffee Break				
		Parallel Sessions (4-6)			
17:10 – 18:50	Production and Maintenance of Vessels and Offshore Structures Room: 01, Chairs: N. Hadžić & M. Hadžina	Design of Vessels and Offshore Structures, Safety and Offshore Engineering (2) Room: 03, Chairs: V. Slapničar & B. Ljubenkov	Hydromechanics of Vessels and Offshore Structures (2) Room: 04, Chairs: N. Degiuli & I. Martić		
17:10 – 17:30	<i>Framework for the Lifetime Extension of Fixed Offshore Platforms in the North Adriatic Sea</i> D. Mimica, D. Skejić, I. Čatipović, J. Parunov	<i>Structural Design of River Floating Passenger Terminal</i> J. Andrić, T. Uroda, M. Tomićić, D. Četković, K. Borčić	<i>Advances in the Linearised Progressive Flooding Simulation Method</i> L. Braidotti, J. Prpić-Oršić		
17:30 – 17:50	<i>Hierarchical Modelling Approach for Ship Production Process</i> N. Hadžić, T. Opetuk, V. Ložar	<i>Hull-superstructure Interaction of Different Types of Modern Cruise Ships</i> J. Andrić, D. Daničić, M. Tomićić	<i>Statistical and Spectral Description of Full-scale Measurements of Ship Motion in Waves</i> T. Petranović, M. Katalinić, H. Mišanović, J. Parunov		
17:50 – 18:10	<i>Analysis and Modelling of the Ship Machinery Module</i> I. Barić, R. Rubeša, M. Hadžina, T. Matulija	<i>Feasibility Study on the Potential Using of Ferrocement for Constructing Floats</i> B. Zima, A. Karczewski	<i>Evaluating Roll Damping in Parametric Rolling: Challenges and Approaches</i> A. Turk, J. Prpić-Oršić, I. Sulovsky, M. Balas		
18:10 – 18:30	<i>Usage of ESAB Railtrac FW 1000 and ESAB TFD1 for Mechanized Welding First Phase of Dymalink Project</i> R. Mimica, P. Perak, N.-N. Đurđević	<i>Design and Production Technology of the Main Hydrofoil of the Moth-class Sailboat</i> B. Ljubenkov, D. Fržop, L. Gallić, M. Dević	<i>CFD Self-propulsion Calculations by Double Body Models</i> I. Sulovsky, J. Prpić-Oršić		
18:30 – 18:50	<i>Reconstruction of Ships Outfitting Parts using Reverse Engineering Methods</i> I. Željko, R. Mimica, T. Pribudić, D. Bazina, I. Trebotić	<i>D3V-SGD: An Open-Source Program for the Design of Ship Grillage Structures</i> P. Prebeg, G. Kos, D. Banjedvrec, T. Pavlović, G. Šikić, J. Andrić			

Friday, 4 October 2024		Event		Venue
Time	Registrations			University of Zadar SEP Building Ground Floor Rooms 01-04
08:30 – 09:00	Parallel Sessions (7-9)			
09:00 – 10:40	Maritime Transportation, Environmentally Friendly Shipping, Safety of Navigation (1) Room: 01, Chairs: M. Kalajžić & A.V. Dainelsen	Autonomous Surface Vessels, Underwater Systems and Marine Engineering Room: 03, Chairs: N. Vulić & A. Ljulić	Applications of Artificial Intelligence in Shipbuilding and Maritime Industry Room: 04, Chairs: J. Parunov & P. Kujala	University of Zadar SEP Building Ground Floor Rooms 01-04 Ulica Šime Vitasovića 1, Zadar
09:00 – 09:20	Contribution of Wind Assisted Propulsion for a Liner Vessel on a Route in the Adriatic Sea A. Čalić, M. Katalinić	Exploring Historical Maritime Cyber-attacks and Introducing Maritime Security Operations Centre as a Solution to Mitigate them A. Našir, R. Leiger, I. Zaitseva-Parnaste, P. Kujala	Leveraging AI and Deep Learning Algorithms to Enhance Leisure Sailing Experiences L. Pagani, P. Gemelli	
09:20 – 09:40	Simulating Navigators' Behaviour under Stress: Development of the "Captain's Game" K. Lange, H.-W. Kurth, T. Krogmann	Study on the Development and Quality Validation of S-100-based MASS Hydrographic Information H.S. Na, Y.S. Choi, D.U. Kim, S.R. Lee, M.S. Kim	Adaptive Neuro-Fuzzy Inference System for the Estimation of Brake Power and Rate of Revolution M. Valčić, I. Martić, N. Degiuli, C.G. Griji	
09:40 – 10:00	A Proposal for Amendments to Annexes I and II of the EU Ship Recycling Regulation J. Čulin, V. Knežević, J. Orović, Z. Pavin	Proliferation of Unmanned Aerial and Maritime Vehicles in Military Operations A. Ljulić, V. Šlapničar, D. Smiljanić	A Fuzzy Set Perspective on COLREG M. Kristić, T. Biočić, M. Car, N. Hasanspahić	
10:00 – 10:20	Advancing CFD Validation Methods for Self-Propelled Inland Waterway Vessels: A Workshop Initiative M. Kalajžić, I. Ivković, M. Vasilev	Marine Propeller Shaft Dimensions: Proposal to Extend the IACS UR M68 Formula to Alloy Steels L. Roldo, N. Vulić	Emerging Stochastic Methods for Weather-Aware Ship Routing M. Balas, J. Prpić-Oršić, M. Valčić	
10:20 – 10:40	Determining Port Wind Limiting Conditions for Safe Manoeuvring and Berthing M. Barić, I. Toman, N. Kostović	Practical, Resilient and Financial Aspects of an Automatic Barge R. Müller, A. Van Coillie, W. Duhme	Enhancing Sailing Yacht Design through Machine Learning: Application of Gaussian Process Regression to Predict Bare Hull Resistance L. Pagani, P. Gemelli	
10:40 – 11:30	Sustainable Slow Steaming for Low Carbon Shipping (STARSHIP) N. Degiuli, I. Martić, C.G. Griji	DIH Innovamare Project: Fostering Collaborative Innovation and Sustainable Solutions for the Blue Economy in the Adriatic Region A. Gundić, M. Valčić, M. Ivanac	Applying the Entrepreneurial Discovery Process to foster Innovation and Skills in the Blue Economy: Insights from the MareSkill Project F. Urem, A. Gundić, T. Radić Lakoš	
11:30 – 12:50	REliability and Uncertainty of Ship decision support system for safe and greener navigation (REBUS) J. Prpić-Oršić, M. Balas, I. Sulovsky, M. Valčić	Enhancing Seafarer Education: Insights from the MICROMET Project A. Gundić, A. Zekić	E-learning Platforms Usage at Maritime Higher Education and Training Institutions L. Marfat, A. Gundić, A. Ćurković, T. Mavra	
11:30 – 11:50	Technical-Commercial Presentations (Special Session) Room: 01, Chair: M. Valčić			
11:50 – 12:10	Sander Klaasse (Wärtsilä Voyage, Europe)			
12:10 – 12:30	Joško Markov (Tankerska plovidba)			
12:30 – 12:50	Lukša Radić (Navis Consult, a Kongsberg company) – Valter Kurlić (Rapska plovidba)			
13:00 – 14:00	Roko Vuletić (JSKRA Shipyard)			
	Lunch Break			

Friday, 4 October 2024				
Time	Event			Venue
14:30 – 15:00	Registrations			
	Parallel Sessions (10-12)			
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15:00 – 15:20				
15:20 – 15:40				
15:40 – 16:00				
16:00 – 16:20				
16:20 – 16:40				
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Saturday, 5 October 2024	
Time	Event
08:00 – 17:30	Symposium Excursion

2 - 5 October 2024, Zadar – Croatia



**The 26th Symposium on Theory and Practice of Shipbuilding
(In memoriam Prof. Leopold Sorta)**

02 - 05 October 2024, Zadar – Croatia

Book of Abstracts

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Section I

Construction, strength and vibration of vessels and offshore structures

Comparative analysis of the VWBM for hull girder fatigue assessment according to IACS Rec. No 34 Rev.1 and Rev.2

Antonio MIKULIĆ^{a,*}, Mario ĆORAK^b, Joško PARUNOV^a

^a *University of Zagreb Faculty of mechanical Engineering and Naval Architecture*

^b *University of Dubrovnik, Maritime Department*

Abstract. After facing some criticism regarding assumptions contained in IACS Rec. No. 34 Rev.1 (2001), efforts have been made by IACS members, resulting in a new revision of this document, which provides a procedure for computation of the long-term wave loads on ocean-going ships for strength and fatigue assessment. The main modifications include a new scatter diagram, modification of the wave spectral model and energy spreading function, as well as ship speed. Previous analyses showed that the extreme wave load is reduced from 10% to 30%, with a larger reduction for smaller ships. The present research aims to investigate the consequences of the IACS Rec. No. 34 Rev.2 on the VWBM for hull girder fatigue assessment. Transfer functions of VWBM are calculated using closed-form expressions, which are convenient for comparative studies where many computations are required. Ships of different types and sizes are subjected to the long-term VWBM analysis comparing fatigue loads based on the procedures proposed in Rev.1 and Rev.2. The analysis is based on the parameters of the two-parameter Weibull, used to approximate the long-term probability distribution of VWBM. Differences in the hull girder fatigue life are then estimated using closed-form expressions for accumulated fatigue damage. The results are also compared to the hull girder fatigue loads from Common Structural Rules.

Keywords. *Fatigue, hull girder, IACS*

* Corresponding Author: Antonio Mikulić, antonio.mikulic@fsb.unizg.hr

Finite element analysis of an unconventional hull designed for aquafarming

Nikola MOMČILOVIĆ^{a,*}, Milan KALAJDŽIĆ^a, Dušan ANTIĆ^b

^a*University of Belgrade, Faculty of Mechanical Engineering, Department of Naval
Architecture*

^b*Argo Navis Bespoke Yachting*

Abstract. In recent years, several designs have emerged for floating vessels intended for aquafarming, where all cargo tanks are located within the hull. These objects are still not addressed in the rules and regulations for ships published by classification societies. In addition, some of the designs significantly differ from conventional ship hulls, implying that such structures need to be checked using direct structural assessments. Therefore, this study presents a finite element analysis of a global model of an unconventional hull designed for aquafarming. Unconventional characteristics of the hull include its large length to height ratio, low length to breadth ratio and large openings spanning from the deck to the inner bottom. Openings serve as cargo tanks for aquafarming. As these features can significantly reduce the strength of the hull, an analysis is performed for several cases, including fully loaded, lightship, and transitory conditions of loaded cargo tanks that the vessel may encounter during its service. The study presents the global response as well as the critical stress zones of the structure, comparing them to the prescribed class-based criteria for standard steel ships. Moreover, in the absence of fully developed rules and regulations, this work provides an overview of the contemporary rules and regulations that can be used in the evaluation of such structures.

Keywords. *unconventional hull, aquafarming, fish farm vessel, FEA.*

* Corresponding Author: Nikola Momčilović, nmomcilovic@mas.bg.ac.rs

Efficiency evaluation of reduction gearbox for diesel electric ship propulsion

Darko PASTORČIĆ^{a,*}, Igor POLJAK^a, Vedran MRZLJAK^b, Vlatko KNEŽEVIĆ^a

^a *University of Zadar, Maritime Department, Zadar, Croatia*

^b *University of Rijeka, Faculty of Engineering, Rijeka, Croatia*

Abstract. This study presents an analysis of the gearbox power losses of the dual fuel diesel (DFDE) electric propulsion of the liquefied natural gas (LNG) carrier. The primary function of reduction gearbox is to reduce speed of electric motor shaft outcome to the propulsion shaft ratio where marine screws have the highest efficiency of the running range. Series of reduction gearbox set performance measurements were carried out for the better understanding of the power losses during actual sailing conditions of the vessel. The single stage reduction gearbox transmits the power of maximal 11.1 MW and comprises double crossed helical gear and pinion and the main thrust bearing. In addition to measurements, an analytical assessment of the gearbox power losses is performed, which took into account gear losses due to sliding of the gear flanks using modified Ohlendorf's power loss factor, sliding bearings losses, seal losses, temperature dependence of the viscosity and main thrust bearing losses. Unfavorable running condition of the vessel is at lower output rotational speed from 26 to 36 min⁻¹, where the efficiency of the reduction gearbox is also lower. The best efficiency of the reduction gearbox is measured on the higher shaft revolutions where the efficiency of reduction approaches 98.5 %.

Keywords. *Reduction gearbox, efficiency, propulsion, electric motor shaft*

* Corresponding Author: Darko Pastorčić, dpastorci@unizd.hr

Structural design of liftable car carrier deck structure made of steel and aluminum

Jerolim ANDRIĆ^{a,*}, Mario PETRAK^a, Mateja TOMIČIĆ^a

^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture*

Abstract. The paper examines the design features of two types of liftable car decks: traditional ones made entirely of steel and an alternative design comprising a steel grillage with an aluminum top plate. In the alternative concept, aluminum stiffened top plating replaces the classic steel stiffened top plating. The stiffened top plating's purpose is to support the local wheel loads from the vehicles stored on the deck. All structural elements' scantlings were determined to meet specified constraints and requirements (such as allowable stresses, buckling, and deflection) to ensure consistent comparison of the different concepts. Structural mass reduction was the main objective in redesigning both deck concepts, and finite element method (FEM) analysis was utilized to assess structural response and feasibility. The paper provides a comparative analysis of the weight and stiffness characteristics of both concepts. Additionally, it briefly discusses the rationality of applying these evaluated liftable deck concepts concerning their impact on overall ship performance, including reducing total ship mass and vertical center of gravity (VCG).

Keywords. *Liftable car decks, aluminum, steel, FEM, comparative study*

* Corresponding Author: Jerolim Andrić, jerolim.andric@fsb.unizg.hr

On the structural response of innovative plastic materials for boatbuilding applications

Serena BERTAGNA ^{a,*}, Natasha TAUCER MARCHESI ^a, Vittorio BUCCI ^a and Alberto MARINO ^a

^a*Department of Engineering and Architecture, University of Trieste, Via A. Valerio 10, 34127 Trieste, Italy*

Abstract. The introduction of innovative materials and the ability to ensure a reduced environmental impact is a topic of significant interest among experts in ship- and boatbuilding sectors. Materials must be able to combine physical and mechanical properties adequate to the intended purpose and uses, while also addressing fundamental aspects of sustainability. As a first aspect, they must ensure recyclability at the end of their lifecycle, combined with low energy consumption and limited exploitation of resources during production. Nowadays, these factors represent key parameters for selecting construction materials, in agreement with the Green Shipbuilding approach. In recent years, innovative plastics able to offer these advantages have been increasingly considered as potential structural materials for small vessels. Indeed, they combine chemical resistance, anti-corrosion properties, and high flexibility while ensuring recyclability possibilities. Given the novelty of adopting such materials for boat construction, it is necessary to investigate their mechanical and strength properties through adequate laboratory testing aimed at characterising maritime applications. The present article, after giving a description of the considered plastic materials in terms of structure and properties, aims to detail a proper experimental campaign for mechanical tests addressed at validating their use for structural purposes in boat constructions.

Keywords. *Innovative plastic materials, environmental sustainability, HDPE, mechanical tests, structural applications*

Acknowledgement. This study was carried out within the consortium iNEST (Interconnected North-Est Innovation Ecosystem) CUP J43C22000320006 funded by the European Union Next-GenerationEU (Piano Nazionale di Ripresa e Resilienza (PNRR)—Missione 4 Componente 2, Investimento 1.5—D.D. 1058 23/06/2022, ECS_00000043). This manuscript reflects only the Authors' views and opinions.

* Corresponding Author: Serena Bertagna, sbertagna@units.it

Section II

Design of vessels and offshore structures, safety and offshore engineering

Improving survivability of twin-screw propeller passenger ship by setting central bulkhead in engine room compartment

Dario BAN^a, Sara Emanuela BLAŠKOVIĆ^{a, *}

^a*University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture*

Abstract. In the common naval architecture practice, cruise passenger ships do not have central subdivision bulkheads to prevent asymmetric damage loading conditions that can lead to large transversal stability heel angles uncomfortable for the passengers in accidental situations. However, an accident of "Costa Concordia" cruise ship shows us that most of the ship survivability problems occurred by her hull breaching could be prevented if additional longitudinal bulkheads had been set in some of breached compartments. In order to investigate the impact of such changes in the subdivision system of the passenger ships, damage stability calculations for one twin-screw propeller SUB-500GT passenger ship are done here, with her subdivision system improved by setting central subdivision bulkhead in the engine room compartment. It is then shown that this change can significantly improve ship's survivability, redundancy and general safety in the engine room damage situations, lowering the amount of water ingress and enabling her mobility to achieve safe return to port.

Keywords. *survivability, SUB-500GT, twin-screw propeller, longitudinal bulkhead, safe return to port*

Acknowledgment: We would like to thank prof. dr. sc. Branko Blagojević for the assistance and support in writing this paper.

* Corresponding Author: Sara Emanuela Blašković, sara.emanuela.magnan.00@fesb.hr

Concept design of an electric 100-passenger ship

Victoria OSTROVSKA^a, Vedran SLAPNIČAR^{b,*}, Josip ANDRIŠIĆ^c, Igor LALOVIĆ^d

^a*Mykolaiv, Ukraine*

^b*Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia*

^{c,d}*Flow Ship Design, Pula, Croatia*

Abstract. This paper focuses on the concept design of a passenger ship tailored to accommodate the needs of 100 passengers, distinguished by its fully electric propulsion with batteries for electric energy storage and the integration of solar panels. Operates in year-round navigation short-sea services, with a typical operational profile of approximately 3 nautical miles distance followed by 30 minutes of sailing and 30 minutes of charging time, targeting a service speed of 7–8 knots. The benefits of the catamaran passenger ship are given as a sustainable coastal means of sea transportation that incorporates technologies to enhance comfort, operational efficiency, and environmental sustainability. As a result, the developed concept design incorporates an inclusive general arrangement for the required number of passengers. Following that, a hull form was created in terms of the efficiency of the electric propulsion, while the power was obtained by several methods. Evaluation of masses and the definition of the centre of gravity allowed for stability calculations for six scenarios, according to the Croatian Register of Shipping. Lastly, the ship's operational profile was learned, and the energy balance and battery pack calculations and options were performed with sensitivity analysis for the possible solutions of the range of displacements.

Keywords. *concept design, electric catamaran passenger ship, battery pack, energy balance*

* Corresponding author: Vedran Slapničar, vedran.slapnicar@fsb.unizg.hr

Updated steel weight estimation for cruise ship concept design

Samuele UTZERI^{a,*}, Luca BRAIDOTTI^a, Nicola NORCIA^a and Alberto MARINÒ^a
^a *University of Trieste, Department of Engineering and Architecture*

Abstract. Estimating the steel weight of ships during the early conceptual stages is of the utmost importance since it represents about 50% of the lightship weight of the ship. From a technical standpoint, it significantly affects cargo capacity, design speed, stability, and ship safety, thus requiring an accurate estimation. The steel weight is usually evaluated using simple empirical formulations during the concept design, mainly based on the ship's main particulars. Those formulas are derived by statistical analysis of past projects and can be applied only for the specific ship type (or types) included in the considered database. In the literature, many formulas are present mainly related to cargo ships. Currently, no empirical formulation is available for cruise ships that are applicable in the very early conceptual stages. The present study aims to identify an empirical formulation for estimating the steel weight of a luxury cruise ship based on calibrating a set of existing empirical formulas.

Keywords. *Ship Design, Steel Weight estimation, Cruise Ships*

* Corresponding Author: Samuele Utzeri, samuele.utzeri@phd.units.it.

Towards Cleaner Oceans and Ports Developing an Eco-Friendly Waste Collecting Vessel

Artur KARCZEWSKI^{a,*}, Maciej REICHEL^a, Hanna PRUSZKO^a, Ewa MARCINKIEWICZ^b

^a*Department of Mechanical Engineering and Ship Technology, Gdansk University of Technology, Gdansk,*

^b*Seatech Engineering LTD, Gdansk, Poland*

Abstract. Each year, approximately 8 million tons of plastic waste enter the oceans, making it one of the most pervasive pollution problems globally. This issue has prompted a global call for preventive measures due to its detrimental impact on marine life, fishery resources, coastal livelihoods, tourism, the environment, and long-term human health. Marine debris is a significant environmental concern, affecting both human health and aesthetics. Ports and their surrounding areas face particularly severe challenges due to high waste accumulation and the difficulty of cleanup operations amidst heavy ship traffic. This paper presents a design methodology for a Waste Collecting Vessel (WCV), a versatile ship capable of multiple functions including surface garbage removal, collection of waste from other ships, oil spill recovery, and weed cutting. Our research provides new insights into the design and operation of eco-friendly small ships, contributing to sustainable maritime environmental management. The culmination of this work is the proposal of a zero-emission autonomous catamaran, equipped with advanced technologies for efficient waste management in ports and coastal.

Keywords. *waste management; WCV; autonomous technologies*

* Corresponding author: Artur Karczewski, artur.karczewski@pg.edu.pl.

Structural design of composite passenger catamaran

Tin DOLŠAK^{a*}, Jerolim ANDRIĆ^a, Tomislav URODA^b, Mateja TOMIČIĆ^a
^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture*
^b *iCat d.o.o, Zagreb, CROATIA*

Abstract. The objective of this thesis is the structural design of composite passenger catamaran, designed by „iCat“ company. The design is carried out through two phases. In the first phase, three design variants were developed. The elements of plating and framing were designed according to the rules of the Croatian Register of Shipping (CRS). Then, a local strength check was performed using the ComposeIT software from the Bureau Veritas (BV) classification society. After that follows comparison of results and selection of the most favorable design variant based on minimum mass criteria. The second phase of the design includes direct calculation of strength using finite element method (FEM). Structural responses were analyzed and a structural adequacy criterion was carried out based on the Tsai-Wu laminate failure criterion. Structural elements that do not satisfy criterion are redesigned. Finally, a buckling check of individual structural elements was performed.

Keywords. *Passenger, catamaran, ship structural design, composite materials, CRS Rules, finite element method, Tsai-Wu criterion*

* Corresponding Author: Tin Dolšak, tin.dolsak@icat.com

Structural design of river floating passenger terminal

Jerolim ANDRIĆ^{a,*}, Tomislav URODA^b, Mateja TOMIČIĆ^a,
Dinko ČETKOVIĆ^c, Kornelija BORČIĆ^a

^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia*

^b *iCat d.o.o, Zagreb, Croatia*

^c *HAV Design Croatia d.o.o.*

Abstract. The paper discusses and highlights the basic challenges in the structural design of a 70-meter river floating passenger terminal. It is designed as a multi-deck floating object characterized by a large superstructure with a specific shape, equipped with solar and glass panels and the absence of transverse/longitudinal bulkheads. The height of the superstructure is larger compared to the height of the lower hull and its influence on longitudinal strength should be considered in the very early design phase. Croatian Register of Shipping (CRS) Rules for the Classification of Inland Navigation Vessels Part 2 – HULL AND HULL EQUIPMENT, July 2021 were used to define design loads, corrosion deductions, safety factors, etc. The main results and challenges have been briefly presented for two design phases: (1) Concept phase where design challenges in structural scantling definition of midship section based on prescribed Rule calculation and partial 3D FE model have been described. (2) Preliminary phase where global structural response has been evaluated based on the full-ship FE model. Feasibility structural calculation due to yielding and buckling issues has been performed for both phases following criteria given in CRS Rules and a feasible design solution has been proposed.

Keywords. *Floating passenger terminal, structural design, CRS Rules, FEM analysis, buckling analysis*

* Corresponding Author: Jerolim Andrić, jerolim.andric@fsb.unizg.hr

Hull-superstructure interaction of different types of modern cruise ships

Jerolim ANDRIĆ^{a,*}, Domagoj DANIČIĆ^a, Mateja TOMIČIĆ^a.

^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia*

Abstract. Cruise ships are very complex structures and an important product of the European shipbuilding industry. The paper investigates the hull-superstructure interaction of modern cruise ship structures. Different topological solutions of superstructure and connections to the lower hull can generate different global structural responses. Key topological parameters (such as the dimensions of large side openings, longitudinal bulkhead stiffness, recess positioning, etc.) significantly shape the distribution of stresses along the hull girder. Two different topological concepts of the Panamax cruise ship have been evaluated and compared concerning distributions of primary longitudinal stresses over the ship's height using full-ship generic finite element (FE) models. One concept adheres to the traditional approach with internal longitudinal bulkheads and a side shell featuring low shear stiffness, while the other introduces a novel "two-tower" design incorporating two internal longitudinal bulkheads with reduced shear stiffness. The influence of the size of side/bulkhead openings on the efficiency of the superstructure in global bending was investigated in terms of stresses using the Caldwell approach for a new "two-tower" concept.

Keywords. *Cruise ships, hull-superstructure interaction, FEM, generic models*

* Corresponding Author: Jerolim Andrić, jerolim.andric@fsb.unizg.hr

Feasibility study on the potential using of ferrocement for constructing floats

Beata ZIMA ^{a,*} and Artur KARCZEWSKI ^a

^a *Gdańsk University of Technology, Faculty of Mechanical Engineering and Ship Technology, Institute of Naval Architecture*

Abstract. In recent years, there has been a significant increase in interest in ferrocement as a material for various engineering constructions. Due to its ease of shaping complex forms, it has been used previously, for example, in constructing ship hulls or tank walls. Apart from the advantages associated with the ability to shape thin elements, improved mechanical properties compared to concrete, and resistance to chemical actions, ferrocement is becoming an increasingly attractive solution for both economic and ecological reasons. The paper presents the results of preliminary analysis aimed at determining the potential use of ferrocement as a material for constructing floats for houseboats. The assumptions regarding the load-bearing structure are presented, and the dimensioning process is described. Due to the lack of standards for the ferrocement structures, the calculations were based on the guidelines of the European standards for concrete and reinforced concrete structures. Subsequently, the focus was on the problems associated with determining the ferrocement strength parameters, as well as discussing the consequences of applying reinforced concrete theory to its calculations. Also, the areas that required reformulation due to the strictly adopted assumptions related to the concrete behavior and the method of load transfer through reinforced sections have been indicated.

Keywords: *ferrocement, float, houseboat, eurocode, strength analysis*

* Corresponding author: Beata Zima, beata.zima@pg.edu.pl

Design and production technology of the main hydrofoil of the Moth-class sailboat

Boris LJUBENKOV^{a,*}, Duje FRŽOP^b, Luka GALIĆ^c, Matej DEVIĆ^d

^a *University of Split, Faculty of Electrical Engineering, Mechanical Engineering and Naval Architecture*

^b *Rand shipyard*

^c *Jan De Nul*

^d *Naval Engineering Solutions*

Abstract. The Moth-class sailboat belongs to the international class of sailboats. It is the fastest single-seater class in the world. A vessel that wants to compete in the Moth class must have a certificate from an International Organization that defines the rules and dimensions of the entire sailboat, which limits design. The equipment of the sailboat includes two hydrofoils - main and stern. Hydrofoils must be defined in accordance with the rules. The paper presents the principle of selection of elements of the main hydrofoil assembly, which includes the foil profile, holder and mechanical angle of incidence regulator. Asymmetric and symmetric foil profiles and hydrofoil holders were considered, which were analyzed with software packages. For the selected foil profile and main hydrofoil holder, the choice of materials, laminate plan and production technology are shown. In conclusion, the advantages and disadvantages of the chosen solutions are commented.

Keywords. *sailboat, Moth-class, hydrofoil, production technology*

* Corresponding Author: Boris Ljubenkovic, e-mail: boris.ljubenkovic@fesb.hr

D3V-SGD: an open source program for the design of ship grillage structures

Pero PREBEG ^{a,*}, Gordan KOS ^b, Dominik BANJEDVOREC ^a, Tomislav PAVLOVIĆ^a,
Gordan ŠIKIĆ ^c and Jerolim ANDRIĆ ^a

^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture*

^b *Croatian Register of Shipping Inland Navigation Division (CRS Inland)*

^c *LINA ET AL*

Abstract. Grillage design is one of the most common tasks in ship structural engineering, as many components of a ship's secondary structures, such as hatch covers and decks, are grillages. This paper presents the current state of development of D3V-SGD, an open-source software tool for the design and analysis of ship grillage structures developed by students and researchers from UNIZAG FSB. Realized as an extension module to D3V, an open-source 3D Modular Viewer in Python, D3V-SGD currently features a parametric model for hatch covers, a GUI with 3D visualization, and automatic generation of analysis models for determining structural responses. These models include both grillage beam analytical methods and FEM using shell elements. For FEM analysis, the open-source program OOFEM has been utilized, recently adopted for the analysis of ship thin-walled structures.

Keywords. *grillage analysis, open source code, finite elements analysis*

* Corresponding Author: Pero Prebeg, pero.prebeg@fsb.unizg.hr.

Section III

Hydromechanics of vessels and offshore structures

A numerical investigation of the wind and air resistance of the containership for different loading conditions and speeds

Carlo Giorgio GRLJ^{a,*}, Nastia DEGIULI^a, Željko TUKOVIĆ^a, Ivana MARTIĆ^a
^a*University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. In this study, the impact of different container configurations and trim on the wind and air resistance along with the impact of speed on the air resistance is assessed by computational fluid dynamics. The study is carried out for the case of a post-Panamax containership sailing in open sea conditions. The mathematical model is based on Reynolds Averaged Navier-Stokes equations with the Realizable k-epsilon turbulence model for the closure of the governing equations. The governing equations are discretized with the finite volume method and solved in a segregated manner using the commercial software package STAR-CCM+. The validation study is conducted for a similar containership for which the experimental results from the wind tunnel are available in the literature. The verification study is performed to assess the numerical uncertainty for the longitudinal and transverse wind load coefficients. The obtained results show that trim has the highest impact on the moment coefficient, while the highest longitudinal wind load coefficients are obtained for the container configurations with every other bay empty. Lower air resistance is obtained for a containership trimmed by bow, while higher values are obtained for a containership trimmed by stern in comparison to an even keel. Regarding the container configuration, the largest air resistance is obtained for the empty containership, which is caused by a larger flow separation in the region behind the containership in comparison to an even keel. The portion of air resistance in the total resistance is in the range of 3.5 - 5.8 % with the lowest value corresponding to the container configuration with fewer containers in the stern and bow regions and the highest value obtained for empty containership.

Keywords. *CFD; Containership; Wind resistance; Air resistance; Container configuration; Trim; Speed*

Acknowledgment. This study has been fully supported by the Croatian Science Foundation under project IP-2020-02-8568.

* Corresponding Author: Carlo Giorgio Grlj, carlo.g.grlj@fsb.unizg.hr

Direct calculation approach for marine structures – nonlinear loads

Andro BAKICA^{a,*}

^a Faculty of Maritime Studies, University of Split, Croatia

Abstract. Majority of the marine structures used to be built and designed using well-established and experience-based methods. The increase in computational power, followed with the improvement in numerical methods, has enabled sophisticated mathematical models to be regularly used in the design of floating structures. Since wave loads are inherent to the design process, their contribution in the structural life-time has to be evaluated statistically. This tedious process requires analysis of all the encountered sea-states where low-order linear hydrodynamic models are ideal due to their solution naturally occurring in the frequency domain. This enables the coupling between the structural model (most often finite element method) and the linear first order loads, which leads to stress RAOs for each structural element. From there, fatigue life and extreme response can be estimated on any structural detail of interest. In the mentioned direct calculation approach, non-linear loads and dynamic effects have always been an issue, but as the ships and offshore structures tend to be larger and lighter, and often operate in rougher seas, these effects are also inflated sometimes even to a degree of structural collapse. This paper discusses state-of-the-art in the design of marine structures when nonlinear loads are considered (green water, breaking wave, slamming, springing etc.). For an accurate representation of the hydro loads, a high-fidelity computational fluid dynamics models are employed, coupled with the 3D finite element model. Hydro-structural coupling regime can also be relevant depending on the structure and wave load environment.

Keywords. *nonlinear loads, CFD-FEM, statistical wave analysis.*

* Corresponding Author: Andro Bakica, abakica@pfst.hr

Scale resolving simulation of unsteady bow thruster hydrodynamics

Mehrdad KAZEMI^{a,*}, Nikolay KORNEV^a
^a *University of Rostock, Germany*

Abstract. The paper presents results of application of scale resolving simulations (hybrid URANS/LES) to the bow thruster hydrodynamics with and without cavitation. The CFD results are verified and validated on the basis of experimental results for integral forces, force fluctuations, mean and unsteady pressure. The error of CFD prediction of the propeller thrust and torque doesn't exceed five percent when using the hybrid SLH model. The agreement between CFD and EFD is significantly improved when the cavitation is taken into account. Analysis of CFD data allows one to identify the main vortex structures of the bow thruster flow: conventional tip vortices, root and hub vortices typical also for podded propellers, secondary vortices created at the tunnel wall, strut and horse shoe vortices. CFD study confirmed increase of thrust fluctuations in comparison with conventional propellers which explains the increase of vibrations when bow thruster is turned on during maneuvering. The mean thrust fluctuation referred to the mean thrust can achieve the range between sixteen and eighteen percent whereas it does not exceed three percent for conventional propellers. When the cavitation is taken into account, it substantially surpasses the effects of turbulence.

Keywords. *Bow thruster, URANS-LES Hybrid method, Cavitation, Unsteady effects*

Acknowledgement. The authors express their sincere gratitude to the German Federal Ministry for Economic Affairs and Climate Action for their support through the project 03SX530E, under the supervision of Dr. J. Turnow. Additionally, they extend their thanks to Jastram GmbH & Co. KG for supplying geometric and experimental data related to their bow thruster.

* Corresponding Author: Mehrdad Kazemi, mehrdad.kazemi@uni-rostock.de

A numerical study on the effect of trim on the total resistance of a container ship model in confined water

Ivana MARTIĆ^{a,*}, Barbara ANUŠIĆ^a, Nastia DEGIULI^a and Carlo Giorgio GRLJ^a
^a*University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. Trim optimization is a promising strategy to improve the ship resistance characteristics and consequently increase its energy efficiency. Most of the research conducted so far regarding trim optimization is focused on unrestricted water. Since sailing in restricted water alters the flow and pressure distribution along the ship hull it is necessary to analyse the effect of trim on the total resistance in shallow and confined water. In this study, the effect of trim on the total resistance of the KCS model is analysed using computational fluid dynamics. Numerical simulations of resistance tests are performed for an even keel and four trim angles in restricted water. Numerical uncertainty for the total resistance, sinkage, and trim angle is assessed using different grid resolutions and time steps. The obtained numerical results are validated against the experimental data available in the literature. A detailed analysis of the free surface elevation, wave patterns, distribution of hydrodynamic pressure and wall shear stress is carried out. It is shown that a reduction of the total resistance in confined water can be achieved by adjusting the trim angle.

Keywords. *trim angle, resistance test, confined water, computational fluid dynamics, Reynolds Averaged Navier–Stokes equations*

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* Corresponding author: Ivana Martić, ivana.martic@fsb.unizg.hr

Marine applications of floating solar photovoltaic systems

Ivan ČATIPOVIĆ^{a,*}, Neven ALUJEVIĆ^a, Inno GATIN^b, Mario MATIJEVIĆ^c, Antonio MIKULIĆ^a, Darko SMOLJAN^a, Krešimir TRONTL^c

^a *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

^b *In Silico, d.o.o., Zagreb, Croatia*

^c *University of Zagreb, Faculty of Electrical Engineering and Computing*

Abstract. Currently, floating photovoltaic (FPV) plants for commercial use are installed on lakes, dams, and low-wave marine sheltered locations. Recently, research efforts have been aimed at enabling FPV systems installation in marine locations with higher waves where significant wave heights up to 2 or 3 m can be expected. In line with these efforts, the presented project, Marine Applications of Floating Solar Photovoltaic Systems (MARSOL), is focused on mathematical and numerical methods for evaluating environmental loads (waves, winds and sea currents) and responses of FPV systems installed at sea. Within the project, the traditional seakeeping model is updated with a model of connections that exist between multiple floating bodies carrying photovoltaic (PV) panels. Comparisons with available experimental results are satisfactory, providing a solid base for future research planned in the project. Also, simplified estimates of changes in the incoming solar radiation due to wave-induced motions of PV panels are conducted to establish the possible losses in the energy yields of FPV plants.

Keywords. *Floating photovoltaic, wave loads, multiple floating bodies.*

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* Corresponding Author: Ivan Čatipović, ivan.catipovic@fsb.unizg.hr

Advances in the linearised progressive flooding simulation method

Luca BRAIDOTTI^{a,*}, Jasna PRPIĆ-ORŠIĆ^b

^a *University of Trieste*

^b *University of Rijeka, Faculty of Engineering, Rijeka, Croatia*

Abstract. To achieve a fast and accurate progressive flooding simulation for decision support purposes, the linearised method was introduced and perfected in recent years being consolidated into a reliable tool. The problem is modelled using a differential algebraic equation system capable of coping with full compartments. The linearised system can be analytically solved allowing the application of larger time steps compared to standard solvers for differential equations. Performances are further improved by applying an adaptive time step in the integration process. Moreover, introducing a correction coefficient on opening areas enables to properly model the free-outflow cases overcoming the issues related to the assumption of deeply submerged openings. The method has been recently validated against new experimental data.

Keywords. *decision support, progressive flooding simulation, linearized method*

Acknowledgement. This work has been fully supported by the Croatian Science Foundation under the project HRZZ-IP-2022-10-2821.

* Corresponding Author: Luca Braidotti, luca.braidotti@gmail.com

Statistical and spectral description of full-scale measurements of ship motion in waves

Tamara PETRANOVIĆ^{a,*}, Marko KATALINIĆ^b, Hrvoje MIHANOVIĆ^c and Joško PARUNOV^a

^a *Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia*

^b *Faculty of Maritime Studies, University of Split, Croatia*

^c *Institute of Oceanography and Fisheries, Split, Croatia*

Abstract. The paper presents new results of the full-scale measurements of waves and ship motions for the research vessel *BIOS DVA* offshore Split in the Adriatic Sea. Experiments were performed by measuring waves simultaneously and ship responses for five different heading angles and two ship speeds of 7 and 3.5 knots. Waves were recorded by a solar-powered floating buoy, while the ship motion was measured with an Inertial Measurement Unit. Time series of waves and ship motion were analyzed using the STATREL software, and a comparison of statistically and spectrally defined characteristics is presented. The new campaign was organized as the comparison of previous measurements with seakeeping calculations concluded that additional experiments were required to improve the accuracy of seakeeping predictions, especially for the mean zero up-crossing period in the following seas. Therefore, special attention is given to the motion in the following waves in addition to analyzing the influence of ship speed on responses.

Keywords. *Full-scale measurements of waves and wave-induced responses, Research ship BIOS DVA, 2D spectral analysis of irregular waves and responses*

* Corresponding Author: Tamara Petranović, e-mail address: tamara.petranovic@fsb.unizg.hr.

Evaluating roll damping in parametric rolling: challenges and approaches

Anton TURK^{a,*}, Jasna PRPIĆ ORŠIĆ^a, Ivan SULOVSKEY^a and Marijana BALAS^a
^a *University of Rijeka, Faculty of Engineering*

Abstract. The prediction of parametric rolling in ships remains a critical area of research due to the significant impact on maritime safety and vessel performance. Among the various parameters influencing parametric rolling, roll damping is notoriously challenging to assess due to its nonlinear nature. Accurate prediction of roll damping is essential for reliable parametric rolling simulations. Traditional methods such as the Ikeda method provide valuable insights but are limited in scope, often tailored to specific instances of wave height and wavelength. Decay tests, while useful for individual cases, lack general applicability across a wide range of conditions. Computational Fluid Dynamics (CFD) offers a more comprehensive approach, enabling the analysis of complex interactions between the vessel and the surrounding fluid. However, CFD simulations are computationally intensive and require significant resources. This paper reviews the current methodologies for assessing roll damping, highlighting their advantages and limitations. It underscores the need for integrated approaches that combine empirical data, analytical methods, and advanced simulations to achieve more accurate and reliable predictions of parametric rolling across diverse maritime conditions.

Keywords. *Parametric rolling, roll damping*

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* Corresponding Author: Anton Turk. Anton.turk@riteh.uniri.hr

CFD self-propulsion calculations by double body models

Ivan SULOVSKY^{a,*}, Jasna PRPIĆ-ORŠIĆ^a

^a *University of Rijeka, Faculty of Engineering, Rijeka, Croatia*

Abstract. The primary objective of this paper is to examine the accuracy of the reduced numerical hydrodynamic model for the purpose of estimating global propulsion quantities. The reduced model, referred as a double body model, avoids the discretization of the free surface in the simulation. Therefore, the turbulent and viscous flow is solved for the wetted part of the hull only, while a symmetrical boundary condition is used for the free surface plane. Using OpenFOAM®, an open-source toolbox for CFD, the volumetric body force method is implemented as a propulsion model which further reduces the computational cost. Publicly available experimental data from model tests, namely KCS containership and JBC bulk carrier, are used for comparing the numerical solution with experimental one. The integral values of thrust and torque show good agreement, although a larger discrepancy is found for the KCS containership. As expected, the hull resistance shows poor accuracy. Furthermore, double body models are compared with a conventional simulations including free surface in order to detect it's possible influence on the results. Computational costs are also discussed in order to subsequently determine the potential advantages of the double body models for self-propulsion calculations.

Keywords. *CFD, self-propulsion, OpenFOAM*

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* Corresponding Author: Ivan Sulovsky, ivan.sulovsky@riteh.uniri.hr

Section IV

Production and maintenance of vessels and offshore structures

Framework for the lifetime extension of fixed offshore platforms in the northern Adriatic Sea

Dalibor MIMICA^a, Davor SKEJIĆ^b, Ivan ĆATIPOVIĆ^c and Joško PARUNOV^{c,*}

^a *Croatian Register of Shipping*

^b *University of Zagreb, Faculty of Civil Engineering*

^c *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. Design of fixed offshore platforms is performed in accordance with the regulatory guidance as API Recommended Practice 2A-WSD. However, when extending the lifetime of existing platforms beyond their designed lifetime, structural degradation, marine growth and updated knowledge of the recorded environmental conditions at the exact location where the platform was operated must be taken into account. In the present study, the specific requirements are reviewed for fixed gas exploitation platforms operating in the Croatian part of the north Adriatic Sea. The paper firstly provides overview of the present offshore activities and existing platforms in the Croatian part of the Adriatic. Further, following aspects relevant for the lifetime extension framework of fixed platforms are considered: description of the environmental conditions and seismic characteristics in the north Adriatic Sea, expected severity of the corrosion and marine growth in the region and procedures for strength and fatigue assessment. The aim of the paper is to review state-of-the-art analysis models and computational tools and to serve as the guidance for the engineers involved in the design, inspection, maintenance, and lifetime extension of fixed offshore platforms in the Adriatic. Also, research needs for the improvement of the existing inspection practice are identified.

Keywords. *Offshore platform, Adriatic Sea, lifetime extension, environmental conditions, structural analysis.*

* Corresponding Author: Joško Parunov, josko.parunov@fsb.unizg.hr.

Hierarchical modelling approach for ship production process

Neven HADŽIĆ^{a,*}, Tihomir OPETUK^a, Viktor LOŽAR^a

^a *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. The mathematical modeling of the ship production process, normally composed of numerous different and labor-intensive technology procedures, is a challenging task, especially regarding model complexity and computing resources. It is, therefore, of interest to research the possibility of model complexity reduction by employing the hierarchical modeling approach by aggregating successive working stations and thus facilitating the evaluation process. Hence, this work presents an overview of the applied hierarchical modeling approach as well as its impact on the accuracy of the estimated key performance indicators like the production rate, the work-in-process, probabilities of blockage and starvation, and identification of bottlenecks. The potential benefit of this kind of approach is reflected in the possibility of modeling complex production systems holistically including all production management levels.

Keywords. *Ship production process, Mathematical modelling, Production system engineering, Key performance indicators*

* Corresponding Author: Neven Hadžić, neven.hadzic@fsb.hr

Analysis and modeling of the ship machinery module

Irena BARIĆ ^a, Rajko RUBEŠA ^b, Marko HADJINA ^{a,*} and Tin MATULJA ^a

^a *University of Rijeka, Faculty of Engineering, Vukovarska 58, HR-51000 Rijeka, Croatia*

^b *Technical School, Vukovarska 58, HR-51000 Rijeka, Croatia*

Abstract In the competitive shipbuilding industry, gaining a competitive advantage between shipyards is necessary. A competitive and sustainable shipyard process must constantly be monitored to increase productivity, efficiency, and quality. One of the major concerns in modern shipbuilding is achieving efficient ship outfitting, particularly for high value-added ships. Maximizing the level of the ship's equipment installation before launching is one of the essential goals in modern shipyards while outfitting after the launching tends to be reduced to a minimum. Therefore, this paper will analyze the current situation in the observed shipyard in general, mainly the ship modular outfitting concept, which could improve its characteristics and impact the ship production process. Hence, the modular outfitting approach's benefits, requirements, and potential drawbacks will be discussed. The module assembly and installation activities will be established as a case study, including all necessary resources for the selected machinery module. A network diagram with a critical path will be provided for analysis while digital computer 3D modelling and visualization of module assembly and installation is developed. Furthermore, such model authors plan to use in further research as a basis for ship design and production digital integration to support the digital transition of the shipbuilding industry.

Keywords. *Ship machinery, modular outfitting, shipbuilding, 3D modelling and visualization, shipbuilding industry, design and production digital integration, digital transformation*

Acknowledgement. This research is supported by funds from the supporting research at the University of Rijeka for the project "Ship design and production integration based on digital twin concept" (uniri-iskusni-tehnic-23-80).

* Corresponding Author: Marko Hadjina, marko.hadjina@riteh.uniri.hr

Usage of ESAB Railtrac FW 1000 and ESAB TFD1 for mechanized welding first phase of Dynalink project

Ratko MIMICA^{a,*} Pjero PERAK^b and Neno-Nenad ĐURĐEVIĆ^b

^a *Brodosplit R&D, Split, Croatia*

^b *Brodosplit Welding School, Split, Croatia*

Abstract. Previous research findings regarding mechanized welding were used as a starting point for project Dynalink. Aim was to test process competitiveness, so mechanized process was compared with hand welding. After successful welding completion with Railtrack, process was retried with Submerged Arc Welding carriage TFD1. Improvements were suggested for further research.

Keywords: *Mechanized welding, weld deposition, heat input*

* Corresponding Author: Ratko Mimica, ratko.mimica@brodosplit.hr

Reconstruction of ships outfitting parts using reverse engineering methods

Ivana ŽELJKOVIĆ^a, Ratko MIMICA^{a,*}, Tomislav PRIBUDIĆ^b, Davor BAZINA^b, Ivan
TREBOTIĆ^b

^a *Brodosplit R&D, Split, Croatia*

^b *Brodosplit d. d., Put Supavla 21, Split, Croatia*

Abstract. After previous successful reverse engineering projects (ship hull, mast deviation, infrastructure scanning), in this paper reverse engineering methods were used to reconstruct ship piping system. Original drawings of those systems were lost and additionally, designated area suffered damage from fire. Pipes were reconstructed from point clouds and connected with shipyard main database.

Keywords: *laser scanning, 3d modeling, reverse engineering*

* Corresponding Author: Ratko Mimica, ratko.mimica@brodosplit.hr

Section V

Maritime transportation, environmentally friendly shipping, safety of navigation

Contribution of wind assisted propulsion for a liner vessel on a route in the Adriatic Sea

Ante ČALIĆ^{a,*} and Marko KATALINIĆ^a

^a*University of Split, Faculty of Maritime Studies*

Abstract. Air pollution from the shipping industry is an ongoing problem that requires exploring innovative technologies for effective resolution. The integration of wind-assisted ship propulsion (WASP) technology offers a promising route towards decarbonisation of the shipping industry. The paper investigates possible fuel savings and CO₂ reduction by implementing wind assisted propulsion on a case-study vessel operating on a known route in the Adriatic Sea. The long-term contribution of added wind propulsion is analysed by implementing a Velocity Prediction Program (VPP) and available meteorological data for the area of interest. VPP is modified to predict the contribution of wind propulsion to the overall propulsion necessary to achieve the vessel design speed. The case study quantifies long-term fuel savings for ship operating a liner route and harnessing favourable (predictable) north-west winds, complementing the conventional propulsion systems.

Keywords. *Wind assisted propulsion, Adriatic Sea route, VPP, air pollution.*

* Corresponding Author: Ante Čalić, acalic@pfst.hr

Simulating Navigators' Behavior under Stress Development of the Captain's Game

Kerstin LANGE^{a,*}, Heinz-Werner KURTH^a, Thilo KROGMANN^a
^a*Jade University: Department of Maritime and Logistics Studies*

Abstract. Stress is a frequent symptom of navigators on board ships. This affects individual decision-making processes and actions (including human errors). To examine the behavior of navigators under the influence of stress, the “Captain’s Game” was developed based on the simulation game method. In a simulated situation on a ship’s bridge, three students in the roles of master, chief mate and second mate have to react to event-based, realistic events on a container vessel passing the English Channel. They shall solve complex situations under time pressure. Stress is generated by time constraints (event cards) and unknown situations that are developing (scenario). A team of observers notes the players’ stress symptoms and reactions regarding

1. Physical stress signs (e.g. hecticness, speech, facial expressions),
2. Interpersonal changes (e.g. irritability, communication problems),
3. Change in management (e.g. loss of situational overview, wrong prioritization),
4. Decisions and actions taken, including their correctness.

In a debriefing, observations of navigators’ behavior are assessed. Students become aware of stress and its effects. They observe behavior changes and human errors. Developed as an analog simulation game, the “Captain’s Game” is characterized by its low implementation effort. It is a valuable opportunity to train students for the ship handling simulator.

Keywords. *Behavioral simulation, serious gaming, decision-making, influence of stress, navigators’ training.*

* Corresponding Author: Kerstin Lange, kerstin.lange@jade-hs.de

A proposal for amendments to Annexes I and II of the EU Ship Recycling Regulation

Jelena ČULIN^{a,*}, Vlatko KNEŽEVIĆ^a, Josip OROVIĆ^a, Zoran PAVIN^a
^a *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. The EU Ship Recycling Regulation (EU SRR), which took full effect on 31 December 2018, restricts or prohibits the installation and use of hazardous materials on ships. These requirements are almost identical to the requirements of The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (HKC), which will enter into force on June 26, 2025. Both HKC and EU SRR make it mandatory for ships to have on board a certified Inventory of Hazardous Materials (IHM). Part I of the IHM lists materials referred to in Annexes I and II (EU SRR) or Appendices I and II (HKC). Presently, two more materials are covered by EU SRR than by HKC. In this work, we propose additional amendments to Annexes I and II to reduce exposure to hazardous materials

Keywords. *Shipbreaking, EU Ship Recycling Regulation, Inventory of Hazardous Materials, hazardous materials on board ships*

* Corresponding Author: Jelena Čulin, jculin@unizd.hr

Advancing CFD validation methods for self-propelled inland waterway vessels a workshop initiative

Milan KALAJDŽIĆ^{a,*}, Ines IVKOVIĆ^a, Matija VASILEV^a
^a*Faculty of Mechanical Engineering, University of Belgrade*

Abstract. This paper represents a workshop about developing methodologies for validating computational fluid dynamics (CFD) simulations concerning full-scale self-propelled inland waterway vessels. Given the absence of previous workshops addressing this vessel category, the primary objective is to establish validation methods through the acquisition of self-propulsion speed and power measurements. Methodological consistency is paramount, emphasizing the creation of comprehensive 3D models covering vessel hull, appendages, superstructures, and propulsion components using original ship documentation and 3D scanning technology where necessary. Result presentation encompasses various hydrodynamic parameters, including resistance forces, thrust, wake fraction, thrust deduction factor, propeller performance, delivered power, shaft speed and vessel speed evaluated under calm water and self-propulsion conditions. Companies and institutions will be invited to join the workshop, where participants will validate their CFD methodologies using standardized models and analyze grid uncertainties across computational densities. The workshop aims to establish a validation framework for CFD simulations in inland waterway cargo vessels, with future plans for extending validation to shallow water river trials. Collaboration and transparency are emphasized, with respect for participants' preferences regarding result disclosure.

Keywords.

* Corresponding Author: Milan Kalajdžić, mdkalajdzic@mas.bg.ac.rs

Determining port wind limiting conditions for safe manoeuvring and berthing

Mate BARIĆ^{a,*}, Ivan TOMAN^a, Nina KOSTOVIĆ^a

^a *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. This paper investigates the impact of lateral wind forces on ferries operating in the port of Gazenica on the Croatian coast of the Adriatic Sea. By analysing wind data from May 2017 to June 2024, the research identifies SE winds as the most significant in terms of frequency and intensity, posing substantial challenges to ferry manoeuvrability. The study evaluates the wind forces acting on three ferries—"Brac," "Ugljan," and "Juraj Dalmatinac"—and compares these forces with their maximum engine thrust capabilities. Findings indicate that extreme SE wind conditions can exceed the thrust capabilities of these ferries, increasing the risk of drifting and grounding, as evidenced by the incident involving the ferry "Cres." The study underscores the need for improved ship design, enhanced propulsion systems, advanced navigational aids, and robust port infrastructure to mitigate the risks associated with high wind speeds. These measures are crucial for ensuring the safety and reliability of maritime operations in the port of Gazenica and similar environments.

Keywords. *Port, safety, wind*

* Corresponding Author: Mate Barić, mbaric@unizd.hr

Application of the AHP method in the decision-making process regarding the establishment of activities in coastal areas

Astrid ZEKIĆ^{a,*}, Dino ŽUPANOVIĆ^a, Luka GRBIĆ^a, Tomislav MAVRA^a
^a *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. The decision to establish activities in coastal areas is a complex process. Decision-making involves various criteria and subcriteria that are applied to assess possible options, requiring multicriteria decision-making. The Analytic Hierarchy Process (AHP) method in multicriteria decision-making allows structuring the problem based on pairwise comparison of quantitative and qualitative factors. The AHP method, based on input data, supports a linear hierarchical structure resulting in ranking different alternatives while controlling the consistency of the process. For the planning of economic facilities in coastal areas, by comparing activities, priority is given to the activity that contributes to economic and social effects and appropriately impacts the environment, safety, and human health. The paper elaborates on the complex issues of decision-making regarding the establishment of activities in coastal areas and analyzes the application of the AHP method in this process. In line with the problem, purpose, and goal of the research, the main output data that will be analyzed and based on which appropriate conclusions will be drawn are scenarios containing economic activities located in coastal areas. The authors draw conclusions on the possibilities, advantages, and limitations of applying multicriteria analysis methods to improve the quality of decision-making regarding the establishment of activities in coastal areas.

Keywords. *establishment of activities, coastal area, multicriteria decision-making, AHP method*

* Corresponding Author: Astrid Zekić, azekic22@unizd.hr

Solar potential for emission reduction in maritime transport: The Adriatic sea case study

Antonio MIKULIĆ^{a,*}, Ivan ĆATIPOVIĆ^a, Krešimir TRONTL^b, Darko SMOLJAN^a, Mario MATIJEVIĆ^b

^a *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

^b *University of Zagreb, Faculty of Electrical Engineering and Computing*

Abstract. Research on renewable energy sources for ships has been ongoing for some time now. The maritime industry's contribution to global greenhouse gas emissions will be taxed as soon as April 2025, when almost all vessels of gross tonnage above 400 will need to pay for their CO₂ emissions from 2024. Therefore, this study investigates the potential of photovoltaic (PV) systems as a clean energy source for reducing greenhouse gas emissions from ships traversing the Adriatic Sea. The research presents a detailed analysis of solar insolation and significant wave height data across the Adriatic Sea. Accounting for factors such as the intensity of solar radiation and the impact of wave heights, it examines the feasibility of using solar energy through PV systems installed on ships. The study will attempt to provide approximations of potential energy savings that could be achieved by integrating PV systems into the energy systems of ships. These estimates can help in understanding the extent to which solar energy can supplement conventional fuel sources in maritime transport, thereby reducing greenhouse gas emissions. This study expands the knowledge on renewable energy in maritime transportation and provides insightful information to researchers, regulators, and shipping industry stakeholders.

Keywords. *Case study, emission reduction, solar potential, ship energy systems*

* Corresponding Author: Ivan Ćatipović, ivan.catipovic@fsb.unizg.hr

Comparative analysis of alternative fuels for environmentally-friendly liner passenger ships

Marko NOVASELIĆ^{a,*}, Marko VALČIĆ^b, Josip OROVIĆ^b
^a *Jadrolinija, Riva 16, 51000 Rijeka, Croatia*
^b *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. In response to climate change, the International Maritime Organization has established an ambitious plan to enhance the environmental performance of ships. Complementing this, the European Union's "Fit for 55" Directive sets out a series of regulatory measures aimed at achieving a zero-emission continent. This has significant implications for maritime passenger transport in EU countries, particularly those with extensive port trade networks. For Croatia, with its complex coastline, numerous islands, and diverse maritime activities, these regulations are especially relevant. The focus is on various passenger ships, such as cruise ferries, RO-RO and RO-Pax ships, operating in environmentally sensitive areas. Key strategies to meet these legislative targets include hull and machinery optimisation, emphasizing the importance of new technologies like dual-fuel and hybrid engines, and exploring alternative fuels. This paper analyses various alternative fuels – biofuel, liquefied natural gas, grey and green methanol, ammonia, hydrogen, and hydrotreated vegetable oil – specifically for use in eco-friendly liner passenger ships. It assesses fuel properties, availability, safety, pricing, cruising range, and life cycle costs. The findings provide strategic guidelines for selecting alternative fuels, ensuring an effective decision-making process.

Keywords. *environmentally friendly shipping, maritime liner shipping, passenger ships, alternative fuels.*

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* Corresponding Author: Marko Novaselić, marko.novaselic@jadrolinija.hr

Eye tracking technology in maritime navigation - applications and benefits

Ivan MIŠLOV*, Mate BARIĆ, Vinko PAVIĆ and Luka GRBIĆ
University of Zadar, Maritime Department, Croatia

Abstract. Contemporary maritime industry places a significant emphasis on understanding human cognition and decision-making processes since human error is a predominant factor in over 80% of maritime accidents. With a decreasing number of crew members on ships, seafarers experience increased workloads and responsibilities, leading to a higher likelihood of errors. Eye tracking technology is a method used to monitor and record the movements of a person's eyes in various situations. By using special glasses or cameras, eye tracking technology records eye movement, gaze duration, blink rate and pupil size, which represent a person's cognitive and emotional state. This paper analyses the different areas where eye-tracking technology can be applicable in maritime navigation, including research on visual attention, gaze patterns, situational awareness, human-machine interfaces, mental workload and training improvement. The data obtained from various studies on eye tracking technology enable the development of preventive measures and corrections of human errors, especially during the seafarer's training phase and in equipment layout and design. Eye tracking technology represents a valuable tool to enhance safety and efficiency in maritime navigation, as shown in this paper, which provides a foundation for future research and practical implementation.

Keywords. *eye tracking technology, maritime navigation, safety of navigation, eye tracking glasses, situational awareness*

* Corresponding Author: Ivan Mišlov, imislov@unizd.hr.

Protection of the underwater part of the ship's hull with antifouling coatings

Ivan STOJANOVIĆ ^a, Ivan FATOVIĆ ^{a,*}, Juraj RUKAVINA ^a, Marin KURTELA ^a, Vesna ALAR ^a

^a *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia*

Abstract. The development of world trade is based on the global transport of goods and people, and the most advantageous and most common form of transport is transport by ships, which, with their service in a demanding medium such as seas and oceans, must withstand numerous challenges such as corrosion and fouling. The hull and the rest of the structure of modern ships are made mainly of carbon steel and aluminum, which are susceptible to corrosion damage in the marine environment and require adequate protection against corrosion. The most commonly used method for corrosion protection on ships is protection with coatings that form an impermeable barrier between steel or aluminum and marine environment. In addition to the corrosive effects of the sea, the outer surface of the ship's hull is also exposed to fouling of marine organisms such as bacteria, algae and shellfish. By settling on the ship's hull, they increase the friction between the hull and seawater, increase the weight of the ship and cause damage to the protective coating. The most commonly used method for protection against fouling are anti-fouling coatings that are applied to the outer surface of the underwater part of the ship's hull. Antifouling coatings have been in use for many years, but with raising awareness of the protection of the sea and marine organisms and the progress of technology, some old types of antifouling coatings based on tributyltin base have been abandoned and banned, and new, more effective and less harmful coatings for the marine world are coming into use. Currently, the most common antifouling coatings in shipbuilding are self-polishing anti-vegetative coatings based on copper biocides. In this paper, the efficiency and quality of antifouling coatings with an insoluble matrix and self-polishing coatings on steel and aluminum substrates were studied.

Keywords: *Corrosion protection, fouling protection, salt chamber, field tests in the sea, XRF, adhesion test*

* Corresponding author: Ivan Fatović, ivan.fatovic@fsb.unizg.hr

Section VI

Autonomous surface vessels, underwater systems and marine engineering

Exploring historical maritime cyber-attacks and introducing Maritime Security Operations Center as a solution to mitigate them

Ahmed NAGI NASR^{a,*}, Roomet LEIGER^a,
Inga ZAITSEVA-PÄRNASTE^a and Pentti KUJALA^a
^a*Tallinn University of Technology*

Abstract. Maritime transportation systems are increasingly embracing advanced technology and relying more on digital solutions, resulting in the escalation of potential cyber threats and the expansion of attack surface. Furthermore, in the upcoming years, the adoption of AI-based navigation and autonomous vessels will further broaden the scope of attack vectors. The widespread use of technologies like Electronic Chart Display and Information System (ECDIS) and Automatic Identification System (AIS) reveals gaps in current cybersecurity protocols within the maritime sector. In this paper, we aim to highlight the consequences of lacking proper security protocols employed for digital systems onboard ships by examining historical cyber-attacks on vessels. Additionally, we will explore the concept of a Maritime Security Operations Center (M-SOC), which can play a major role in enhancing cybersecurity in the maritime sector. The unique nature of M-SOC, which operates on real-time threat detection, can enhance resilience and protect critical infrastructure. Moreover, M-SOC serves as a centralized hub for analyzing cybersecurity data and coordinating response efforts.

Keywords. *Cyber Security, Cyber Attacks, M-SOC, AIS spoofing, ECDIS*

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* Corresponding Author: Ahmed Nagi Nasr, Email: ahmed.nasr@taltech.ee

Study on the development and quality validation of S-100-based MASS hydrographic information

Hyun-Sik NA^{a,*}, Yun-Soo CHOI^a, Dae-Uk KIM^b, Seung-Ryul LEE^b, Min-Sung KIM^a

^a *University of Seoul*

^b *U&I Ocean Technology*

Abstract. This research aims to develop and validate a smart hydrographic information system for Maritime Autonomous Surface Ships (MASS) to ensure the safety and efficiency of navigation. At the 106th meeting of the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO), it was decided to introduce the S-100 standard alongside the existing S-57 in the Electronic Chart Display and Information System (ECDIS) starting from 2026, with full implementation by 2029. This adoption is expected to overcome the limitations of the S-57 standard and enable integrated operation of various maritime data. However, the production of unverified maritime data can lead to errors and inaccuracies, posing serious risks to the maritime safety of MASS. Therefore, this research researched the development of a hydrographic information for MASS based on the S-100 standard to support the advancement of marine new technologies. It then used a test dataset for product specifications to validate the structural integrity of the data through software. The validation results were classified according to the error severity criteria proposed by the International Hydrographic Organization (IHO) to verify the accuracy and reliability of maritime data. Furthermore, actual validation results were confirmed through logical verification based on S-97. This research is expected to contribute to the advancement of marine new technologies and to the quality management of hydrographic information data, thereby ensuring the accuracy and reliability of maritime data, which will contribute to the safe operation and efficiency of MASS.

Keywords. *IHO, MASS, reliability, quality management*

* Corresponding Author: Hyun-Sik Na, nhs2101@uos.ac.kr

Proliferation of unmanned aerial and maritime vehicles in military operations

Andrija LJULJ^{a,*}, Vedran SLAPNIČAR^b, Dražen SMILJANIĆ^a

^a *University of Defence and Security dr. Franjo Tuđman, Zagreb, Croatia*

^b *University of Zagreb Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia*

Abstract. This paper presents an analysis of the proliferation of unmanned aerial and maritime vehicles (UAMVs) and their implications for future military operations. Although initially, the development and production of such vehicles were under state control, they recently moved to the private sector, and their capabilities were constantly improved. They are used for civilian and military purposes. Since there has been a drastic drop in the cost of UAMV production, they are becoming available to almost all armed forces, while previously, it was the privilege of only a few countries. The rapid development of UAMV for military purposes is considered as a new technological revolution that is already significantly changing the character and way of conducting armed conflicts, and it is estimated that their participation and importance in future potential disputes will be increased. The development of UAMVs and their use in armed conflicts has led to their proliferation and production race. The paper analyses the experience of UAMV use in recent military conflicts and identifies its advantages and limitations. Finally, it draws conclusions and recommendations for strategic military planners on implementing those technological changes within the armed forces and provides an adequate response to this threat.

Keywords. *Unmanned aerial and maritime vehicles, armed forces, military operations, strategy*

* Corresponding author: Andrija Ljulj, andrija.ljulj@sois-ft.hr

Marine propeller shaft dimensions: proposal to extend the IACS UR M68 formula to alloy steels

Liane ROLDO ^{a,*}, Nenad VULIĆ ^a

^a *Faculty of Maritime Studies, University of Split, Split, Croatia*

Abstract. On modern ships, particularly small coastal tourist ships around 50 meters in length, ship owners often prefer stainless steel propeller shafts, lubricated by an emulsion of grease and seawater, with no aft sealing. The IACS Unified Requirement UR M68 prescribes the expression for evaluating the shaft diameter based on service loading and tensile strength of the shaft material. However, it should be noted that the formula is only applicable to shafts made of carbon, carbon-manganese, and alloyed steels. Stainless steel is excluded. The aim of the paper is to propose the extension of the UR M68 formula for propeller shaft dimensions to cover stainless steel shafts. The chosen dimensions are dependent upon the shaft line concept, especially the type of lubricant, the material and the predetermined shaft load (torque or power at the relevant speed). These are currently the only available initial quantities for dimensioning the propeller shaft. Dimensioning propeller shafts, including stainless steel ones, is a crucial aspect in the development of marine propulsion shaft systems. The presented approach is based upon the fact that the expected failure mechanism of the shaft is fatigue due to cyclic loading. Additionally, it highlights and implements the relationship between fatigue strength and the tensile strength of the shaft material.

Keywords. *stainless steel, fatigue strength, tensile strength, propeller shaft.*

* Corresponding Author: Liane Roldo, lroldo@pfst.hr

Practical, resilient and financial aspects of an automatic barge

Rainer MÜLLER^{a,*}, Antoon VAN COILLIE^b, Wiebke DUHME^a

^a*Institute of Shipping Economics and Logistics*

^b*ZULU Associates*

Abstract. The global climate change already has adverse effects on Inland Waterway Transports (IWT). Low water levels often impact rivers, causing severe issues in IWT. One adaption measure is new design concepts for ships to operate in shallow waters. At first, this study describes an exploration of the design of the X-Barge - an autonomous barge solution, developed focusing primarily on enhancing resilience and sustainability in IWT. Second, a cost-benefit analysis (CBA) to assess the operational and financial viability of this approach is shown. The X-Barge will be a 1,500-ton/80 TEU (Twenty-foot Equivalent Unit) barge, specifically tailored to operate in diverse European waterways. The barge's autonomous functionality relies on AI-driven navigation systems, eliminating the need for human crew during transit. For the cost-benefit analysis, costs for implementing resilience strategies will be analysed. Benefits arise from the decreased damage costs caused by disturbances. Because of the innovative nature of the automatic barge, costs and benefits cannot be estimated precisely. However, the first results of the CBA are displayed. The outcomes of this research contribute valuable insights into the practical implementation of autonomous technology for resilience IWT and its operational and financial viability.

Keywords. *autonomous surface vessels, artificial intelligence, resilience, climate change*

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* Corresponding Author: Rainer Müller, rmueller@isl.org

Section VII

Applications of artificial intelligence in shipbuilding and maritime industry

Leveraging AI and Deep Learning Algorithms to Enhance Leisure Sailing Experiences

Laura PAGANI^{*} and Paolo GEMELLI^b

^a *Università Studi di Genova (Italy)*

^b *Università Studi di Genova (Italy)*

Abstract. This paper explores the transformative potential of artificial intelligence (AI) in revolutionizing leisure sailing experiences. Traditionally, leisure activities such as sailing have offered limited opportunities for personalization. However, recent advancements in AI enable dynamic customization of onboard environments based on individuals' emotions and preferences. Using leisure sailing as a case study, this paper demonstrates how AI can be leveraged to create personalized and engaging experiences. By analyzing real-time data from onboard sensors, AI systems can adjust environmental factors such as lighting, music, ventilation, colours, and furniture layout to optimize comfort and enjoyment. The paper also delves into the technical challenges of implementing AI in leisure sailing, including data collection, real-time processing, and ethical considerations around privacy and consent. It emphasizes the potential for AI to enhance the leisure experience, inspiring further research and development in this area. In conclusion, this paper envisions a future where AI is seamlessly integrated into leisure sailing, creating tailored, immersive experiences that maximize participant comfort and enjoyment.

Keywords. *Artificial Intelligence, Leisure Sailing, Personalization*

^{*} Corresponding Author: Laura Pagani, laura.pagani@edu.unige.it.

Adaptive neuro-fuzzy inference system for the estimation of brake power and rate of revolution

Marko VALČIĆ^{a,*}, Ivana MARTIĆ^b, Nastia DEGIULI^b, Carlo Giorgio GRLJ^b

^a *University of Zadar, Maritime Department*

^b *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. The characteristics of merchant ship propulsion systems represent a significant part of the preliminary ship design process. In this sense, the brake power and the rate of revolution of the main ship engine are of particular interest. Estimating these quantities represents a complex problem because it is often carried out based on data from existing ships, which are usually very uncertain and unreliable. In this paper, an adaptive neuro-fuzzy inference system (ANFIS) is proposed to estimate the brake power and the rate of revolution based on selected input variables (overall ship length, breadth, deadweight, and ship speed). The model was created and evaluated using data from 6600 bulk carriers of different sizes. The visualization of the developed fuzzy inference system, i.e. the mapping of the input to the target variables, indicates a fine smoothing of uncertain data, which makes the application of the model particularly suitable in the early stages of ship design, but also in a better understanding of the complex interdependencies of the mentioned variables.

Keywords. *ANFIS, estimation, uncertainty, brake power, rate of revolution, early ship design*

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* Corresponding Author: Marko Valčić, mvalcic@unizd.hr

A fuzzy set perspective on COLREG

Miho KRISTIĆ^{a,*}, Tonči BIOČIĆ^a, Maro CAR^a, Nermin HASANSPAHIĆ^a
^a*University of Dubrovnik, Maritime Department*

Abstract. Maritime navigation is strictly regulated by a set of rules prescribed in the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs). Some terms used in Rules could be defined as linguistic variables, as the Rules are written for human navigators. People frequently use similar terms like large, small, or sufficient, but it could be challenging to describe such linguistic variables to be understandable by machines. Fuzzy sets could define unclear terms that people successfully use in daily communication. While in classical theory, elements might belong or not belong in a set, fuzzy sets consist of components with degrees of membership in sets. Fuzzy variables are described by membership functions, which are always normalised. Elements with full membership have a value equal to one, but there could be elements with membership less than one or zero. The research aims to present a possible description of some linguistic variables used in COLREG using fuzzy theory. The study was conducted on the navigational simulator through interviews and simulations among maritime experts. Membership estimation by experts was done by using the horizontal scheme method. The research results were statistically analysed. Research data usage defined the fuzzy membership functions' range and shape. Fuzzy variables can be used in fuzzy systems, which could simulate humane reasoning and be used by autonomous ships.

Keywords. *safety of navigation; collision avoidance; autonomous ships, traffic separation scheme*

* Corresponding Author: Miho Kristić, miho.kristic@unidu.hr

Emerging stochastic methods for weather-aware ship routing

Marijana BALAS^{a,*}, Jasna PRPIĆ-ORŠIĆ^a, Marko VALČIĆ^{a,b}

^a *University of Rijeka, Faculty of Engineering, Rijeka, Croatia*

^b *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. Optimal ship routing is crucial for enhancing safety, reducing travel time, and minimizing fuel consumption. This paper introduces and examines recent advancements in stochastic optimization techniques, emerging methods and models for weather-aware ship routing. As marine transportation faces increasing challenges due to climate change and extreme weather events, the need for robust and efficient routing strategies has become imperative. A ship route that is subject to uncertainties is considered stochastic. Therefore, a comprehensive overview of emerging stochastic optimization methods that address the inherent uncertainties in weather forecasting and their impact on optimal routing is presented. The paper explores various approaches, including Markov decision processes, stochastic dynamic programming, and scenario-based optimization, highlights their applications in fuel consumption minimization, ensuring safety and improving time reliability. The integration of ensemble weather forecasts and probabilistic models to capture the stochastic nature of oceanic and atmospheric conditions is discussed. Additionally, computational challenges associated with these methods are analyzed along with recent algorithmic improvements that enhance their scalability and real-time applicability. The inclusion of multiple objectives, such as environmental impact and economic factors, within the stochastic framework is also addressed. Finally, a promising research direction is identified and potential synergies with machine learning techniques to further account for an increasingly uncertain marine environment.

Keywords. *ship weather routing, dynamic environment, route modelling, stochastic optimization*

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* Corresponding Author: Marijana Balas, marijana.balas@riteh.uniri.hr

Enhancing sailing yacht design through machine learning application of Gaussian process regression to predict bare hull resistance

Laura PAGANI^{a,*}, Paolo GEMELLI^a
^a *DAD- Università Studi di Genova*

Abstract. The evaluation of sailing yacht hull resistance plays a pivotal role in enhancing vessel performance, reducing fuel consumption, and optimizing overall efficiency. Traditional methods for assessing hull resistance typically rely on costly and labor-intensive experiments or computational fluid dynamics (CFD) simulations. However, these approaches can be prohibitive due to their complexity and resource requirements. This paper presents a novel approach using machine learning (ML) to predict the resistance of sailing yacht bare hulls, offering a more efficient alternative to conventional methods. Specifically, we employ a Gaussian Process Regression (GPR) model, utilizing the Delft systematic hull series dataset, which includes 50 distinct sailing yacht hull forms alongside their corresponding resistance measurements across Froude numbers ranging from 0.1 to 0.6. The performance of the GPR model, as well as other ML models, is rigorously assessed through metrics such as Root Mean Square Error (RMSE), R-squared, and Mean Squared Error (MSE). Our findings indicate that ML, particularly the Gaussian Process Regression model, effectively predicts hull resistance, demonstrating substantial potential for incorporation at the early design stages of yachts. This integration can significantly aid in the hydrodynamic optimization of hull forms. In conclusion, the application of machine learning, especially the Gaussian Process Regression model, emerges as a robust tool in the naval architecture domain, facilitating significant strides in the design and optimization of sailing yachts and potentially broader ship types. This study underscores the transformative impact of ML in naval engineering, offering scalable, accurate, and cost-effective solutions for yacht resistance evaluation.

Keywords. *Hull resistance, machine learning approach*

* Corresponding Author: Laura Pagani, laura.pagani@edu.unige.it

Section VIII

Education and training in shipbuilding and maritime industry

Technology evaluation of augmented and mixed reality systems in shipbuilding processes: preliminary report

Ratko MIMICA ^{a,*}, Ivana ŽELJKOVIĆ ^a, Vincent SETTLER ^b, Nina KÖSTER ^b, Adam GAŚIOREK ^c and Michal NEUFELD ^c

^a *Brodosplit R&D, Croatia,*

^b *TUHH University, Germany*

^c *Transition Technologies PSC, Poland*

Abstract. This preliminary report will present the latest results of a demonstration level testing of augmented (AR) and mixed reality (MR) devices in shipbuilding processes as a part of the Mari4_YARD project. The main goal of these tests and the project is to develop human-centric solutions which can preserve industry-specific knowledge, enhance the possibilities of presented technologies and improve work tasks' performance. The tests will also help to define what kind of performance level indicators can be measured in the shipyard's digital and real environment and can they be achieved.

Keywords. *Augmented Reality, Mixed Reality, Worker Training, Key Performance Indicators*

* Corresponding Author: Ratko Mimica, ratko.mimica@brodosplit.hr.

The importance of implementing the practice of maritime company branding as a preferred employer on the example of the maritime labor market - literature review

Šimun VUČETIĆ^{a,*}, Luka GRBIĆ^a, Marko ŠUNDOV^b, Mate BARIĆ^a
^a *University of Zadar, Maritime Department, Zadar, Croatia*
^b *Stano-Uprava d.o.o.*

Abstract. It is generally known that human resources with specific knowledge and skills are crucial for the successful operation of modern maritime companies. With the growth and development of existing and the establishment of new maritime companies in the world, there is a stronger and greater need to search for and attract quality human resources in the maritime sector in more innovative ways. Like other business entities, maritime companies today are forced to look for and apply various innovative ways with the aim of attracting new and high-quality human resources. One of the ways is through the application of "Employer Branding" as one of the common practices of mostly two departments in a modern maritime company. Employer branding as a newer term in economics is also applied in the maritime industry and has three goals. The first goal is to provide a positive image of the maritime company as a healthy, stimulating, long-term profitable company with a positive multicultural atmosphere for the future seafarer, while the second is related to the recruitment of capable, certified, talented and educated seafarers around the world. The third goal is reflected in the fact of achieving a competitive advantage for the maritime company itself, under the condition that the first two goals are realized. The aim of this paper is to show the importance of applying the "Employer Branding" as a practice that modern maritime companies apply through a review of currently available literature and conducted research on the example of maritime companies around the world.

Keywords. *Maritime company, employer branding, maritime labor market and seafarers.*

* Corresponding Author: Šime Vučetić, svucetic22@unizd.hr

Advanced integrated CFD-VR model of ship main engine fuel line fire

Dario OGRIZOVIĆ^a, Darko GLUJIĆ^{a,*}, Dean BERNEČIĆ^a, Goran VIZENTIN^a,
Goran VUKELIĆ^a

^a *University of Rijeka, Faculty of Maritime Studies, Rijeka, Croatia*

Abstract. Motion-capture-based virtual reality (VR) technologies have shown promise in firefighting training so far, enabling participants to collaborate in environments that are typically hard to access. Most virtual reality firefighting scenarios rely on fire appearance designed by VR game developers and give little concern about the actual fire spread dynamics. For a better success of VR training, it is essential for fire and smoke to act as close to real-life as possible. This is especially true for applications in maritime firefighting training since the crew, once at sea, must rely on its own capabilities and must be prepared to the maximum extent possible. In this study, that challenge was approached by employing computational fluid dynamics (CFD) to simulate fire spread, and then import the results of temperature and smoke distribution into the VR environment. That was done for the case of a fire on the ship main engine fuel line. CFD analysis results are imported into VR environment of the ship engine room using unique computer code. Developed firefighting scenario can be used for advanced training of the engine room crew as it comes closer to real-life settings while pushing VR training technology one step further, maximizing training effectiveness.

Keywords. *CFD-VR model, fuel line, main engine*

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* Corresponding Author: Darko Glujić, darko.glujic@pfri.uniri.hr

SIRE 2.0 - integration of human factors into the tanker inspection program

Vinko PAVIĆ*, Mate BARIĆ, Luka GRBIĆ and Ivan MIŠLOV
University of Zadar, Maritime Department, Croatia

Abstract. The safety of tanker operations has been monitored through the Ship Inspection Report Program (SIRE). This standard kept the operations of tankers as safe as possible through frequent hardware and management process inspections. Lately, the effectiveness of the SIRE inspections in the tanker industry has shown a stagnant trend, and adequate improvement of high safety standards is needed. Accordingly, the SIRE program is being revised to the SIRE 2.0 version with a high focus on human performance and a more human-centric approach. The transition to SIRE 2.0 brings significant changes to the tanker inspection program and is very focused on the crew's knowledge, skills, and commitment to ensuring the safe conduct of all operations on tanker vessels. The dynamic nature of SIRE 2.0 inspection will require crew and vessel operators to be well-trained, upskilled, and updated continuously. This paper aims to examine key challenges with SIRE 2.0 implementation regarding human elements as each inspection will be different for each vessel.

Keywords. *SIRE 2.0, tanker inspection, human factor, tanker safety*

* Corresponding Author: Vinko Pavić, vpavic1@unizd.hr.

Section IX

Maritime economics, logistics and law

Navigating economic crises operational efficiency and firm performance of shipyards and supplier firms in a maritime cluster

Antoni Vike DANIELSEN^{a,*}, Viktoriia KOILO^a
^a *NTNU Aalesund*

Abstract. This study investigates firm performance within a maritime industrial cluster during a period of economic and financial turbulence, focusing on the operational efficiency and financial outcomes of shipyards and their suppliers from 2010 to 2020. During this period, the maritime cluster in Møre og Romsdal, Norway, experienced a transition from a positive outlook to significant challenges following the 2014 oil price collapse and the subsequent decline of the dominating offshore market and the following market restructuring. Utilizing Data Envelopment Analysis (DEA) to assess relative efficiency and regression analysis to identify external determinants of firm performance, the study evaluates the resilience and adaptability of firms within the shipyard and supplier industry through these turbulent times. Results indicate that, despite significant market wise challenges, some firms maintained their efficiency and financial performance, suggesting effective strategic management and adaptive capabilities. To the contrary, identifying firms with specific inefficiencies and vulnerabilities, the study offers insights identifying areas for managerial interventions to better enable a higher level of resilience. These findings contribute to the understanding of effective strategic management and operational efficiency in sustaining firm performance within the shipbuilding and supplier industry amidst economic turbulence.

Keywords. *Firm Performance, Maritime Cluster, Operational Efficiency, Strategic Management, Economic Turbulence*

* Corresponding Author: Antoni Vike Danielsen, antoni.v.danielsen@ntnu.no

Historia est magistra vitae

Hvar naval arsenal – Building, repair and maintenance of the patrol police galleys of the Eastern Adriatic town - communes under the authority of Venice

Nives LOKOŠEK^{a,*} and Florian ŠTEFIĆ^b

^a *Lokošek projekt Ltd.*

^b *Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb*

Abstract. At the time of the First World Maritime Revolution around 1300, the Venetian General Commandment of the Sea reorganized its navy in 1330; its war ships operated from Corfu to Levant and on the Levant, while the Venetian Adriatic Fleet stationed for centuries on the island of Hvar. The city of Hvar was developing under the Venetian rule (1420 – 1797) as a naval arsenal for building (in times of conjuncture), repair and maintenance of the patrol galleys of the eastern Adriatic towns-communes under Venice. It was a fast and efficient replacement of ships on the slipways, as well as quality building and maintenance of *serial ships* on the ground floor of a monumental arsenal building. The naval arsenal in Hvar, due to its favorable geographical location was the extended arm of the Great arsenal of Venice, and thanks to this fact, the Hvar arsenal transmitted new and developed its own know-how and experience, and technologically, socially and economically influenced the development of the city of Hvar, middle Dalmatia and especially of Adriatic shipbuilding, although in the circumstances of a rigid governance of the Venetian oligarchy, to the interests and profits of which all was subordinated and strictly supervised.

Keywords. *Venetian thalassocracy, Hvar, naval arsenal, patrol/police and serial ships*

* corresponding author: Nives Lokošek, nives.lokosekprojekt@gmail.com

Benchmarking study of Nigeria's ship building capabilities applying Porter's diamond model

Chinedum ONYEMECHI^{a,*}, Abiodun SULE^b, Chinemerem IGBOANUSI^a

^a *Dept of Maritime Management Technology*

Federal University of Technology Owerri, Nigeria

^b *Nigerian Institute of Oceanography and Marine Research, Victoria Island, Lagos, Nigeria*

Abstract. The work surveyed current position of most Nigerian Ship building outfits through a benchmark study of the building and repair capabilities of these yards vis a' vis the offshore ocean oil and gas production subsector and posed a great need for massive investments derived from well established methods like, diamond model. An analysis of Nigeria's shipbuilding drive was made using existing facilities in her shipyard sector. Nigeria's local content development model is based on both the Cabotage policy and Nigeria's local content policy which requires that ships operating in Nigerian coastal waters be built, owned and manned by Nigerians. Nigeria's local content policy further elongates the Cabotage pillars by further insisting that first place prequalification status be given to Nigerian built vessels applying for contracts in Nigerian oil and gas community.

Keywords. *Shipping supply chain, Offshore Logistics, Maritime Strategy, Shipyard Technology, Offshore Support Vessels*

* Corresponding Author: Chinedum Onyemechi, c_onyemechi@yahoo.com

The 'Regia Nave Puglia' around the world (1898-1923)

Bruno CIANCI^{a,*}

^a *University of Genoa, Italy*

Abstract. The 'Regia Nave Puglia' is one of the very few naval ships built in the Kingdom of Italy to have survived in some form the grip of time. Built to provide service and assistance to overseas colonies, this armoured cruiser (or 'ariete torpediniere') of the 'Regioni' Class was the first warship to be built and launched in the new Taranto Naval Arsenal (1898), a site created from scratch in a depressed area and inaugurated in 1889. During the years of service (1901-23) the 'Puglia' made long voyages to display the Italian naval ensign in the most distant seas, calling at dozens of ports on all continents. The history of this naval unit and her crews has been meticulously reconstructed thanks to the documents held at Ufficio Storico Marina Militare (Rome), at Vittoriale degli Italiani (the house-museum of poet-soldier Gabriele d'Annunzio, which houses the ship) and thanks to other unpublished material discovered by the author. Among the several events witnessed by the 'Puglia' and her crews are worth a mention the Boxer rebellion in China, the Italian-Ottoman war (1911-12), the First World War and the anti-Italian revolts in Split (1920) that lead to the loss of two crew members.

Keywords. *History, naval ships, Regia Nave Puglia*

* Corresponding Author: Bruno Cianci, brunocianci70@gmail.com

Section X

Projects Dissemination

Sustainable Slow Steaming for Low Carbon Shipping – STARSHIP

Nastia DEGIULI^{a,*}, Ivana MARTIĆ^a, Carlo Giorgio GRLJ^a

^a *University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture*

Abstract. Slow steaming is a popular measure for commercial vessels, as a way of reducing fuel consumption, and therefore operating costs. Reducing ship speed is one of the measures to meet International Maritime Organization (IMO) requirements for GreenHouse Gas (GHG) emissions. The slow steaming approach was introduced for container shipping by Maersk Lines and later has been applied to other types of ships including tankers and dry bulk ships. Tankers and dry bulk ships sail almost half of their time in ballast load conditions. This results in significant changes in the underwater hull form shape and the associated hydrodynamic characteristics which are rarely given any consideration. With the current trend towards operation according to the slow steaming approach, ships are operating in conditions that are significantly different from those for which they were designed and optimized. Thus, sailing in off-design conditions can cause several occurrences such as a change in the propulsion and propeller efficiency, a change in the level of vibration, the loss of turbocharger efficiency, and the loss of heat recovery systems efficiency. Therefore, it is important to analyze the ship overall performance in off-design conditions. The project deals with three main issues related to sailing in off-design conditions, namely the change in the propulsion and propeller efficiency, the change in the main engine operation conditions, and the change in the level of vibration of the line shaft. The project is intended to improve understanding and provide new insights into the before mentioned problems due to sailing in off-design conditions. The project results will enable ship operators and shipowners to gain new insights related to the application of the slow steaming approach or sailing at different loading conditions. Thus, recommendations related to sailing in off-design conditions will be provided based on the obtained project results.

Keywords. *ship, slow steaming, CFD, towing tank experiments, fuel consumption, CO₂ emission, main engine performance, vibrations, fatigue*

Acknowledgment. This study has been fully supported by the Croatian Science Foundation under project IP-2020-02-8568.

* Corresponding Author: Nastia Degiuli, nastia.degiuli@fsb.unizg.hr

REliability and Uncertainty of Ship decision support system for safe and greener navigation

Jasna PRPIĆ-ORŠIĆ^{a,*}, Marijana BALAS^a, Ivan SULOVSKEY^a, Marko VALČIĆ^{a,b}

^a *University of Rijeka, Faculty of Engineering, Rijeka, Croatia*

^b *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. The goal of the research in a frame of CSF (Croatian Science Foundation) project REliability and Uncertainty of Ship decision support system for safe and greener navigation – REBUS is the analysis of reliability and uncertainties related to Decision Support System (DSS) is planned for ship captains as well as machine commanders, which would contribute to "greener" and safer navigation of ships. Research related to DSS analysis will proceed in two basic directions: Uncertainty analysis and reliability assessment of the decision support system for more energy efficient navigation while reducing greenhouse gas emissions; Uncertainty analysis and reliability assessment of the system for timely response in case of a flooding. Measurements of navigation and operational parameters of the ship using various measurement systems will be analyzed from the point of view of defining uncertainty and evaluating the reliability of the measurements themselves. The goal is to systematically analyze the shipboard decision support system, taking into account design, engineering, and maritime expertise, to create a safer and more environmentally efficient or "greener" ship and navigation.

Keywords. *Decision support system, ship motion, CFD, route optimization, green navigation*

Acknowledgement. This work has been fully supported by the Croatian Science Foundation under the project IP-2022-10-2821.

* Corresponding Author: Jasna Prpić-Oršić, jasna.prpicorsic@riteh.uniri.hr

DIH InnovaMare project fostering collaborative innovation and sustainable solutions for the blue economy in the Adriatic Region

Ana GUNDIĆ^{a,*}, Mako VALČIĆ^a, Mateo IVANAC^b
^a *University of Zadar, Maritime Department, Zadar, Croatia*
^b *Croatian Chamber of Economy*

Abstract. DIH Innovamare project addresses pressing challenges in the Adriatic region through its commitment to sustainable digital and green transformations, specifically targeting marine technologies and environmental preservation. By promoting collaboration among research centers, public and private sectors, and actively engaging young researchers, the project aims to develop market-oriented solutions. Key outcomes include the creation of educational modules for enhancing innovation capacity, the deployment of autonomous robots for real-time environmental monitoring, and the establishment of the Living Lab Adriatic Sea to test new marine technologies. The project also aims to alleviate funding challenges by organizing workshops and developing cross-border investment instruments. These comprehensive strategies position DIH Innovamare to increase regional resilience, stimulate sustainable economic growth, and generate innovative solutions that benefit the blue economy while aligning with the sustainable development goals of the region. The initiative emphasizes best practices and stakeholder connectivity to foster a robust, resource-efficient culture in the maritime sector. By championing innovation and cross-sector collaboration, DIH Innovamare seeks to tackle environmental challenges effectively and drive competitive advancements within the maritime industry, paving the way for a sustainable future in the Adriatic Sea.

Keywords. *Green transformations, Innovamare, Living Lab Adriatic Sea*

* Corresponding Author: Ana Gundić, agundic@unizd.hr

Applying the entrepreneurial discovery process to foster innovation and skills in the Blue Economy Insights from the MareSkill project

Ana GUNDIĆ^{a,*}, Tanja RADIĆ LAKOŠ^b, Frane UREM^b
^a *University of Zadar, Maritime Department, Zadar, Croatia*
^b *Šibenik University of Applied Sciences*

Abstract. This presentation will detail the utilization of the Entrepreneurial Discovery Process (EDP) methodological framework in the Interreg VI-A Italy-Croatia MareSkill project. The goal of this methodology is to pinpoint and develop particular competencies for the sectors of the blue economy, including marine and coastal tourism, aquaculture, and offshore energy, that focus on innovation and entrepreneurship. Since EDP includes literature on the policy and practice of stakeholders from academia to industry and policymakers, it facilitates the shifting of focus on mapping of new skill and innovation domains. At this stage, a templating structure has been formulated to fill up some voids and prospects in the existing and forthcoming educational and training schemes that are necessary for aiding the conversion into a sustainable blue economy. The results will contribute to the elaboration of approaches and experimental activities for upgrading and retraining of the personnel as well as to the definition of strategic priorities for particular sectors. It is expected that this methodology will be useful in strengthening cross-border collaboration, stimulating innovation and workforce in the strategic domains of the blue economy in the Italy-Croatia region.

Keywords. *entrepreneurial discovery process, blue economy, blues skills development*

Acknowledgement. This presentation was funded by the (Interreg VI-A) Italy- Croatia Programme of the European Union (ITHR0200456 - Smart and innovative blue skills for competitive blue economy MareSkill).

* Corresponding Authors: Ana Gundić, agundic@unizd.hr
Tanja Radić Lakoš, tradic@vus.hr, Frane Urem, frane.urem@vus.hr

Enhancing seafarer education insights from the MICROMET project

Ana GUNDIĆ^{a,*}, Astrid ZEKIĆ^a

^a*University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. The MICROMET project, led by the University of Zadar's Maritime Department in collaboration with European institutions and supported by Erasmus+, addresses the evolving educational needs of seafarers in the LNG, tanker, and cruise ship sectors. This initiative focuses on the recognition and validation of competencies acquired through both STCW and non-STCW short courses. This presentation will share preliminary findings from the project, showcasing the critical role of lifelong learning and the potential for establishing micro-credentials within the industry. A systematic analysis of the collected data aims to map missing competencies and identify educational gaps in seafarers' education and training. By fostering a framework for micro-credential recognition, the project aims to benefit seafarers, educational institutions, and maritime companies. Research methodology and initial insights will emphasize the need for collaborative dialogue among maritime higher education institutions, maritime training centres, shipping companies and seafarers, bridging the disconnect between educational practices and practical maritime demands.

Keywords. *STCW convention, MICROMET project, seafarers' education*

* Corresponding Author: Ana Gundić, agundic@unizd.hr

E-learning platforms usage at maritime higher education and training institutions

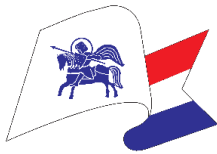
Lovre MARFAT^a, Ana GUNDIĆ^a, Antonio ĆURKOVIĆ^a, Tomislav MAVRA^{a,*}
^a *University of Zadar, Maritime Department, Zadar, Croatia*

Abstract. E-learning platforms are essential for education in the digital age, allowing institutions to overcome traditional teaching methods and provide education tailored to the students' needs. In higher education institutions, especially maritime higher education, e-learning platforms can be useful for providing access to specialized knowledge and skills crucial for professional development. They are designed to support various forms of learning and offer functionalities such as discussion forums, quizzes, assignments, and student progress tracking. However, besides general limitations in using online platforms in maritime education, additional limitations are related to acquisition of professional STCW competencies. Choosing the appropriate e-learning platform involves a thorough analysis of features such as content creation tools, communication functionalities, assessment capabilities, integration with other digital tools and support provided to educators and students. The experiences and opinions of students and professors on using online platforms can be helpful when choosing the appropriate platform. The study presents research results from the institutional project 'Acquisition of STCW Competences in Nautical Study Programs Using E-learning and Distance Learning (E-NAUT),' which can be used to propose guidelines for distance learning in nautical study programs.

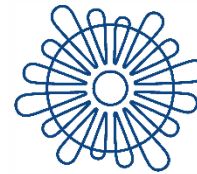
Keywords. *STCW convention, E-NAUT project, Competences*

* Corresponding Author: Tomislav Mavra, tomislav.mavra@gmail.com

Supporting Organizations



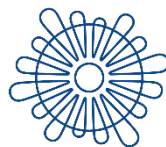
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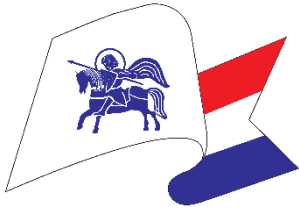


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Sveučilište u Rijeci, Pomorski fakultet
University of Rijeka, Faculty of Maritime Studies





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Pomorski odjel osnovan je krajem 2004. godine. Ustrojbene jedinice Odjela su odsjeci, i to:

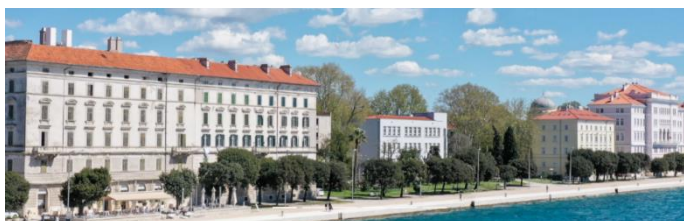
- **Nautički odsjek** - nositelj studijskog programa Nautika i tehnologija pomorskog prometa
- **Brodostrojarški odsjek** - nositelj studijskog programa Brodostrojarstvo i tehnologija pomorskog prometa.

Studij nautike i tehnologije pomorskog prometa osposobljava studente za vođenje broda, ali istodobno i za mogućnost sudjelovanja u upravljanju brodarskim tvrtkama ili upravljanju pomorskom plovidbom. Sadržaji u skladu s Konvencijom STCW 78/95 koji su potrebni za stjecanje najviših zvanja u pomorstvu (I časnik palube i Zapovjednik broda na brodu većem od 3000 BT) obuhvaćeni su u prve dvije studijske godine starog programa tj. za studente koji su 2012./2013. god. ili prije upisali prvu godinu Nautike i tehnologije pomorskog prometa.

Studij brodostrojarstva i tehnologije pomorskog prometa osposobljava studente za obavljanje poslova održavanja i upravljanja brodskim postrojenjem, ali istodobno i za mogućnost sudjelovanja u upravljanju brodarskim tvrtkama upošljavanju u brodogradilištima itd. Sadržaji u skladu s Konvencijom STCW 78/95 koji su potrebni za stjecanje najviših zvanja u pomorstvu (II časnik stroja na brodu porivne snage od 3000 kW ili jačim i Upravitelj stroja broda na brodu porivne snage od 3000 kW ili jačim) obuhvaćeni su u prve dvije studijske godine starog programa tj. za studente koji su 2012./2013. god. ili prije upisali prvu godinu Brodostrojarstva i tehnologije pomorskog prometa.

Poseban program obrazovanja pomoraca za nautičare i brodstrojare- po završetku Posebnog programa pomoraca polaznici stječu uvjete za pristup polaganju ispita za stjecanje ovlaštenja za zvanje prvog časnika palube na brodovima od 3000 BT ili većim te drugog časnika stroja na brodu sa strojem porivne snage od 3000 kW ili jačim

Tečajevi za pomorce - Pomorski odjel organizira tečajeve za pomorce u skladu s Konvencijom STCW 78/95.



Company Profile

Jadrolinija is one of the oldest Croatian companies engaged in maritime transport. Since 1947, Jadrolinija has built an impressive, nearly century-long tradition in connecting the Croatian mainland with the Adriatic islands.

Not only is Jadrolinija's navigation crucial for the development of island communities throughout the year, but it is also a key factor in Croatia's tourism offerings, which largely depend on the beauty of the Adriatic coast. The summer and tourist season bring an increase in demand for Jadrolinija's services, leading to a rise in passenger transport capacity requirements.

During the summer season, the ships perform over 600 departures daily, with the most frequented routes operating continuously 24 hours a day. The number of transported passengers increases year after year, reaching 12 million passengers and over 3.5 million vehicles. To handle such significant maritime traffic, Jadrolinija relies on a large fleet consisting of 59 vessels, including 14 catamarans, 4 classic passenger ships, 39 ferries, and 2 ferries for international lines. These ships operate on 38 local routes to the islands of the Adriatic and 3 international routes connecting Italy and Croatia. The key to Jadrolinija's success lies at the intersection of nurturing its rich tradition and looking toward the future.

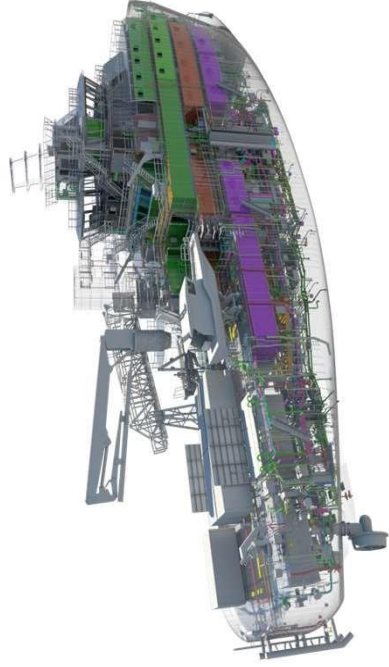


The modernization of the fleet and looking toward the future are the foundations of Jadrolinija's business and the key to its longevity. The emphasis on fleet renewal has been particularly focused in recent years, and when considering all investments from 2018 to the present, along with plans for the next year, we are witnessing the largest fleet renewal cycle in Jadrolinija's history, with a total of 16 investments. In addition to investments in the fleet, Jadrolinija is also actively developing its passenger services, constantly improving the quality and comfort of travel. There are many plans for the future, with progress and stepping into the future at their core.

To secure its position as a leader in maritime passenger transport in the Adriatic, Jadrolinija must continuously invest in the development of its services and in fleet renewal, which is the main tool of its business. This development also includes a shift toward green technologies and renewable energy sources, with the development of new vessels that will pave the way for this transition currently underway.



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TSI d.o.o. is a Croatian ship design and engineering company based in Rijeka, founded in 2014. TSI specializes in crafting innovative solutions for some of the world's largest and most advanced vessels. Whether it's a sleek luxury cruise liner or a robust ferry, TSI's designs are tailored to perfection, merging aesthetic excellence with cutting-edge technology.

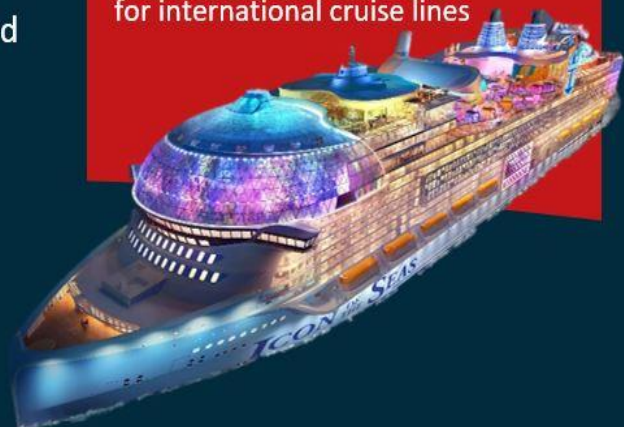
TSI's team consists of over 180 engineers, many with decades of experience, working closely with shipyards and shipowners across Europe in creating some of the most iconic cruise ships in the world: Disney Wish, AIDA, ICON series, Carnival series etc.

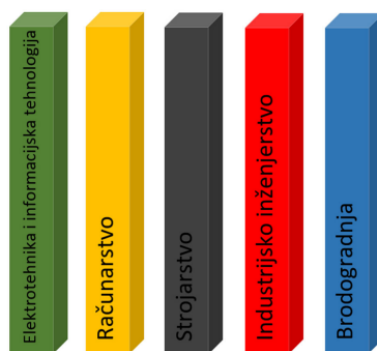
TSI has become synonymous with superior quality and groundbreaking design, ensuring that every vessel sails not just as a mode of transport, but as a statement of luxury and innovation.

MEYER

Since 2016, TSI has been part of the globally renowned **MEYER Group**, an international leader in shipbuilding with shipyards in Germany and Finland.

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University of Rijeka, Faculty of Maritime Studies

The University of Rijeka Faculty of Maritime Studies is a leading higher education institution for the education of personnel in the field of shipping and transport, not only in the Republic of Croatia but also in the wider region. The Faculty develops scientific research and expert work within the framework of the needs of the maritime industry, for the benefit of the local and regional community. It is an extraordinary responsibility to maintain such a unique position and cultivate tradition.

We set high standards for the education of students in order to actively integrate them into the labour market and wider society. We provide high quality, efficient and innovative higher education, we encourage open communication and partnership. Students are our best supporters, and we want to be the **port of knowledge** for each of them, from which they set sail and to which they are happy to return.

Higher education cannot achieve the desired level of quality without the transfer of knowledge from research to teaching. Maintaining a leadership position and being a **lighthouse of ideas** in science and research means that we continuously promote scientific research and the development of research careers, promote interdisciplinarity, strengthen the

capacity to attract scientific research projects, publish scientific papers, but also bring our knowledge closer to society through various forms of popularisation of science.

We actively participate, represent and promote the Faculty at university, national and international levels, promote international cooperation and mobility of staff and students, strengthen cooperation with the business community, advocate more active participation in civil society organisations, maritime heritage conservation and revitalisation programmes and initiatives that have an impact on the development of society and the community, because ***Navigare necesse est / One must sail.***

We have 75 years of built, valuable and rich heritage. Students and staff, their ideas and mutual cooperation are our greatest values. It is up to us to continue building, to be ***pilots of change*** within the framework of a strategically thought-out, organised, transparent, financially responsible and sustainable operation and to remain what we are – leaders in staff education and research in the maritime field, which is of particular interest to our Republic of Croatia and the wider surroundings.

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Faculty of Maritime Studies



Innovamare

Digital Innovation Hub Innovamare - DIH Innovamare is a cross-border initiative founded in Šibenik, Croatia. It was established on February 15, 2023, through the InnoVaMare project, funded by the Interreg Italy-Croatia cross-border cooperation program with a budget of €5.6 million. The digital innovation HUB Innovamare aims to become a central place for technology transfer, strengthening cooperation and connecting stakeholders on a cross-border and transnational level from the public, private and scientific research sectors for the development, testing and validation of marine technologies with the mission of the sustainability of the Adriatic Sea. DIH Innovamare was founded by the Croatian Chamber of Economy, Šibenik-Knin County, the Ruđer Bošković Institute, and the University of Zadar.

Innovamare focuses on:

- Developing underwater robotics and sensor technologies.
- Providing digital tools for networking.
- Promoting innovative financing models for maritime projects.
- Educating the business and scientific communities on new business models and innovation management.

Members of the Innovamare platform include companies, researchers, research institutions, solution providers, and stakeholders in underwater robotics and sensors. The platform supports networking, knowledge sharing, and collaborative project development. Membership benefits include visibility, access to funding opportunities, and participation in joint pilot activities. We have established Living Lab in Adriatic sea that is providing 15 infrastructural sites in Šibenik, Zadar,

Dubrovnik, Bari and Venice to our members to test and validate their solutions in real-life environment efficiently and with minimal environmental impact.

Key features and benefits of our DIH Innovamare include:

Collaborative Space – offices and lecture venues for interdisciplinary collaboration, where industry experts, researchers, and technology innovators can connect, exchange ideas, and work together on projects.

Technological Expertise - Access to a vast pool of technological expertise, including robotics, sensors, automation, and data analytics, enabling the development of groundbreaking solutions.

Testing and Development - State-of-the-art facilities and resources for testing and developing innovative robotic and sensoric solutions in real-world marine environments in our Adriatic Living lab.

Knowledge Sharing - Workshops, seminars, and training programs to foster knowledge sharing, skills development, and awareness about sustainable practices in the blue economy, including our Innovamare Academy that gathers experts from academia and industry.

Networking Opportunities - Regular networking events and conferences, bringing together stakeholders from various sectors to foster collaboration, partnerships, and investment opportunities.

Opening markets – we are able to represent companies for ADRION or MED region.

To become a member, interested parties can join via the Innovamare web platform, which serves as the main communication hub for offering and requesting solutions related to marine technology innovations.

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