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Navigating the Future:
Decarbonization, Digitalisation and Safety

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Influence of Different Heat Treatments on the Mechanical Properties of 42CrMo4 Steel for the Manufacture of Intermediate Shafts

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The shipbuilding industry is a highly specialized field of engineering that necessitates the use of materials capable of withstanding the demands of extreme operating conditions, including high stresses, corrosive environments, and dynamic loads. In this context, the application of heat treatment to 42CrMo4 steel enables the attainment of the requisite levels of hardness and strength, which directly influence the reliability and longevity of ship parts and components. The objective of this study is to investigate the impact of diverse heat treatment techniques on the hardness and strength of 42CrMo4 steel, with the aim of identifying the most effective heat treatment for a steel alloy intended for the production of an intermediate shaft. The methodology employed a theoretical approach and experimental procedures. A series of heat treatments and hardness tests were carried out, while tensile strength results were obtained using an equation that relates Brinell hardness and tensile strength of the material. The results of the study indicate that the heat treatments have a considerable effect on the hardness and strength of steel. The International Association of Classification Societies (IACS) Unified Requirement (UR) M68 limits the minimal specified tensile strength for alloy steels to no greater than 800 N/mm². Upon completion of the heat treatments, it was observed that the steel exhibited tensile strength in both its original and annealed conditions that satisfied the requisite standard as prescribed in the UR M68.

KEYWORDS

Marine shaftline, Heat treatment, Hardness, Tensile strength, 42CrMo4 steel, DIN 743-3

Identifying the Risk of Offshore Wind Farm Installation to the Safety of Navigation – An Overview of the Current State

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The increasing number of both fixed and floating offshore wind farms (OWFs) has led to significant concerns regarding their impact on safety of navigation. The purpose of this paper is to provide a comprehensive analysis of existing research on the subject, gathering as much as possible previous findings and methodologies. Strengths and limitations in addressing complex maritime safety challenges such as this are identified through a critical analysis of existing methodologies. The paper emphasizes the importance of integrating the historical data of multiple real-world navigation tools such as Automatic Identification System and meteorological conditions to enhance the accuracy and reliability of risk assessment. The article also explores innovative approaches to effectively prioritize and facilitate navigation risks through a holistic approach that maximizes similarity to a real-world situation. Using advanced stochastic methods, meteorological data, maritime traffic density data, Monte Carlo simulations and taking into account Maritime Spatial Planning (MSP), this paper presents a novel approach to solve problems arising from the theoretical installation of OWFs. Furthermore, possible gaps in the existing knowledge about the effects of large-scale OWFs on the control of maritime traffic flows and the resulting possible changes in route patterns are highlighted. The insights gained form the basis for further work and suggest a new research direction focusing on the development of a comprehensive risk assessment framework integrating all necessary data. In conclusion, this paper can also be a valuable resource for researchers, policy makers and maritime industry stakeholders. It aims to broaden the understanding of the challenges associated with OWFs as a relatively new and emerging maritime technology and their impact on the safety of navigation.

KEYWORDS

Rrisk assessment, Offshore wind farms, Safety of navigation, Automatic Identification System, Collision probability

Cruise Ship Navigational Practices in the Central and Southern Part of the Adriatic East Coast – Biševo and Svetac Island Region

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The operational standards of the cruise industry differ from those of most shipping sectors. To meet passenger demand for appealing itineraries, cruise ships mainly sail in coastal areas with significant natural and cultural values. In addition, the emergence of new cruise destinations presents challenges for routing decisions in new cruise regions of notable natural and cultural importance, particularly as cruise ships predominantly operate in coastal navigation.This paper analyses data from a study on the navigational practises of cruise ships in the central and southern part of the Adriatic east coast in the periods: from August to October 2014, from June to July 2015 and from May to September 2022. The aim of the study is to determine the routes of cruise ships by documenting the daily movements of cruise ships of more than 50,000 GT and to determine areas of potentially elevated navigational risk by analysing the navigation routes used, ship interactions, proximity to the coast and the characteristics of the area of the islands of Biševo and Svetac. The comparison of cruise ship navigational practises in the region over three time periods shows that the established coastal routes have become standard practise. The proximity of these routes to the coast as well as the interactions of vessels in the coastal areas indicate potential safety risks.

KEYWORDS

Cruise ships, Navigational safety, Routing, Adriatic East Coast, Biševo island, Svetac island

Propeller Performance Characteristics Calculation and Optimization Tool

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In this paper a computational tool designed to calculate and optimize the performance characteristics of marine propellers, specifically Wageningen B-series propellers, is presented. The tool consists of two main modules: a thrust calculator, which estimates the thrust and efficiency of a propeller based on empirical and experimental data, and an optimization module, which utilizes brute-force and genetic algorithm methods to determine the optimal propeller configurations. By integrating basic input parameters such as ship speed, propeller diameter, pitch, and other essential characteristics, the tool is used to find a solution for improving propulsion efficiency. The effectiveness of the tool is demonstrated through case studies on two vessels, a container ship and a special-purpose vessel, where significant improvements in propeller performance were identified. The tool described in this paper represents a straight forward method for propulsion performance optimization in practical maritime operations.

KEYWORDS
Wageningen B-series, Propeller efficiency, Thrust calculator, Open water characteristics

Development of Corrosion Wastage Assessment Methodology for Water Ballast Tanks: An Aging Bulk Carrier

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Various environmental factors, operating conditions, transport routes, the type of transported cargo, maintenance practices, and other external and internal factors significantly influence the development of corrosion. Cargo holds and water ballast tanks are particularly susceptible to corrosion damage. This study investigates the extent to which steel thickness reduction due to corrosion contributes to the degradation of steel structures and whether this reduction aligns with the adopted Common Structural Rules (CSR). The analysis is based on an aging bulk carrier and three types of ballast tanks within the cargo hold area: top-side tanks, hopper-side tanks, and double-bottom tanks. Thickness measurements were conducted on nine specific transverse structural locations, and a corrosion wastage assessment methodology was developed based on a nonlinear stochastic model. The corrosion growth rate was modeled using a probabilistic approach where the corrosion rate parameter d0 follows a Weibull distribution. The model also incorporates 95% confidence intervals to reflect uncertainty and assess early risk exceedance relative to CSR corrosion margins. The results revealed significant differences in corrosion behavior among ballast tank areas and identified critical zones where corrosion thresholds are reached earlier than expected. The proposed methodology demonstrates its applicability in assessing structural degradation patterns and validating CSR-based corrosion allowances.

KEYWORDS

Corrosion wastage, Corrosion margin, Nonlinear behaviour, Bulk carrier

The Mediterranean Sea as a Security Challenge Today

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Globalization represents a comprehensive economic, technological, informational, political, and cultural connection of the world as a whole, supported by information technologies. In the context of modernization, this process leads to the creation of a "risk society" which must be analyzed through the lens of reflexive modernization. The risk society encompasses the consequences of globalization, including migration, terrorism, changes in sociocultural identity, and the stability of Western societies. Conflicts and the global economic crisis have led to significant migratory flows towards Europe, particularly through the Mediterranean and Balkan routes. At the center of the migration crisis are economic migrants seeking a better life, as well as forced migrants fleeing wars and persecution in their home countries. Today, the European Union faces challenges arising from the influx of migrants, and the legal status of these migrants in international waters is becoming a crucial issue.The Mediterranean Sea has always had strategic importance as a transportation, economic, and geopolitical space connecting Europe, Africa, and Asia. However, contemporary security challenges in the region are becoming increasingly complex and dynamic, primarily due to migration flows, organized crime, maritime disputes, and environmental threats. Additionally, geopolitical tensions among coastal states, energy interests, and the military presence of global and regional powers further affect the stability of the region. The Republic of Croatia and the Croatian Navy have recognized security challenges related to the Mediterranean Sea, including migration crises, terrorism, illegal trade, environmental threats, and geopolitical tensions, and in this context, as a member of NATO, the EU, and the European Border and Coast Guard Agency (Frontex), contribute to collective security through several key initiatives. This article analyzes key security threats in the Mediterranean, their causes and consequences, as well as possible strategies for managing them. Using an interdisciplinary approach, it will demonstrate how international cooperation, maritime security policies, and technological innovations can contribute to the stabilization of this extremely important area.

KEYWORDS

Mediterranean Sea, Refugee crisis, Croatian navy, NATO and EU organization

Analysis of Fish Fund Exploitation in the European Union, Case Study of the Republic of Croatia, and the Eastern Coast of the Adriatic Sea

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Most maritime states have declared an economic zone that includes all the sovereign rights of the fishing zone, as well as those rights they have based on the continental shelf. In addition, they also have jurisdiction over scientific research and the preservation of waters above that zone. The problem that arose with the entry into the European Union (EU) is that the Exclusive Economic Zone (EEZ) of the Republic of Croatia (RoC) became the "European Sea", allowing fishing by all EU member fishing boats, which leads to increased exploitation. Constant surveillance of the sea area, the fishing sea, should enable the timely detection of all suspicious objects that are potentially poaching or illegal fishing. This paper shows how the RoC supervises and controls the fishing sea, and analyzes data on the national affiliation of fishing boats that fish in the fishing zones of the EEZ of the RoC. It also analyzes the number of observed boats in individual zones, thus visualizing fishing intensity. The collected data were processed in Matlab, and using the approximation model, the ratio between the exploitation of EEZ by Croatian and Italian fishing boats in the observed period and the projection for the next year based on the obtained results was presented.

KEYWORDS

Supervision, Protection, Control, Adriatic sea, Exclusive economic zone, Fishing

Motion Control in Hydraulic Cylinder Subjected to Negative Load in the Tender Crane Lifting System

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Marine hydraulics has become one of the most used power- and torque delivery systems, primarily due to the highly efficient transfer of large both linear and rotary forces and torques. The application areas are many and one of them is yacht tender crane lifting system. Tender crane lifting system on yachts consists of 3 hydraulic cylinders and 1 hydraulic motor and block and tackle system of 8 pulleys and a flexible rope in order to obtain a large stroke of lifting rope with small stroke of piston rod of the hydraulic cylinder. An oscillation in hydraulic cylinder similar to stick slip effect were occurring on the tender crane lifting system on the yacht during the lowering of the tender. In this article analysis of tender crane lifting system on the yacht was done. Corresponding kinematic and kinetic relation movements between hydraulic cylinder and flexible rope was analysed analytically. The analysis of hydraulic system was done by program FluidSIM6. Different variants the hydraulic system of tender crane lifting system were analysed, basic variant with on-off 4/3 directional control valve without counter balance valve and with proportional 4/3 directional control valve and with two different the pumping configurations. The analysis showed that replacing 4/3-way directional valve by 4/3-way proportional valve and increasing the size of pump the oscillation in hydraulic cylinder should not appear. The proposed variant was applied in service and showed expected results.

KEYWORDS

Tender crane lifting system, Block and tackle system, Hydraulic cylinder, Stick slip phenomena

A Model for Selecting the Most Suitable Renewable Source of Energy on Vessels Using Bayesian Networks

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Maritime transport has a negative impact on the environment. Therefore, the International Maritime Organization and the European Union have adopted legislation that limits the emission of harmful outputs from ships. The basic way to reduce the negative impact is the application of renewable energy sources. However, renewables are not evenly available everywhere. In addition to the above, not all types of ships are equally suitable for the application of different types of energy. As this is a complex problem, a model based on the theory of conditional probability, i.e. Bayesian networks, was made. The proposed model analyzes the availability of a certain type of energy, the energy needs of the ship and the possibility of the ship as a platform for the installation of the renewable energy system. After conducting an energy and economic analysis, the optimal solution is proposed. As such, it can serve in the decision-making process on the choice of renewable energy source.

KEYWORDS
Renewable energy sources, Electrification, model, Bayesian network, Decision algorithm

Maritime Cyber Risk Management and Cyber Security in Maritime Industry – Regulatory Framework and Cyber Security Requirements

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Maritime industry is increasingly using new technologies and information systems that rely on digitalization, integration, and automation, which call for cyber risk management procedures on board. Both cyber security and cyber risks are important because of their potential effect on personnel, ship, environment, company and cargo. Cyber security is concerned with the protection of information technology, operational technology, information and data from unauthorized access, manipulation and disruption which may cause extremely high financial costs in the case of cyber-attacks on the maritime industry. This brings the greater risk of unauthorized access or cybersecurity attacks to ships' systems and networks as well as maritime industry as whole. Enhancing cyber risk management and cybersecurity on maritime vessels necessitates a comprehensive understanding of relevant standards and regulations, particularly NIS2 and NIST CSF 2.0. Compliance with NIS2 standards is vital, as failure to meet these requirements can lead to operational disruptions and reputational harm within the maritime sector. To effectively strengthen cybersecurity measures, organizations must also integrate best practices based on the approach to cyber risk management described herein provides a foundation for better understanding and managing cyber risks, thus enabling a risk management approach to address cyber threats and vulnerabilities as well as NIST CSF 2.0 framework, which provides structured guidance for improving critical infrastructure cyber security.

KEYWORDS

Maritime cybersecurity, NIS2, NIST, Cyber risk management, Regulation, Standards

Mediterranean Sea Emission Control Area Implementation Challenges

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Since 1975 Mediterranean countries have been working together to protect the Mediterranean Sea under the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC 79) adopted on 15 December 2022 the Mediterranean Sea Emission Control Area for Sulphur Oxides and Particulate Matter (Med SOx ECA) to further limit air pollution from ships, pursuant to Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL), it being the fifth ECA following the Baltic Sea, North Sea, North American, and US Caribbean Sea. Hence, from 1 May 2025, ships operating in the entire Mediterranean Sea will be required to burn fuel with a sulphur content not exceeding 0.1%. The paper focuses on analysing the extent of improvements accomplished in the ECAs that had been proclaimed previously, the issues still outstanding, and the effects of Med SOx ECA on ship operators, flag states and port control. The authors applied qualitative research based on official documents, literature surveys, current research reports on the subject, as well as authors' previous experience and research. Given the impacts of emissions on public health and that of the ecosystems and long periods necessary for achieving positive effects following regulatory changes in shipping sector, ECA is in the traffic-busy and heavily populated Mediterranean being created with substantial delay. There is a need to introduce nitrogen oxides emission control in the zone as well. The application of alterative compliance solutions such as scrubbers should be closely monitored for their potential polluting effect on seawater. The availability of low-sulphur fuel and proper fuel changeover procedures should be ensured from the part of operators.

KEYWORDS
Emission control area, Air pollution, Mediterranean Sea, Sulphur oxides

Trade-Offs in Meeting the MARPOL Annex VI Requirements with the Focus on Costs

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Maritime transport is considered the most energy-efficient and environmentally friendly way of transporting large volumes of goods. The environmental aspect of maritime transport is regulated by the MARPOL Convention, which now has six annexes dealing with various elements of pollution from ships. In this paper, the authors address air pollution from ships. Air pollution from ships is dealt with in the MARPOL Annex VI. Ocean-going ships emit climate-changing pollutants (greenhouse gases) and local pollutants that lead to cardiovascular and lung diseases and premature deaths. By transporting around 12 billion tons of cargo per year, maritime transport causes around 3% of all man-made greenhouse gas emissions, 13% of sulphur oxide emissions and 15% of nitrogen oxide emissions. As a result, maritime transport causes around 265,000 premature deaths worldwide. Without remedial actions, maritime transport emissions could increase by 130% by 2050 compared to 2008 levels, however, by 2025, new ships must be 30% more energy efficient than in 2014, and the maritime sector is gradually included in the Emissions Trading System (EU ETS) since 2024. Currently, many propulsion technologies can be installed in newbuilds, while the existing fleet can be retrofitted in various ways to meet the new regulations. It is also possible to use cleaner but more expensive fuel. However, current solutions cannot address all air pollutants simultaneously or at a reasonable cost, so compromises are needed. The aim of the paper is to explore different ways to reduce air emissions from maritime transport and express them in monetary terms, either in terms of capital, operating or voyage costs.

KEYWORDS

Maritime transport, Air pollution, MARPOL Annex VI, Costs

Adopting Bio-Methanol and Green Methanol in the Maritime Commercial Industry - The case of Greece and Italy

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Among maritime alternative fuels, bio-methanol and green methanol variations are emerging as promising solutions to reduce GHG emissions while leveraging existing port and chemical industries infrastructure. This study investigates the adoption of these renewable fuels in the maritime industry, focusing on the cases of Greece and Italy due to their pivotal role in the maritime commercial activities and represent distinct economic and regulatory landscapes. This paper evaluates the current state of bio-methanol and green methanol adoption in the aforementioned countries, examining critical factors such as policy incentives, technological readiness and economic feasibility. Through review of industry reports and stakeholder engagement (interviews), important key enablers and barriers are presented to comply with IMO's decarbonization strategy. Special focus is given in the energy market status and corresponding methanol production costs, plus the capacity estimation of biomethanol production in different regions of Greece and Italy. The findings highlight notable differences in the adoption dynamics amongst Greece and Italy, influenced by variations in energy policy frameworks and industrial priorities. Greece can produce sustainably biomethanol in small scales (5,000-25,000 tonnes per year), whereas in Italy can expand to small and medium production scales (10,000-50,000 tonnes per year). The study concludes with actionable recommendations for policy makers and industry stakeholders (methanol producers, ship operators, etc.) to accelerate the transition towards sustainable fuels with a focus on green methanol use cases. These insights contribute to the broader understanding of renewable fuels adoption and offer a roadmap for scaling the use of bio-methanol and green methanol in maritime operations across Mediterranean region and beyond.

KEYWORDS

Biomethanol, Green methanol, Maritime industry, Decarbonization, Renewable energy, Alternative fuels

Decarbonization and Energy Efficiency Through Smart Shipping

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Climate change is a demanding problem whose impact is already substantial. Around one-fifth of global greenhouse gas emissions (GHG) belong to transport, while maritime transport accounts for 3% with a constantly rising trend. IMO's target is to reduce CO_2 emissions by 70-80% up to 2040, therefore, maritime companies will have to pursue operational excellence and modernization of existing fleet to reduce energy consumption and thus GHG emissions, while adopting the transition to decarbonized fuels for the new build vessels. This research exposes attainable ways of optimizing energy consumption on the fleet of liner vessels by analyzing and fine-tuning the vessel's operational profile during the voyage. Along with the establishment of enhanced connectivity and smart ships, the operational profile can be settled for the vessel, enabling monitoring and assessment of data after which a request for eventual optimization of operational condition can be sent to the vessel in real-time from the shore, concurrently enhancing safety and support. The fleet of liner vessels has been monitored from the fleet navigation center established ashore, the flow of operational data has been set up through various software and reports from ships as well as through established sensors onboard. Using action research method in correspondence with captains and line managers analyses and optimization have been carried out on the fleet of vessels with different sizes and capacities. Through comparative analysis of data, it has been discovered that significant fuel savings thus reduction of GHG emissions as well can be achieved by optimization of excessive use of power on the vessels and establishment of adaptive routing. While the adoption of decarbonized fuels for newbuild vessels is set up as a long-term solution for maritime companies, these measures are showing a large potential for the existing fleet by offering instant implementation and solutions for energy consumption optimization to meet recent and future IMO criteria of air pollution prevention and energy efficiency.

KEYWORDS

Decarbonization, Greenhouse gas, Power management, Constant power, Smart ships, Energy efficiency

Maritime Transportation System and Future Infrastructure for Offshore Storage of CO2 from Onboard CCS

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Carbon capture and storage (CCS) is a necessary part of reducing CO_2 emissions and restricting the increase of global temperatures to below 1.5°C. It is a key means of decarbonising energy-intensive industries, including shipping. However, the current pace of CCS deployment is too slow. Onboard carbon-capture and storage provides an immediate opportunity for existing fleets to achieve emission reductions in short- and medium terms. To ensure a successful energy transition, development of a complete CCS value chain is necessary. This work presents a model for optimising country-wide infrastructure needed for the value chain of CO_2 from onboard ships for offshore storage in Norway. The value chain elements included are intermediate storage hubs onshore at coastal locations, final offshore storage reservoirs, pipelines connecting offshore facilities to shore, and CO_2 transport ship option. The model can be used to communicate the potential of onboard CCS to the decision-makers and aims to enable data-driven investment decisions for the development of CCS infrastructure and increase interest of ship owners to invest in onboard CCS. The model can also be extended to include CO_2 volumes from onshore industry facilities including transport links to ports with intermediate storage, and volumes transported by ships from European industrial sources. Outcomes of the model include the overall maritime CO_2 transport network: location and size of storage hubs, CO_2 volumes for intermediate and final storage, future Norwegian CO_2 carrier fleet composition. The model is tested on various volume scenarios based on the current ship traffic and its applicability for onboard capture. Results demonstrate most favourable coastal locations for intermediate storage of CO_2 based on which and how many offshore final storage facilities will be available.

KEYWORDS

Maritime logistics, Transportation system design, Carbon capture and storage, Ship technology

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Review of the Decision-Making Process for the use of Monitored Systems On-Board

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In general, the basic duties of a nautical officer on duty on the bridge during navigation include planning and monitoring the navigation route, avoiding collisions, supervising and managing navigational data and handling the internal and external communication system. The nautical officer is exposed to various types of stress during navigation. Regulation V/15 of the SOLAS Convention (Safety of Life at Sea-SOLAS) states that the navigating bridge of the ship should not be used for purposes other than navigation, communication and other functions necessary for the safe handling of the ship, machinery and cargo, on this basis, bridge positions should be such that the bridge crew and the pilot have easier access to assess the circumstances, perform tasks and safely control the ship under all operating and navigational conditions (International Maritime Organization, 2011). The excessive workload of the navigation officer leads to an increased risk in decision-making during difficult navigational procedures. The purpose of this paper is to propose measures that can help reduce the workload of the navigation officer by evaluating the priority of tasks and the importance and urgency of messages received, as well as the process of sending or receiving messages, notifications, and warnings via ship communication equipment.

KEYWORDS
Navigation officer, Decision-making, Navigational bridge, Time

Induction Motor Multiple Fault Analysis Using Stray Flux Signals: A Review

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The asynchronous motor, also known as an induction motor, is the most commonly used motor in the maritime industry. Due to its robustness, reliability and low maintenance, it is used in a wide range of applications, e.g. in pumps, compressors, fans, deck machinery, propulsion etc. However, like any other machine, induction motors also have faults and vulnerabilities caused by electrical, mechanical and environmental influences that can be critical for the operation of the system, such as bearing, rotor and stator faults. Early detection of faults therefore helps to prevent damage or a sudden stop of the induction motor. There are several methods for fault detection in induction motors based on measured physical quantities, e.g. current, vibration, speed, temperature, torque, sound, air gap magnetic field and stray flux magnetic field method. Based on the available literature from the Clarivate Web of Science database, this study presents a literature review on multiple faults limited to the combination of broken rotor bar and bearing fault detection using Stray Flux Signature Method (SFSA). The SFSA is a non-invasive detection method that analyses the external magnetic field of the motor (magnetic leakage field) to detect faults. Motor Current Signature Analysis (MCSA) is a method that analyses current waveforms to detect mechanical and electrical faults. The results of the analysis show that there are only a few publications on this method and the fault combination compared to Motor Current Signature Analysis. This was the basis for a thorough literature review on the stray field method and fault combination.

KEYWORDS
Induction motor, Broken rotor bar, Bearing faults, Stray flux, Current

AI Meets Maritime Training: Precision Analytics for Enhanced Safety and Performance

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Traditional simulator-based training for maritime professionals is critical for ensuring safety at sea but often depends on subjective trainer assessments of technical skills, behavioral focus, communication, and body language, posing challenges such as subjectivity, difficulty in measuring key features, and cognitive limitations. Addressing these issues, this study develops an AI-driven framework to enhance maritime training by objectively assessing trainee performance through visual focus tracking, speech recognition, and stress detection, improving readiness for high-risk scenarios. The system integrates AI techniques, including visual focus determination using eye tracking, pupil dilation analysis, and computer vision, communication analysis through a maritime-specific speech-to-text model and natural language processing, communication correctness using large language models, and mental stress detection via vocal pitch. Models were evaluated on data from simulated maritime scenarios with seafarers exposed to controlled high-stress events. The AI algorithms achieved high accuracy, with ~92% for visual detection, ~91% for maritime speech recognition, and ~90% for stress detection, surpassing existing benchmarks. The system provides insights into visual attention, adherence to communication checklists, and stress levels under demanding conditions. This study demonstrates how AI can transform maritime training by delivering objective performance analytics, enabling personalized feedback, and improving preparedness for real-world operational challenges.

KEYWORDS

Artificial intelligence, Maritime training, Simulator assessment, Situational awareness, Computer vision, Speech recognition

Augmented Reality as a Tool to Maritime Traffic Safety

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Predicting possibility of ships' collision is a challenging task for computers in real conditions. It is even more challenging in little zones with many types of ships, mostly out of Automatic identification system (AIS). In the paper we consider new technique to help port authorities in that task. The paper aims to propose usage of augmented reality for presentation of possible risks to operators in Vessel Traffic System (VTS) centers, port authorities etc. This solution should be easily accessible. The input to the proposed was the camera installed in the port. Video recordings were used to detect sailing objects. YOLO v9 (You only look once, version 9) artificial neural network (ANN) was the framework for this task. Considered framework include Android application based on the Unity platform for data visualization. Results lead to the conclusion that the framework is promising. Current progress visualizes velocity of body mass center. This is tracked in consecutive frames. Although the research framework is promising, some obstacles were reported in the paper. For example, the ANN detects two sailing objects in some cases where there are not two objects in that image region.

KEYWORDS

Augmented reality, Video surveillance, Collision avoidance, Artificial neural network

Reliability and Validity of the Questionnaire for Examining the Integration of Ergonomic Practice Among Seafarers

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The aim of this study was to examine the reliability and validity of a newly constructed questionnaire for ergonomic practice integration assessment among seafarers. In doing so, test-retest reliability and factor analysis were applied to a sample of 45 experienced seafarers. Results indicated that the questionnaire is highly reliable and valid, demonstrating statistically significant reliability identified through non-significant difference between test and retest ($p > 0.05$). Factor analysis revealed a two-dimensional latent structure, namely Knowledge and Application of Ergonomic Principles, and Health Issues and Efficiency, explaining 33% and 24% of the variability of manifestations, respectively. It can be concluded that this newly constructed questionnaire is a reliable and valid tool for assessing the integration of ergonomic practice among seafarers and can be used in contemporary practice.

KEYWORDS

Ergonomic practices, Seafarers, Reliability, Validity, Factor analysis

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The Influence of Piracy on Security of Ships

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Piracy poses a considerable threat to the international maritime fleet and subsequently global trade. It is therefore of global significance to raise awareness of the importance of thorough analysis to tackle the problem effectively. With the increase in piracy, the protection of crew members and maritime assets has become a major concern. Piracy not only endangers human lives but also disrupts global trade, shipping safety, and economic stability. This research aims to assess the risks of piracy and develop targeted security measures for ships sailing in high-risk areas. By analyzing the patterns of pirate attacks, identifying the most vulnerable types of ships, and evaluating existing security systems, the aim is to create a reliable security system. The study also proposes a risk assessment methodology and security models tailored to different areas of attack and provides insights to help shipping companies and security authorities develop and maintain effective maritime security strategies. These strategies aim to increase the safety of crew and cargo while mitigating the economic impact of piracy. In addition, understanding the motives and methods of pirates is critical to refining security protocols and optimizing the security of the ship. This paper underscores the need for a robust approach to maritime security, particularly for countering pirate attacks.

KEYWORDS
Piracy attacks, High-risk areas, Security of ships, Safety of navigation, SOLAS, IMO

Analysis of Security Checks in the Cruise Port Area - Case Study of the Republic of Croatia

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In the maritime industry, extremely high attention is paid to the aspect of safety. This is important above all, both for the ship itself, and for the safety of the crew, cargo and other passengers on that ship. Vacations on cruise ships are becoming more and more interesting to a large number of people around the world. Considering the fact that cruise ships have become very luxurious "cities in miniature", more and more attention is paid to a high level of security both on the ships themselves and in the ports where these ships dock during the cruise. Since there are a large number of passengers and crew members on cruise ships, the degree of exposure and the possibility of potentially dangerous situations increases significantly compared to other types of ships. The aim of this research is first of all to provide an overview of the literature on the importance of the aspect of security in cruise ports and to analyze which of the types of documents, equipment, tools and technology, offered in this paper, are used from the aspect of security checks on case study of cruise ports in the Republic of Croatia.

KEYWORDS

Port security, Cruise ship, Cruise ports, Republic of Croatia.

Future Seafarers' Personal Values: Cross Cultural Study Among Maritime Universities' Students

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Seafarers are considered key workers who play a crucial role in international trade. A large number of studies have investigated various factors affecting the well-being, motivation and work performance of seafarers. According to the results of studies in the general population, personal values could be important for the well-being of seafarers but have not yet been investigated. The aim of this study was therefore to investigate the differences in the personal values of future seafarers in a cross-cultural context. 423 students from maritime universities in Croatia, Spain and Iran took part in the online study. The participants completed the demographic questionnaire and the Portrait Value Questionnaire. The results show the differences in the perceived importance of values between students from different countries. More specifically, Croatian students perceived conservation less important than Spanish and Iranian students, while openness to change and self-enhancement were more important for Iranian students than for Croatian and Spanish students. In addition, differences were found in conformity, self-direction, stimulation, hedonism, power, security, and achievement. Iranian students considered the above values more important than Spanish and Croatian students. These results underline the importance of cross-cultural training for different stakeholders in the maritime sector.

KEYWORDS
Seafaring, Maritime universities, Personal values, Cross-cultural training

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Challenges and Strategies for the Improvement of the Well-being of Seafarers: A Systematic Literature Review

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Careers in maritime industry have numerous challenges that significantly impact the mental and physical health of seafarers e.g. prolonged isolation, stressful working conditions, physical exhaustion, and limited access to healthcare. These factors often directly affect seafarers' well-being, safety, and the overall efficiency of maritime operations. The well-being of seafarers encompasses physical, mental, emotional, and social health and represents a crucial factor in safety maintenance at sea. Leading international maritime and health organizations developed guidelines to improve the working conditions of seafarers in terms of better management of working hours, rest periods, communication with family, and access to healthcare. This study employs a systematic literature review to analyze key stressors in the maritime industry, explore secondary quantitative and qualitative research findings on seafarers' mental health, and examine existing initiatives aimed at enhancing well-being. Furthermore, the study proposes specific stress management strategies to mitigate negative effects and improve the quality of seafarers' life. The implementation of the strategies is essential as it would preserve the health of seafarers, safety on board, and enhance operational efficiency, which ultimately contributes to a long-term sustainability of the maritime profession.

KEYWORDS
Well-being, Seafarer, Health, Strategy

The Perceived Issues and Challenges in Onboard Training Implementation

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The competence of seafarers relies on the quality of education and training provided by maritime education and training institutions (METIs) and on practical training on ships, termed onboard training. Onboard training has played a key role in maritime education and Training (MET) as one of the critical components of prospective seafarers' skill development. However, numerous studies have identified issues and challenges in the implementation of onboard training globally. Such challenges include the availability of training berths for students, the lack of appropriate mentoring structures during onboard training and the cost of maintaining training ships. In addition, there are several external factors/forces that could affect onboard training implementation. Moreover, social disruptions such as the COVID-19 pandemic and technological advancements, including the development of the Maritime Autonomous Surface Ship (MASS), have impacted discussions regarding the nature and relevance of onboard training in the future. In the situation of the anticipated shortage of seafarers in international shipping, the insufficient available training berths for students leads to a worse scenario in the long term. Furthermore, concerns exist about the quality of onboard training. In this study, semi-structured interviews and focus groups were used to collect data from 48 individuals at METIs, 24 seafarers, and 75 students to identify the challenges and potential factors in onboard training in contemporary shipping. Through qualitative analysis using thematic analysis, several themes were identified under two main categories: "issues and challenges in the implementation of onboard training" and "factors affecting onboard training". The findings of the study offer insights into challenges in implementing onboard training and factors that affect onboard training and associated MET systems in contemporary shipping from the METI perspective.

KEYWORDS

Maritime education and training, Onboard training, Practical training for seafarers, Theories of learning

A Comprehensive Study on Challenges and Opportunities in Maritime Education and Training in India

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Maritime Education and Training (MET) in India faces evolving challenges driven by technological advancements, environmental imperatives, and industry demands. This mixed-methods study investigates cadet satisfaction, institutional disparities, and systemic barriers to MET modernization. Qualitative insights from six maritime professors were triangulated with quantitative survey data from 645 cadets across six Indian MET institutions. Regression analysis revealed that assessment fairness ($\beta = 0.259$), pedagogical innovation ($\beta = 0.242$), and curriculum relevance ($\beta = 0.231$) were the strongest predictors of cadet satisfaction, collectively explaining 50.9% of variance. Cluster analysis identified three cadet groups: a dissatisfied cohort (18%) critiquing outdated infrastructure and assessments, a moderately satisfied majority (64%) emphasizing gaps in industry exposure, and a highly satisfied cluster (18%) valuing technology-integrated pedagogy. Qualitative findings highlighted critical gaps: outdated training technologies, misalignment between curricula and industry needs, and insufficient integration of sustainability principles. Professors emphasized the urgency of adopting Extended Reality (XR) tools for immersive learning and fostering industry partnerships to bridge skill gaps. Quantitative sentiment analysis of open-ended responses underscored cadet demands for practical training (e.g., "More hands-on simulations") and modernized facilities. The study proposes actionable strategies: (1) integrating XR technologies to simulate real-world maritime scenarios, (2) aligning curriculum with International Maritime Organization (IMO) sustainability targets, and (3) institutionalizing industry collaborations through internships and curriculum co-design. These recommendations aim to enhance MET's responsiveness to global trends while addressing India's maritime workforce needs. The findings hold significance for policymakers and MET institutions seeking to balance academic rigor with industry relevance, ensuring graduates are equipped to navigate technological, environmental, and operational challenges in a dynamic maritime sector.

KEYWORDS

Maritime education and training (MET), Curriculum innovation, Industry collaboration, Immersive learning, Sustainability

Simulating Growing Complexity in Maritime Traffic

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Continuous research and developments in maritime traffic often result in new levels of complexity. Technological innovation accompanied by enhanced and amended regulatory schemes result in new situations that need to be handled on board and also need to be managed from shore-based monitoring stations. Maritime Education and Training (MET) has to address these advancements, human factors, and regulatory updates, adapting them into syllabuses and course works. This also requires further enhancement of simulation-based training. In this paper we discuss increasing complexity and present investigations and results of a simulation experiment focusing on the design, implementation and conduction of a combined simulation exercise involving full-mission ship-handling simulation and full mission VTS-simulation. A complex scenario provides trainees with realistic interactions between actors from different institutions within the maritime domain. This study specifically aims to answer how such simulation setups can address operational challenges and improve navigational safety under increasing traffic complexity. The experiment involved maneuvering a container vessel entering a harbor terminal with pilot onboard, while receiving additional navigational assistance from a shore-based VTS station. The investigation focuses on how VTS-provided assistance supports safety of navigation, especially when navigation aids (e.g., buoys or beacons) are unavailable due to technical or environmental challenges. The outcome of the experiment is discussed in the light of the feedback from involved experts gained during focus group discussion of the debriefing session. Main outcome and conclusion from the experiment is, that the growing complexity of maritime traffic rises the need for realistic simulation scenarios. Technical developments and improvements require adequate operational procedures for smooth interaction of the different actors ensuring safe and efficient traffic flow. Simulations also provide insights to improve regulatory frameworks and human-operator training, mitigating risks from technical failures or adverse conditions.

KEYWORDS

Maritime transportation system, Simulation, Mixed traffic, VTS, MASS, Remote control

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Shore Excursions: Perception and Determinants of Cruise Passenger Choice

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The aim of this article is to investigate the factors that influence cruise passengers to participate in shore excursions. Through a self-administered questionnaire, data were collected from a sample of 403 people during the 2019-2020 season in the port of Las Palmas (Gran Canaria), a major cruise passengers' hub in the Canary Islands. The study is based on an exploratory factor analysis, followed by the application of several logit models to identify which of these models best fits the behavior of cruise passengers in relation to excursions. The results of the study show that passengers who participated in excursions rated the excursion offer positively, indicating a clear relationship between the excursion experience and the perception of the service offered. On the other hand, passengers who decided not to participate in these activities showed a significantly lower rating of the excursion offer, suggesting that the decision not to participate may be related to negative perceptions or a lack of adequate information about the activities available. The results show that the ease of booking and of refund in case of cancellation have the greatest positive effect on the likelihood of purchasing an excursion, followed by those related to safety, while those related to price and limited time onshore decrease this likelihood. The results also indicate that having taken a shore excursion in the previous port of call increases the likelihood of taking an excursion offered by the cruise line. This finding has important implications for both cruise lines and destinations, as it highlights the need to improve the promotion of available excursions, while underscoring the importance of understanding passengers' motivations and preferences. Taken together, these data provide rich insights that can help to develop more effective strategies to encourage cruise passengers to participate in excursions during their time onshore.

KEYWORDS

Cruise tourism, Shore excursion, Consumer behavior, Canary Islands, Exploratory factor analysis, Logit model

Proposal For a Floating Syllabus in Maritime English for Seafaring Marine Engineers

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This research has been aimed at re-designing the existing course in ME (Maritime English) as ESP (English for Specific Purposes) that has been delivered to marine engineers as part of the Special Education Program for Seafarers at the Faculty of Maritime Studies in Split for the last 14 years. The goal has been to adjust a fairly rigid syllabus and a limited course time to the individual needs of the trainees and their diversity in terms of age, previous education, English proficiency, current jobs, motivation, and career plans. Over the years, the trainees have taken part in a series of short in-class surveys revealing their expectations regarding the course. Their responses as well as the results of their self-evaluations, initial tests and final exams have produced valuable guidelines. Finally, in order to obtain a clearer picture of the trainees' preferences, they have been given a table with a list of 25 mandatory topics covered by the ME course, followed by a few empty lines for suggestions, and have been asked to break down the 50-hour course by allocating the time to each unit. This approach has been a great help in finding a balance in the ESP concept that inherently includes both general and vocational English, i.e. in developing a floating syllabus that can be adjusted to each group and each individual within a group. The course is expanded by 10 non-mandatory class hours to be voluntarily attended by marine engineers in line with their specific needs (grammar, terminology, written communication, mother tongue interference, pronunciation, and the like). Hopefully, the proposed floating syllabus may help other ESP teachers dealing with similar dilemmas and issues to customize their syllabi.

KEYWORDS

Maritime English, Marine engineers, Survey, Floating syllabus

Vertical Flight (in)Efficiency: A Systematic Review of Benefits, Challenges, and Implementation Considerations

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Vertical Flight Efficiency (VFE) has emerged as a promising avenue in Air Traffic Management (ATM) domain due to its potential to optimize fuel consumption, mitigate environmental impacts, and improve airline cost efficiency. This review article critically evaluates the benefits and limitations of VFE, with a particular emphasis on Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO). The aim of the study is to present outcomes of a systematic synthesis of literature in the field of study, thus detailing the benefits and challenges associated with VFE. The methodology relies on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, ensuring a methodologically transparent approach to literature selection and data extraction. Accordingly, the review categorizes studies according to their insights into benefits of VFE, while also identifying key constraints, including those arising from atmospheric conditions, aircraft performance models, and operational complexities. The analysis indicates that significant advancements in fuel efficiency, reduced trip durations, lower Air Traffic Controller workload, decreased fuel costs, and emissions reductions are achievable. However, these potential gains are often constrained by external factors, including meteorological instability, vast technical and exploitation specifications of aircraft, and the operational limitations imposed by existing Air Traffic Control (ATC) practices. Additionally, the increased procedural complexity of implementing VFE strategies, i.e. CDO and CCO procedures, may elevate operational risks and pose difficulties in ensuring compliance with vertical profiles. Furthermore, the inability to distinguish when aircraft is on optimal CCO/CDO profile versus at level-offs, also complicates traffic monitoring. Moreover, the introduction of these procedures requires careful planning to avoid capacitive bottlenecks and maintain safety standards in congested airspace. In conclusion, the review paper emphasizes the necessity of balancing VFE's environmental and operational benefits with its inherent limitations. Although VFE presents a promising pathway for enhancing sustainability and efficiency of ATM system, its effective implementation requires addressing considerable technical and procedural challenges Therefore, this review paper outlines the relevancy and necessity of future research which should be oriented towards developing comprehensive models and strategies that integrate VFE within broader ATM systems, thereby enabling a pragmatic approach to maximize its benefits within operational constraints.

KEYWORDS

Vertical flight efficiency, Continuous descent operations, Continuous climb operations, Air traffic management

Challenges for Port Infrastructure and the Future Hinterland Distribution of Green Ammonia in Germany

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Ammonia is emerging as a central component in the transition towards sustainable energy systems. It is expected to play a significant role in the future energy landscape, offering a versatile solution for energy storage and transport. This study explores the challenges and opportunities associated with port infrastructure and the future hinterland distribution of green ammonia, focusing on infrastructure, logistics and policy frameworks. A systematic review of existing infrastructure, including ocean-going vessels, barges and tank cars was conducted. Scenario-based estimations were used to determine the projected quantity of transport units required for effective hinterland distribution. The analysis highlights following key factors a successful green ammonia economy in Germany:

- The German federal government's plans indicate a significant increase in ammonia demand by 2035.
- Planned capacity expansions at key import ports aim to accommodate ~24 million metric tons per annum.
- Current world fleet of ocean-going vessels to be expanded by up to 26 vessels required for supplying only Germany.
- Distribution scenarios indicate a demand for 320 full trips with barges per year and 3,724 additional tank cars.

Germany faces critical challenges in scaling its port infrastructure and ammonia distribution network to meet future demand. Additionally, Germany is largely dependent on its neighboring countries for importing the required quantities of ammonia. While import port expansions are underway, hinterland transport capacity remains a bottleneck. The increase in traffic volumes tightens the existing shortage of skilled labor, while production capacities for ships and other transport equipment remain limited. The planned hydrogen core network might be insufficient and ammonia pipelines should be reconsidered. Germany must approach all challenges associated with the hydrogen economy, including infrastructure integration, regulatory frameworks and market readiness. These issues are crucial for the country's transition to green ammonia. Further research should focus on policy incentives and technological advancements.

KEYWORDS

Green ammonia, Energy transition, Hinterland distribution, Port infrastructure

ADS-B Technology as a Support to the Air Traffic Management System

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Automatic Dependent Surveillance – Broadcast (ADS-B) is a surveillance system developed to allow for a wide exchange of flight and navigational information via data-link network between Air Navigation Service Providers (ANSPs) and the airspace users, as well as between airspace users themselves. The system relies on installation of an on-board transceiver, usually coupled with aircraft S-mode transponder equipment, and a ground radio equipment that feeds the Air Traffic Services' data transmission channels. Data exchange is performed via two principal modes: ADS-B In and ADS-B Out, providing both sides with a complete air picture. The future Air Traffic Management (ATM) system heavily depends on the wide and safe use of ADS-B technology in support of increase and optimization of airspace capacity, situational awareness, efficiency and safety of air transport operations. In order to establish itself as a primary surveillance mechanism, and besides of adoption of wider implementation strategy, ADS-B needs to conform to all of requirements that allow for a safe aircraft separation in a cooperative environment. This research paper provides a review of a current implementation of ADS-B status as a support to ATM system with an outlook of key areas of scientific research on perceived deficiencies of the system. In that regard, the paper focuses on the transmission range and interference aspects, accuracy of transmitted data and vulnerability of ADS-B systems to malicious attacks.

KEYWORDS

Air Traffic management, ADS-B, Data-link, Situational awareness

Diversifying Aerodrome' Non-Aeronautical Revenues through Renewable Energy Investments

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The agenda of the aviation industry in Europe is to strive towards sustainable development, and ultimately to achieve net-zero carbon emissions from flight operations by 2050. To do so many aviation stakeholders are turning to business diversification and trying to maximise the efficiency of their peripheral business activities. Aerodrome operators represent no exception in that regard. Simultaneously with the increase in market share of low-cost carriers over the last two decades, aerodrome operators were trying to maximise their profit margins, primarily through non-aeronautical revenues. However, in contrast to previous years, nowadays due to geopolitical reasons and the strategic determinants of the European Commission, aerodrome operators have become one of the prominent representatives of sustainable development within the aviation industry. Foremost due to investments in renewable energy, a decision which brings multiple benefits, where the opportunity to generate a new type of non-aeronautical revenue, while simultaneously making cost-savings, stands out. In that respect, this research paper provides insights on how to exploit aeronautical data, periodically publicated by Air Navigation Service Providers (ANSPs), to obtain preliminary insights on the feasibility of renewable energy investments. The paper also details the findings of a case study addressing investment feasibility into solar and wind power plants at several aerodromes located across the Republic of Croatia.

KEYWORDS
Aviation industry, Sustainable development, Renewable energy, Non-aeronautical revenues

Climate Resilience Assessment Framework for Intermodal Ports

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The adaption to the climate change is essential for intermodal ports to maintain its competitiveness on the freight transport market. A resilience framework supports the identification of potential threats and weak points in the operations and in the business continuity plans. Therefore, the aim of this paper is to develop a resilience framework for intermodal hubs to identify and assess hazards, key functions and infrastructure, and improve resilience measures. Key functions and infrastructure elements are revealed through interviews with employees on multiple levels, on-site visits and overview of organizational documents. Hazard risks are determined based on historical weather data and impact on operation. A data model was developed to calculate the infrastructure's resilience indicators, namely the vulnerability, recoverability and reliability that were used to assess the business continuity plan. The proposed resilience framework has been applied to the Budapest Free Port in Hungary to demonstrate and validate the method. It was found that the port is vulnerable to heavy wind, drought and flood. Furthermore, a railway bridge between the port and the nearest marshalling yard is the cornerstone of the intermodal freight transport yet there is still no replacement plan during a breakdown. Resilience measures were proposed to mitigate the impacts of potential hazards. Resilience measures can help to improve the robustness of the intermodal port and the freight transport chains. However, other weak points outside of the port pose a greater risk on the inland waterways and railway corridors, such the unregulated Danube and the lack of reliable railway freight corridors.

KEYWORDS

Resilience framework, Climate change, Intermodal port, Vulnerability, Recoverability, Business continuity plan

Analysis of Fleet Management Policies for Offshore Platform Supply Vessels: The Brazilian Case

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Offshore activities are crucial in the petroleum industry. Maritime oil and gas installations require different cargo types with different consumption rates to operate. A heterogeneous fleet of platform supply vessels (PSVs) supplies cargo to installations. PSVs are the most expensive resource and the higher greenhouse gas (GHG) emitter from the offshore logistics, besides being a scarce resource for most offshore regions.

A proper PSV fleet management is vital for efficient offshore logistics. The PSV fleet management in Brazil is specially challenging due to the non-availability of the spot market, variations and uncertainties in delivery order demands and due dates, inspection and corrective vessel maintenance, and multiple time windows for service at installations. PSV fleet management aims to satisfy cargo delivery requests in time and quantity (delivery service level), avoid delays, and achieve balance among delivery service level, vessel operating costs, and GHG emissions.

We developed PSV fleet management policies considering delivery service level or fuel consumption goals. The policies are composed of new fleet management procedures such as vessel control, vessel assignment to voyages including cargo selection, vessel routing and speed selection, and dynamic re-routing. The procedures were coupled in a discrete-event simulator to evaluate the policies performance for long time horizon.

We tested in a real case eight policies based on the developed procedures and compared with one policy without the procedures, representing the real operational scenario. The new policies reached an increasing in delivery service level, a reduction of fuel consumption (up to 40%), a reduction in voyage delays to almost zero, and a potential reduction of 18% in the fleet size.

The comparative analysis of policies shows their different impacts on indicators, allowing managers to select the best fleet management policy considering the trade-offs between delivery service level, costs, and emissions, depending on their goals.

KEYWORDS
Offshore oil and gas logistics, Platform supply vessels, Fleet management policies, Delivery service level, Vessel costs, Brazilian case

1 year of crisis in the Red Sea: what impact for the Adriatic ports?

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Geopolitical events in the Gulf of Aden have targeted merchant ships using the Suez Canal, particularly container ships. Since the first Houthi attacks, liner shipping companies have been bypassing the African continent via the Cape of Good Hope to secure trade between Asia, the Mediterranean and Europe. This major operational adjustment is having an impact on Mediterranean port connectivity and on the ports of the Adriatic Sea. The purpose of this presentation is to analyse the impact of this crisis on containerised traffic in Adriatic ports and on the strategies of shipping lines set up to serve this region. We will use the AIS signals emitted by ships over a period of one year before and after the first attack to assess the consequences of this political and maritime crisis. The Mediterranean Sea, by virtue of its geography and as a consequence of the crisis, has become a cul de sac. Companies are deploying new strategies to serve Mediterranean ports, and the Adriatic in particular. This reorganisation has had numerous consequences for the ports and their customers. Shipowners are relying mainly on the main hubs in the western Mediterranean, and even on other European hubs.

KEYWORDS

Maritime transport, Adriatic sea ports, Crisis, Ccontainer, AIS

Gaining Competitive Advantage through Green Port Technologies – Case of Selected Adriatic and Ionian ports

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Ports are important transport, industrial and energy hubs that can create the conditions for environmentally friendly operations and therefore influence the greening of the logistics chain. Ports represent a major added value for the European economy as they are points where supply chains intersect and where different stakeholders with different business interests work together. One would think that by now all have a common interest in the environment and the greening of transport, however, this is not always the case as the focus is still often on, performance and profitability maximisation. By correctly and consistently implementing greening activities and new technologies, ports can become role models for other logistics actors. Therefore, appropriate port development strategies must be established. The progressive ports include the greening concepts necessary for the decarbonization of port activities and their sustainable development in general. Ports no longer compete only in terms of their throughput, but also in terms of green development. Ports need to prepare technical, operational and financial measures that promote sustainable development. These include the electrification of port equipment (e.g. electric cranes, trucks or forklifts), the installation of shore power for ships (cold ironing), the use of alternative energy sources (e.g. solar or wind energy), the use of improved energy efficiency technologies (e.g. LED lighting and energy-saving machinery) and environmentally friendly terminal renovations and expansions, etc. Adriatic-Ionian ports could gain a competitive advantage by timely investing in green technologies, as many major shipowners and business partners prefer to work with environmentally responsible ports. The literature review shows that the authors generally use three main groups of parameters to describe ports and their performance: Dimensional parameters (quay length, total and covered storage areas, etc.), Equipment parameters (number of ship-to-shore cranes, different gantry cranes – RTG Rubber Tired Gantry Crane, RMG Rail Mounted Gantry Crane, etc.), Production parameters (number of units handled in TEU – Twenty-foot equivalent unit, tonnage, etc.). In this research, the authors are looking for new parameters that represent the environmental, social and economic sustainability of terminal design and operation on a life cycle basis.

KEYWORDS

Ports, Container terminals, Green development, Sustainable development

Integrating Hyperspectral Imaging and the Spectral Angle Mapper Algorithm for Sustainable Biofouling Management along the Qatar Coast

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Globally, non-indigenous biofouling organisms are recognized as serious threats to biodiversity, economy, and human health. Our recent study confirmed that biofouling organisms associated with marine structures and litter along the Qatar coast pose significant ecological and economic concerns. Effective management of biofouling requires detection and classification methods. This study explores the integration of hyperspectral imaging (HSI) and spectral angle mapper (SAM) algorithm to address marine biofouling issues sustainably. HSI provides a non-invasive, high-resolution approach to capture the spectral signatures of various biofouling organisms, while the SAM algorithm enables accurate classification by comparing spectral similarities. Sampling of biofouling organisms associated with marine structures and litter along the Qatar coast was conducted in December 2024. The hyperspectral images of the collected samples were captured using a VNIR (400–1000nm) hyperspectral camera. Atmospheric correction, noise reduction, and normalization were applied to account for varying illumination conditions. The SAM algorithm classified each pixel based on the angle between its spectral vector and reference spectra of known biofouling species. Classification results were validated against ground truth data using metrics such as overall accuracy and confusion matrices. Distinct spectral signatures were identified for major biofouling types, including barnacles, mollusks, and algae. Pre-processing minimized spectral overlap between closely related species. The SAM algorithm achieved an overall accuracy exceeding 90%, with particularly high accuracy for barnacles. Its robustness was demonstrated under varying light conditions. This study highlights the effectiveness of interesting HSI and SAM algorithm for detecting and classifying biofouling monitoring, contributing to sustainable coastal management. Future work will focus on incorporating machine learning classifiers to enhance discrimination between closely related species.

KEYWORDS

Biofouling, Marine litter, Hyperspectral imaging, Spectral angle mapper, Qatar

Sustainable Development in Croatian Maritime Journals – Literature Review and Thematic Analysis

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The basic strategic document for Croatia's orientation towards sustainable development is currently the "National Development Strategy of the Republic of Croatia until 2030", which defines priorities and goals that are in line with the "2030 Agenda for Sustainable Development" and the "European Green Deal". In order to implement the mentioned priorities and goals, it is necessary to continuously develop and monitor new scientific knowledge on different but interrelated aspects of sustainability (the economic, social, environmental and cultural). The aim of this paper is therefore to review and analyse scientific papers in which sustainable development is mentioned in maritime journals and to identify and describe the themas represented in these selected scientific papers. Based on the methodology of a semi-systematic review of the literature and using the method of thematic analysis of the collected scientific papers, this paper analyses scientific papers that mention the term „sustainable development" ("sustainability", "sustainable", „sustainably" etc.) in the title, abstract or keywords and were published in the period from 2014 to 2024 in the following four Croatian maritime journals: "Naše more", "Pomorski zbornik", "Pomorstvo" and "Transactions on maritime science" (ToMS). The application of the aforementioned methodology and method enables the collection, analysis and synthesis of relevant scientific findings on different maritime aspects of sustainable development published in renowned Croatian maritime research journals in the last ten years, as well as the identification and description of established themes and research findings. The results of the thematic analysis will help to bring together and link different interdisciplinary approaches and to clarify and facilitate the understanding of the connections between the diversity of issues related to different maritime aspects of sustainable development and the relationship between the sea and society, as well as contributing to the current knowledge on environmental aspects of maritime sociology.

KEYWORDS

Sustainable development, Croatian scientific maritime journals, Semi-systematic literature review, Thematic analysis, Maritime sociology

A Research on Direct Connection of Shore Power for Domestic Vessels

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Receiving the electric power from shore side which is called as "shore power" has been used to reduce the acoustic noise and emissions from onboard diesel generator at the port. It is also expected to contribute to save energy consumption and to lower operating costs. However, the number of ports where shore power is available for cargo vessels is limited, because its facilities cost is not affordable for all organizations managing the port. The initial costs and maintenance costs of shore power facility which consists of transformers, frequency converters, and cable management systems must be borne by the port management organization. If onboard electric system can connect to the shore side electric system directly, several of equipments can be omitted, which may suppress those cost. This study approached the following technical issues for the low-cost installation of shore power equipment for domestic cargo vessels of less than 500 tons, which consume little power while moored.

  1. Decrease in motor torque due to voltage drop.
  2. Decrease in pump capacity due to lower speed caused by lower frequency.
  3. Magnetic saturation of a transformer.
  4. Upper limitation of receiving power.

To clarify real onboard operation, investigations were conducted to measure the power demand while moored or loading/unloading and actual pump head. Based on these data, the performance of onboard equipment was evaluated when it operates on shore power. The results revealed that the above concerns may not cause problems in many cases for general cargo vessels of less than 500 tons. With some restrictions, the cost of shore power equipment can be reduced because power can be supplied directly from the shore-side electric system to the ship without transformers and frequency converters.

KEYWORDS

Shore power, Domestic cargo vessels, Voltage drop, Frequency drop

The Socio-Economic and Environmental Effects of the Marina Industry and Nautical Tourism on Local Communities

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This paper investigates the multifaceted economic, social, and environmental impacts of the marina industry on local communities and the natural environment, emphasizing the crucial role of locals in marina development plans. Marinas and nautical tourism are recognized for their socio-economic contributions to local communities worldwide through creating income, new jobs, and employment opportunities. However, the marina industry also generates undesirable social and environmental footprints, leading to the degradation of natural resources and the quality of local lives. A balanced approach is not just a suggestion but a necessity. Marinas and nautical tourism businesses must rethink their practices to actively include local community members in their plans and activities, fostering more sustainable development. This study explores the attitudes and opinions of locals on the benefits and adverse effects of the marina industry in a coastal area with numerous marinas, nautical tourism activities, and plans for industry expansion. Data were collected using a structured survey and analyzed through descriptive statistics and correlation analysis. The results show diverse effects, with key positive impacts such as contributions to local economic prosperity and job creation. Significant environmental concerns, including pollution and resource degradation, contrast these. Positive correlations between economic benefits and community well-being underline the importance of fostering economic growth, while weak negative correlations with environmental impacts highlight the need for sustainable practices. These findings emphasize the necessity of integrating community perspectives into marina planning to achieve balanced development that mitigates negative consequences while enhancing benefits. The study underscores the importance of sustainable and inclusive approaches in tourism-driven economies, particularly in coastal areas heavily reliant on marina and nautical tourism industries.

KEYWORDS

Marina industry, Nautical tourism, Local communities, Socio-Economic Impacts, Environmental Impacts, Sustainable Development

Comparison of Port Community Systems in Maritime Ports – Case study

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Port Community Systems (PCS) are essential tools for modernizing port operations, enhancing efficiency, and fostering sustainability within the maritime industry. This research examines the implementation and application of PCS in the ports of Rijeka, Ploče, and Split, focusing on their distinctive strategies and contributions to Croatia's economy. Leveraging advancements in information and communication technologies (ICT), PCS facilitates seamless data exchange and coordination among stakeholders, optimizing logistics processes and reducing operational costs. The research highlights the integration of PCS with national systems like CIMIS (Croatian Integrated Maritime Information System) and international logistics platforms, as well as participation in significant EU-funded initiatives such as INTESA (Improving Efficiency and Security of Maritime Traffic in the Adriatic), SUSPORT (Sustainable Ports), and POR2CORE (Upgrade of the Rijeka Port infrastructure). The implementation of PCS in each port showcases distinct features: Ploče prioritizes its transformation into a logistics hub, Split adopts a modular strategy for enhancing operations, and Rijeka emphasizes its integration with the Trans-European Transport Network (TEN-T). By analyzing the technical and operational frameworks of PCS, this paper underscores its role in driving the digital transformation of Croatian ports, enhancing their competitiveness, and ensuring compliance with global environmental and efficiency standards. The findings provide valuable insights into the challenges and opportunities for PCS adoption, offering a roadmap for future developments in maritime logistics.

KEYWORDS

Port community systems, Maritime ports, Digitalization, Comparative analysis, Port operations

Logistics Services as a Relevant Factor in the Development of Ports of Nautical Tourism

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Nautical tourism comprises diverse marine-based leisure activities, including sailing, yachting, and water recreation. Its definition is complex due to the integration of leisure, sport, and maritime sectors. Nautical tourism ports serve as critical infrastructure, providing mooring, berthing, maintenance, and essential services for vessels and their users. This research paper investigates the integration of logistics services as necessary components for the development of nautical tourism ports. It explores how implementing a Logistics Service Center (LSC) can enhance economic performance, operational efficiency, and environmental sustainability. The research aims to assess how logistics services and LSC implementation can bridge service gaps, reduce ecological impact, and support Croatia's strategic objectives for sustainable nautical tourism. The research combines qualitative and quantitative methodologies. Data collection includes an analysis of existing logistics services in nautical tourism ports, operational capacity, and environmental impacts. Financial projections are examined to assess revenue and cost implications, while environmental assessments focus on antifouling systems and wastewater management. Preliminary results suggest that integrating logistics services in nautical tourism ports enhances economic performance, operational efficiency, and environmental sustainability. Analysis of logistics services and operational capacity indicates potential efficiency gains and improved service quality. Financial projections indicate that establishing a Logistics Service Center (LSC) can increase revenue and optimize costs. Environmental assessments highlight the role of advanced antifouling systems and wastewater management in reducing ecological impact. The integration of logistics services in nautical tourism ports presents a viable model for enhancing economic performance, operational efficiency, and environmental sustainability. Implementing a Logistics Service Center (LSC) can address service gaps, optimize operational capacity, and mitigate ecological impacts. Aligning logistics services with Croatia's strategic goals for sustainable tourism can further support the long-term development of nautical tourism infrastructure. Further research should explore policy frameworks and industry standards to optimize LSC implementation and support long-term nautical tourism sustainability.

KEYWORDS

Nautical tourism, Logistics service center, Sustainable management, Marine environment

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Optimal Locations for Biomethanol Production Through Electrified Steam Methane Reforming: A Case tudy Across Southern Europe

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This study explores optimal locations for establishing biomethanol production plants in Southern Europe, using an innovative electrified Steam Methane Reforming (SMR) process. This technology replaces the conventional fossil-fueled furnaces with electric resistance-heated reactors, reducing CO_2 emissions and improving energy efficiency. Using biomass or biogas as feedstock, combined with renewable electricity to heat the reactor further enhances the sustainability of biomethanol, making it a promising biofuel for the maritime sector. Key factors such as biomass, electricity and water cost and availability and proximity to existing infrastructure and to ports, where the potential end-users are located, were considered. The study identified four suitable locations for the biomethanol plants: Marghera and Ravenna in Italy and Elefsina and Thessaloniki in Greece. Ports were prioritized due to their role as storage and bunkering hubs, ensuring efficient biomethanol distribution to maritime stakeholders. This study demonstrates how innovative technologies can accelerate maritime decarbonization, by strategically positioning the biomethanol plants in industrial and logistical hubs. These locations were carefully chosen to optimize operational efficiency and reduce emissions. The study emphasizes the need to align technical advancements with strategic geographic positioning and highlights the advantages of selecting sites close to critical infrastructure. This approach ensures maximum environmental impact while supporting the maritime sector's transition to sustainable fuels.

KEYWORDS

Biomethanol, Steam methane reforming, Maritime decarbonization, Green shipping, Biofuel, Shipping fuel

Analysis of the Optimization of Managing the Tug Fleet

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Port tugboats are an important element of port activity and issues of navigation safety. Safe operations are very important for the normal functioning of the port. Among the most difficult jobs in ports are the entry of ships into the ports, mooring and unloading ships, where tugboats are of the greatest importance. The role of a tugboat goes far beyond just towing and pushing ships. They are the guardians of maritime safety by providing the necessary support in day-to-day operations as well as in emergency and rescue situations. Without their presence, the global maritime trade chain would be seriously threatened, and the risk of accidents and environmental disasters greatly increased. The object of the research is the domestic fleet with a focus on the company "Brodospas" and its operations in the port of Ploče. The aim of the paper is to analyze the methods of optimizing the management of the tugboat fleet and to identify factors that affect costs and efficiency, with a focus on the company "Brodospas". The paper contributes to a better understanding of the specific challenges in the management of the fleet of port tugboats and provides concrete proposals for improving operations in this sector. In order to gain insight into the optimization of tugboat fleet management, the research analyzed technical data, business costs and operational performance of the tugboat fleet, as well as the impact of organizational resources on business efficiency. Based on the analysis of fuel consumption, it was found that older generations of tractors (built in the 20th century) had an average consumption of up to 50% higher, and the maintenance costs were incomparably higher. New tugboats become more profitable in the long term because the combination of reduced fuel and maintenance costs directly affects lower operating costs during their exploitation. It can be safely concluded that these compact yet immensely powerful vessels play an important role in ensuring the smooth operation of ports around the world.

KEYWORDS

Port tugboat, Navigation safety, Fleet management, Business optimization

Current European Union Tax Incentives Arising from the Application of Greenhouse Gas Emissions Trading System - Challenges for the Croatian Shipping Industry

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Paper examines the legal framework governing the taxation of shipping companies in Croatia. European Union (EU) regulations come into play when Member States grant tax exemptions or reductions to specific sectors, as such measures are classified as State aid. One example of State aid tailored to the shipping industry is the tonnage tax, a scheme dependent on the tonnage of a ship. Under the tonnage tax regime, the tax amount is not based on the profits generated from shipping activities. Instead, it is calculated as a flat rate directly related to the ship's tonnage. This makes tonnage tax a predictable taxation method for shipowners, with an overall tax burden generally lower than that of corporate income tax. At the EU level, the tonnage tax is regulated under the 2004 EU Guidelines on State Aid to Maritime Transport. Croatia adopted this system in 2013, and it has been extended in 2020. The paper analyses the main requirements of the Croatian tonnage tax regime. In addition, the paper also addresses the EU's current tax incentives aimed at decarbonizing the shipping sector, particularly through the introduction of the EU greenhouse gas emissions trading system with the changes of the Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the EU.

KEYWORDS

Tonnage tax, State aid, Croatian tonnage tax system, Decarbonization of shipping, Greenhouse gas emissions trading system

Safety and Insurance Aspects of the Enforcement of Search and Rescue Operations at (the Mediterranean) Sea from the Perspective of Protection of Public Health

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The objectives of the analysis of legal regulations within the framework of this scientific research topic are to point out the currently valid provisions that prescribe the obligation of the shipmaster to comply with the obligations arising from international and European maritime legal provisions on search and rescue at sea - UNCLOS convention, SAR convention, SOLAS convention and Regulation (EU) No 656/2014 (regardless of the nationality of the persons in distress at sea) and to indicate concerns that third-country nationals, as rescued persons at sea, could pose a risk to public health. An analysis of international and European de lege lata provisions and new European provisions contained in Regulation (EU) 2024/1356 (which will start to apply from June 12, 2026) which establishes uniform rules on screening (preliminary health check) of third-country nationals who, without fulfilling the entry conditions, have crossed the external border of the EU Member States in an unauthorised manner (irregular migrants) or have been disembarked after a search and rescue operation will be carried out. Their obligatory pre-entry screening would show if they pose a possible threat to public health to identify any need for health care or isolation on public health grounds. The research results point to the conclusion that the mentioned persons do not pose a serious risk to public health, however, conducting rescue operations at sea by commercial ships may pose safety and health risks that may threaten the ship's seaworthiness. The results of the scientific-research analysis of this topic indicate that rescued persons on commercial ships can represent a health risk for the ship's crew members, but also for the regular execution of the navigation venture, therefore shipowners' liability insurance through P&I Clubs is one of the most important types of insurance taken out by shipowners. A special emphasis in the paper will be put on the specifics of risks in P&I insurance coverage (with reference to issues of health threats – infectious disease) and issues of financial costs recovery for the rescue operation (compensation for expenses - loss of fuel, deviation, delay, quarantine, etc.) and expenses that may not be covered, according to the P&I Clubs Rules.

KEYWORDS

Public health, Search and rescue at sea, Safety, Insurance

Rethinking Compulsory Liability Insurance for Boaters in Croatian Waters

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This paper examines the concept of compulsory liability insurance for boat and yacht owners regarding third-party claims, as governed by Croatian law. It critically analyses the provisions of the Croatian Compulsory Insurance in Traffic Act of 2005, alongside its subsequent amendments. The author evaluates relevant premium and claims data published by the Croatian Insurance Bureau, addressing increasing criticisms within the yacht chartering sector regarding the relatively low insurance limits and the narrow scope of coverage. To enhance understanding of the legal framework, the paper provides a historical overview of the applicable legislative provisions. Furthermore, it explores potential legislative improvements and proposes specific amendments (de lege ferenda) to address identified shortcomings. The conclusions drawn and the suggestions offered are based on a balanced assessment of the arguments for and against increasing insurance limits and expanding the scope of coverage.

KEYWORDS

Marine insurance, Compulsory insurance, Boat, Yacht, Liability

Concession Agreement in Sports Ports

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The Maritime Domain and Seaports Act (2023) regulates the status of special-purpose ports in the Republic of Croatia. One of the special-purpose ports is a sports port. A sports port is a port intended for the mooring, storage and maintenance of boats registered in the Croatian Register of boats for non-commercial use, owned by members and concessionaires of the sports port. A sports port is granted as a concession to an economic entity. A maritime domain concession for a sports port is granted to legal entities of the sports system that practise sports on or in the sea and have active participants in at least three age categories. The concession agreement grants the management of the sports port to the concessionaire of the port. A concession agreement is an administrative agreement concluded in writing. The concession agreement regulates in detail the powers of the concession grantor and the rights and obligations of the concessionaire, in particular the port area assigned for concession, the term of the concession, the fee to be paid for the concession, the possibility of concluding a commercial cooperation agreement and/or a sub-concession agreement, the grounds for revoking the concession, the termination of the concession as well as the interpretation of the agreement and the method of dispute resolution. The paper provides an overview and analysis of the main provisions of concession agreements in sports ports.

KEYWORDS

Maritime domain, Sports port, Concessionaire, Concession Agreement, Boats for Non-commercial Use

Development of Occupational Standards and Qualification Standards in Maritime Education

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The development and enhancement of study programs at maritime faculties are based on alignment with the Croatian Qualifications Framework (HKO) [Hrvatski kvalifikacijski okvir, 2017]. The methodology focuses on equipping students to meet labour market demands [Andrews & Russell, 2012] by acquiring relevant knowledge and skills. Key steps include linking occupational standards, qualifications, and study programs through sectoral needs analysis [Crnković-Pozaić, 2011] and defining learning outcomes that are assessed within educational programs. Due to the transformation of the domestic and international maritime market in the context of high specialization, the emergence of new occupations [Weinberger, 2014], knowledge, and competencies, the development of new technologies and technological trends, the demand for technological knowledge as a fundamental life skill, and the gradual shift towards decarbonization and the blue-green transition, educational programs are continuously adapted to ensure the relevance of acquired competencies. This study proposes a structured methodology for aligning educational programs with occupational and qualification standards, resulting in a competency-based framework that better connects maritime education with labor market needs. Both top-down and bottom-up approaches are employed to align programs with qualification standards [Divjak & Begićević Ređep, 2016]. A systematic approach to program development enables the integration of technological innovations [Frey & Osborne, 2013] and the creation of professionals capable of addressing the needs of both domestic and international markets.

KEYWORDS

Croatian qualification framework, Occupational standards, Qualifications standards, Learning outcomes

Analysis of the Impact of the Cruise Industry on Socio – Economic Development of the City of Split

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This paper assesses the economic and environmental significance of the cruise industry in the area of the city of Split. The aim of the research is to determine the share of cruise tourism in the overall tourism traffic of the city and to evaluate the positive and negative effects of cruise tourism on the city. For this purpose, a survey of citizens of all age groups and interviews with individuals from the tourism and maritime sectors were conducted. Data from similar studies and information on the city's tourism revenues were also used. The results indicate that cruise tourism represents a relatively small share of the overall tourism traffic in the city of Split. Negative impacts, such as traffic congestion and pollution, can be mitigated by reducing the seasonality of the cruise industry. In addition to financial revenues, cruise tourism contributes to promoting the city in foreign markets as an attractive tourist and cultural destination.

KEYWORDS

Socio – economic development, Cruise tourism, Financial revenues, Traffic, Cultural destination

Optimizing Airfoil Spoilers for Enhanced Boat Performance and Stability

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The integration of airfoils and hydrofoils in small boats is often regarded as a secondary feature for enhancing stability, with limited adoption across the marine industry. However, their potential to significantly improve the performance and operational capabilities of speed boats, patrol vessels, and underwater drones is substantial. Foils have the capacity to optimize the aerodynamic efficiency of boats, resulting in enhanced speed and fuel economy. This paper highlights notable applications of hydrofoils in maritime vessels, such as the Pegasus-class fast patrol boats of the U.S. Navy, which can cruise at 48 knots and hold the record for the fastest transit of the Panama Canal. Additionally, the All American Marine 78' Reliance, a hydrofoil catamaran capable of carrying 118 passengers, and the Waydoo Flyer, an electric surfboard with a carbon fiber body and slip-resistant wooden deck, are examples that demonstrate the effective use of hydrofoils. However, airfoils remain less explored in maritime contexts.

Building on the work of Tianshu Liu regarding airfoil lift control, this study explores the potential applications of airfoils in marine environments. Numerical simulations are employed using GAMBIT and FLUENT solvers to analyze fluid flow around a NACA4412 airfoil profile, which is discretized into 12,150 cells with both fine and coarse mesh resolutions to ensure computational accuracy. The PRESTO! solver in ANSYS Fluent is utilized for pressure interpolation, ensuring precision in the fluid dynamics calculations. The results indicate minimal error, with the continuity equation converging below a specified threshold after 100 iterations. Comprehensive analyses of dynamic pressure, velocity magnitude, and total pressure validate the airfoil's performance under maritime conditions. This research aims to identify the optimal airfoil configuration that balances lift and weight, thereby optimizing stability and efficiency in marine applications.

KEYWORDS

Airfoil, GAMBIT, FLUENT, PRESTO!, Hydrodynamics, Boat Extensions, Computational fluid dynamics, Marine performance

Modern Approach to Storage Optimization

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The modern Boxbay system offers a revolutionary solution for container storage at the Port of Koper. This automated vertical storage system significantly increases storage capacity by up to 100%, optimizing space utilization and reducing the need for horizontal storage areas. With direct access to any container without moving others, the system greatly enhances storage efficiency and handling operations. Boxbay is based on sustainable principles, utilizing green energy with integrated solar panels directly on the storage structures. This approach reduces CO_2 emissions while improving the port's energy self-sufficiency. By minimizing the use of traditional equipment, such as forklifts and handlers, Boxbay reduces noise and emissions in the port. Additionally, the system addresses labor shortages by reducing the demand for manual work, thus improving worker safety and lowering the risk of workplace accidents. Although the initial investment in the Boxbay system is substantial, operational savings ensure cost recovery within a few years. The system is adaptable to different types of cargo and seamlessly integrates with other terminals and logistics processes. Beyond enhancing storage capabilities, Boxbay supports the port's sustainable expansion without requiring additional horizontal space, which is limited due to geographical and environmental constraints in Koper.

KEYWORDS

Boxbay, automation, Vertical storage, Green energy, CO_2 emissions, Efficiency, Spatial optimization, Safety.

Automated Hinterland Terminal and Port Connectivity

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The hinterland terminal in Sežana presents a strategic opportunity to alleviate congestion at the Port of Koper and improve logistical efficiency. The RED (Robotized Empty Depot) system automates the handling of empty containers, increasing storage density by up to 60% and reducing truck handling times to under 15 minutes. This system uses electric cranes that eliminate CO_2 emissions, contributing to sustainable operations. Automation reduces reliance on manual labor, enhances safety, and cuts operating costs. With its compatibility with rail transport, the RED system facilitates efficient movement of empty containers between the hinterland terminal and the port. Though it requires a high initial investment, costs are recouped within eight years due to greater efficiency and lower operational expenses. Improving connectivity between the port and the hinterland terminal is crucial. The construction of a double-track railway between Koper and Sežana will significantly enhance cargo flow, reduce dependency on road transport, and support sustainable development. This expanded rail capacity will handle more daily trains, reduce truck traffic, and lower CO_2 emissions. Additionally, shifting certain types of cargo to the hinterland terminal will free up storage space in the port for other critical operations, such as storing full or empty containers. Integrating the hinterland terminal with automated systems like RED and enhancing rail connectivity provide the Port of Koper with greater flexibility, sustainability, and competitiveness in global logistics. This strategy ensures long-term stability and environmentally friendly improvements to logistical processes.

KEYWORDS

RED system, Hinterland terminal, Automation, railway, CO_2 emissions, Sustainability, Logistics optimization, Cargo flow

Blue Economy - Impact of the Port on the Environment and the Community (On the Example of the Port of Šibenik d.d.)

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This study analyzes the impact of the Šibenik d.d., industrial port, on the environment and the quality of life of the local community, aiming to identify key ecological challenges and residents' perceptions. The research covers ecological aspects, such as air and water quality, noise, and effects on the marine ecosystem, as well as social aspects, including the perceptions and attitudes of the local population towards sustainability and the effects of port activities. The research problem addresses the increasing ecological pressures caused by port activities and the need to balance economic development with environmental preservation. The objectives of the study include analyzing the port's environmental impact, assessing its effects on the quality of life of residents, and investigating community attitudes towards potential solutions for reducing negative impacts. The results show that most respondents perceive the industrial port as a source of air, water, and noise pollution. Additionally, residents support the introduction of stricter environmental regulations and the adoption of sustainable practices, such as the use of renewable energy sources and noise reduction measures. The study confirmed the hypotheses about the negative impacts of the port and the need for more sustainable management. It was concluded that implementing measures aimed at reducing ecological pressures could significantly improve the quality of life in the community and contribute to environmental preservation.

KEYWORDS

Blue economy, Industrial port, Environment, Šibenik, Pollution, Sustainability

Water quality assessment using Sentinel-3 – Case study on the Cetina River estuary

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Marine environments such as the Adriatic Sea are crucial for sustaining human life, as they support economic activities such as tourism, fishing and trade, as well as ecological functions such as biodiversity conservation. These waters are vulnerable to contamination by various pollutants, including outbreaks of cyanobacteria and other harmful algal blooms (HABs), which pose significant risks to human health, marine life and economic activities. While traditional in situ sampling provides valuable data on water quality, it can be labor intensive and limited in its spatial coverage. Satellite remote sensing offers a complementary approach that enables continuous, wide- area monitoring, which can be crucial for the timely detection of algal blooms. However, converting satellite imagery into accurate, actionable water quality information requires validated methods that can reliably link the observed data to actual biological and chemical conditions in the water. Developing and refining these methods for the Adriatic Sea can improve our ability to monitor and respond to ecological threats to ensure the health and sustainability of these vital marine resources. This paper focuses on the analysis of the Cetina River estuary in the Adriatic Sea. By calculating water quality indices such as the Normalized Difference Chlorophyll Index (NDCI) and chlorophyll-a concentration, parameters such as the presence of algal blooms and overall water quality will be assessed. The seasonal changes and the environmental impact of the observed trends will be analyzed and compared. By integrating data on the size of water bodies, sea surface temperature (SST), salinity and the presence of chlorophyll, a comprehensive visualization of the evolution of these factors over time will be created. This holistic approach will enable a deeper understanding of physical and biological dynamics and the identification of potential environmental drivers, providing important insights for the monitoring and conservation of this vital marine ecosystem.

KEYWORDS
Sentinel 3, Water quality, Chlorophyll, NDCI, Cetina river

Analysis of the Impact of Natural Disasters on the Competitiveness of the Port of Ploče: Challenges and Solutions in the Rail System

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The role of railway infrastructure in the hinterland of the Port of Ploče is critical for maintaining the logistics chain essential to supporting intermodal transport connections with Bosnia and Herzegovina. However, weaknesses in this infrastructure, such as the geographically challenging terrain, aging structures, insufficient regular maintenance, and a lack of technical modernization, hinder the efficient distribution of cargo and lead to increased costs. The aim of this paper is to review and analyze available databases to explore the correlations between natural disasters and their consequences, which have directly disrupted the operations of the Port of Ploče. These disruptions have caused complete interruptions in cargo delivery and shipment not only through the rail but also through road transport, posing serious threats to the logistics chain. The results of this research point to the fact that the impact of the aforementioned unfavorable consequences is not exclusively of local character. Instead, they underscore the urgent need to enhance the resilience of transport connections to mitigate the negative effects of natural disasters on the broader logistics system. Strengthening the resilience of transport infrastructure, despite the current challenges in accurately predicting natural disasters, implies upgrading infrastructure, diversifying transport routes, and adapting the existing network. These actions are crucial to maintaining the stability and efficiency of the logistics chain during sudden and unpredictable events.

KEYWORDS

Natural disasters, Port of Ploče, Rail transport, Competitiveness

Detection of Oil Spills Using Image Classification Models on Sentinel-1 SAR Imagery

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Approximately 80% of the world's freight traffic is carried out by sea, and the increase in demand for energy has led to an increasing transport of oil, which increases the risk of accidents. At the same time, climate changes cause more frequent and intense storms, high waves and strong winds, further increasing the likelihood of incidents at sea. This study uses machine learning to detect oil spills using Sentinel-1 SAR satellite imagery. SAR data is ideal for maritime surveillance because it is not subject to time or light limitations. Sentinel-1 data, available through the European Space Agency's (ESA) Copernicus Open Access Hub, was used to build a model for image classification. The data was converted from GeoTIFF to JPEG to adapt to the application of machine learning, and the classification is based on two categories: 0_class (no spill) and 1_class (with spill). The VGG16 transfer learning model, a pre-trained convolutional neural network, was used to classify the images. The model was was validated against known cases, including the incident of December 15, 2024, when two derelict ships spilled oil along the Black Sea. The model achieved an accuracy of 93%, successfully identifying spill areas in SAR imagery. Additional metrics, such as high precision, recall, and F1-scores, underscored its reliability and effectiveness in distinguishing oil spill areas from non-spill regions. This transfer learning approach reduces training time while providing a reliable and scalable technology for monitoring oil spills and reducing their environmental impact.

KEYWORDS

Satellite image, Oil spill, detection, Learning model, Sentinel 1

Analysis of Energy Savings on Ships Through the Integration of Solar Power and Resonant Energy Transfer

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The research on integrating solar energy and resonant energy transfer in the maritime industry is significant for sustainability and energy efficiency in shipping. This paper aims to know how integrating solar energy and resonant energy transfer can enhance operational efficiency in ships while aligning with international environmental regulations for reducing greenhouse gas emissions in maritime transport. The study shows the systematic review of existing research on solar power integration in naval systems and the application of resonant energy transfer for energy optimization. Key methods include analyzing the performance of solar panels on vessels and simulating resonant energy transfer for efficient power distribution across shipboard systems. The meta-analysis suggests that these technologies could significantly improve the sustainability and efficiency of the maritime sector. The paper concludes that integrating solar energy and resonant energy transfer in marine applications holds significant potential to improve energy efficiency and sustainability in the shipping industry. This integration could enable the advancements in energy technologies, enhancing overall performance and aligning with global sustainability goals.

KEYWORDS

Solar energy, Resonant energy transfer, Ships, Sustainability, Energy efficiency, Naval operations

Application of Intelligent Engines on Ships

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The maritime industry is experiencing rapid advancements in the application of intelligent engines, aimed at enhancing operational efficiency, safety, and environmental sustainability. This review synthesizes recent research on the integration of digital twins, machine learning, and intelligent control systems in marine engines. It examines studies published between 2014 and 2024, focusing on key technological innovations such as real-time fault diagnosis, predictive maintenance, energy management systems, and lifecycle system optimizations. The paper highlights the increasing role of data-driven solutions and smart technologies, including big data analytics and machine vision models, in improving the performance and reliability of ship engine rooms. Additionally, it critically evaluates the potential of intelligent engines to reduce emissions and optimize fuel efficiency. Utilizing the Prisma 2020 methodology, this review provides a comprehensive overview of current developments, identifying challenges, trends, and future directions for implementing intelligent engine systems in maritime operations. The findings aim to guide future research and practical applications in the development of smarter, more sustainable ships.

KEYWORDS

Digital twin, Intelligent engine room, Fuel efficiency, Fault diagnostics

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A New Entrance into Split via the Vučevica Tunnel: Opportunities and Challenges

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This study examines the inadequate traffic connectivity between the Dalmatian hinterland and the coast, particularly in the Split–Solin-Kaštela and Split–Solin-Dugopolje areas. These connectivity issues lead to increased transport costs and delays in passenger traffic. Given the key role of road infrastructure in passenger transport, it is essential to evaluate the performance of existing infrastructure in these regions, with the goal of optimizing costs and improving overall traffic connectivity. Traffic congestion, caused by insufficient road capacity, an increase in the number of motor vehicles per household, and irregular scheduling of bus lines, significantly hinders the development and full potential of sea ports, despite the availability of resource bases. The primary objective of this study is to assess the cost-effectiveness of reorganizing the traffic system in the Dalmatian hinterland and the gravitational area of the City of Split, compared to the current traffic system. This includes a pre-planned reconstruction, such as the construction of the Vučevica tunnel, which is anticipated to improve connectivity and alleviate congestion. The study also aims to evaluate the potential effects of modernization on traffic fluidity and efficiency in the examined areas. To gain public insight, a polling method was employed to gather feedback on the proposed solution, specifically regarding the construction of the Vučevica tunnel. The collected data provided valuable input from potential future users of the project. The findings indicate considerable benefits, including a significant reduction in transport costs (e.g. fuel consumption) due to the shortened route between the northern and southern sides of Kozjak Mountain. Additionally, the research points to improved traffic fluidity, better connectivity, reduced strain on existing road infrastructure, and increased development potential in the Dalmatian Zagora, the City of Split, and its surrounding areas, including Split port. Public opinion suggests that the Vučevica tunnel could unlock new markets, enhance the competitiveness of sea ports, and strengthen the economy of Split and its county, offering multiple economic, social, and ecological advantages.

KEYWORDS

Vučevica tunnel, Gravitational area, City of Split, Road infrastructure, Traffic congestion

The Impact of Ferry Routes on the Development of Zadar County Islands

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Ferry transport plays a vital role in connecting island communities with the mainland, fostering economic development, accessibility, and social cohesion. The uneven connectivity of islands leads to uneven development, with more remote islands facing greater challenges in retaining their population and growing their economies. This study examines the impact of ferry routes on the socio-economic development of Zadar County islands, focusing on population trends, economic activities, and infrastructure improvements. Two surveys were conducted: the first in May 2024 and the second in December 2024. The surveys targeted island residents and stakeholders to assess their perceptions of ferry services and their impact on daily life and economic activities. Additionally, transport and socio-economic data from local authorities and institutions were integrated to support the findings. Preliminary analysis indicates that islands with frequent and reliable ferry services exhibit higher rates of population retention (+15%) and economic activity. Survey responses highlight improved access to essential services and economic opportunities as key benefits. Challenges include seasonal variations in service frequency and environmental sustainability concerns. Ferry transport is a cornerstone for the sustainable development of Zadar County islands. Continued investments in improving ferry service frequency, affordability, and eco-friendliness are essential to fostering balanced and long-term regional development.

KEYWORDS

Ferry transport, Island development, Zadar county, Socio-economic impact, Accessibility, Sustainable transport

Development of Procedures for Upgrading the GMDSS Communication Systems

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The Global Maritime Distress and Safety System (GMDSS) plays a critical role in ensuring maritime safety by providing a set of communication protocols and equipment for vessels during distress situations. The system is designed to facilitate emergency communication between ships, rescue coordination centers, and shore stations, helping to manage search and rescue operations effectively. As technology evolves, it is essential that the GMDSS is upgraded to integrate modern communication systems, eliminating outdated procedures and ensuring that it remains effective in emergency situations. A key aspect of the GMDSS's ongoing development is its alignment with amendments made to the International Convention for the Safety of Life at Sea (SOLAS), particularly SOLAS Chapter IV, which governs radio communications. Hence, the aim of this literature review is to explore the ongoing development of procedures for upgrading the GMDSS communication systems to enhance maritime safety at sea, through integrated modern technologies and looking at the global compliance that aligns with IMO amendments to SOLAS Chapter IV and international standards. This review looks to explore the ongoing development of procedures to upgrade the GMDSS, emphasizing the importance of integrating new technologies and ensuring global compliance with IMO standards. Through the analysis of existing research, IMO publications, and proceedings from the TransNav conferences (2021, 2023). This review seeks to create a comprehensive knowledge base for the future of GMDSS communication systems. The integration of emerging technologies, such as automated distress signaling, and the adoption of standardized global procedures are crucial to reducing operational burdens and simplifying regulatory compliance for maritime operators. In conclusion, upgrading GMDSS communication systems is vital for enhancing maritime safety. By focusing on technological advancements and ensuring compliance with IMO standards, this review will inform future research, policies, and practices that will streamline GMDSS procedures and ultimately improve emergency response capabilities at sea.

KEYWORDS

Communication systems, GDMSS, Maritime safety, Distress signaling, Technologies

Reporting Hazardous Occurences at Sea from the Aspect of Maritime Professionals

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As near-misses are considered precursors to accidents and share the same root causes, reporting them to improve safety and reduce accidents is imperative. Near-miss reporting in shipping is a regulatory requirement under the International Safety Management Code (ISM Code) intended to improve maritime safety and pollution prevention. This objective is achieved by trustworthy reporting of hazardous occurrences on board ships. After reporting, serious near-miss events are investigated and analysed. Data obtained is used to implement corrective actions such as more adequate and safer procedures. However, seafarers are not reporting all observed near-miss events due to various factors that act as barriers and thus prevent reporting. Besides underreporting, which is recognised as the most significant problem in near-miss management systems implemented on board ships, fabricated near-miss reports are the second one. Therefore, the aim of this research is to investigate what types of near-miss seafarers report, if they fabricate them, and if so, why. To achieve the aim of the study, the authors created a short questionnaire for active and experienced seafarers. The questionnaire was internationally distributed and, in the end, involved 102 participants. The responses were analysed by descriptive statistics, and furthermore, the participants were divided into groups (division by rank and by experience) to investigate are there statistically important differences between them. The analysis of variance (ANOVA) was used to identify possible differences. The analysis of responses pointed out that seafarers fabricate near-miss reports frequently to comply with company requested near-miss report quotas. However, although they fabricate reports, most respondents believe that near-miss management systems improve safety at sea. In addition, no significant differences were observed between the groups except for one. When asked if they report near-miss events that did not happen at all to comply with company requirements, statistically significant differences were found when respondents were divided by experience – the most experienced seafarers (over 20 years of experience) tend to report more fabricated near-misses. Although considered important for maritime safety, near-miss management systems are compromised with fabricated reports to comply with requested reports "quotas", whereas the most experienced maritime professionals fabricate more than others. It can be concluded that learning from near-misses and incidents in the maritime industry relies on a significant number of fabricated reports and focuses on inexistent events. Instead of leading to safer shipping, conclusions drawn from such reports create an unsafe atmosphere where actual and serious events are kept hidden, and learning is disabled.

KEYWORDS

Near-miss, Maritime safety, Maritime industry, Accident prevention, Llearning from incidents (LFI)

Handling Large Tankers in Narrow Channels: Situational Awareness and Lessons Learned from a Case Study of Collision and Grounding Off Port Limits (Singapore)

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The Singapore Straits, located at the crossroads of the world's two largest trade routes, is a major maritime hub connecting the East to the West. Its efficient port infrastructure makes Singapore one of the busiest ports in the world. However, the high traffic density and limited berths and anchorages pose a major challenge for shipping, especially for large vessels. Although the Port of Singapore offers well-organized terminal access, many ships anchor off port limits (OPL) to save costs, often under commercial pressure despite the risks involved. Handling large tankers, such as Aframax vessels, in such confined and dynamic environment requires precise planning, effective bridge resource management, and strict adherence to prescribed ISM (International Safety Management) and SMS (Safety Management System) procedures. Good work organization combined with situational awareness is essential to ensure safe navigation and mitigate the risks associated with crowded anchorages and unpredictable environmental factors. Neglecting these aspects can lead to serious consequences, including collisions and groundings. This paper examines a real-life case study in which an Aframax tanker collided and ran aground at an OPL anchorage near Singapore. The incident highlights the consequences of inadequate situational awareness and the importance of following established safety procedures. Recommendations are made to improve decision-making processes and ensure safer operating practices in similar high-risk scenarios.

KEYWORDS

Handling large tanker, Situational Awareness (SA), Off Port Limits (OPL), Collision and grounding

Use of Satellites for Observing Carbon Dioxide Air-Sea Flux

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Carbon Dioxide (CO2) is a gas present in the atmosphere (around 421 ppm) and soluble in water. In air it acts as a greenhouse gas. In water it can be found in lakes as well as in seawater. The burning of fossil fuels is cause of increasing the amount of carbon dioxide in the air thus causing the climate change. The rise of carbon dioxide in the atmosphere leads to more carbon dioxide dissolution in the water causing ocean acidification. On the other hand, plants in photosynthesis absorb more carbon dioxide from the air than they release in cellular respiration, thus helping in carbon balance of Earth atmosphere. As carbon dioxide dissolves in the oceans, carbonic acid which leads to lowering pH value of the Earth oceans (from 8.15 to 8.05 from 1950 to 2020). This trend will cause some species such as mollusks and corals to have problems in building their shells and skeletons. Since colder waters can absorb more carbon dioxide than warmer waters, this can influence the ocean currents that regulate Earth climate. The salinity of the sea also affects the absorption of carbon dioxide. About one quarter of all carbon dioxide emissions are absorbed by the ocean. The absorption of carbon dioxide causes also warming of the seas. Oceans assist in removing carbon dioxide from the atmosphere: phytoplankton accumulate carbon dioxide through photosynthesis and their chlorophyll colors the ocean's waters. Satellites can use this color to measure chlorophyll, which enables the calculation of how much carbon dioxide is absorbed or emitted. Sentinel-3A is a European Space Agency (ESA) Earth observation satellite, which measures the air–sea flux of carbon dioxide which depends on ocean biological activity, waves, and temperature of the sea surface. The air-sea flux is the number of carbon dioxide molecules per unit surface area per unit of time that enter the ocean surface from the air.

KEYWORDS
Satellites, Carbon dioxide, Air-sea flux, Climate change

Dynamic Risk Assessment for New Types of Ro-Pax Ferries

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Advancements in maritime technology, expanding traffic, and stricter environmental standards present increasing challenges for operating RO-PAX vessels. Traditional risk assessment methods remain static and retrospective, which makes them ineffective for addressing the evolving complexities of navigational hazards in current RO-PAX vessels. The transition to predictive risk assessments that operate in real-time becomes essential to address modern navigation challenges. Researchers plan to create a complex dynamic risk assessment (DRA) model that will address the specific needs of modern RO-PAX vessels. The model combines operational, environmental, and technical data inputs to deliver real-time navigation and port operations risk analysis. The model aims to improve risk assessment precision and response time through machine learning techniques and Big Data analytics. The model will use machine learning to analyze previous incidents and adjust its algorithms based on new information. Big Data analytics will supply essential computational power for processing the extensive data generated by maritime operations. Implementing these technologies will improve safety measures at sea alongside operational performance.

KEYWORDS

Dynamic risk assessment (DRA), RO-PAX, Vessel safety, Machine learning

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Footprint of Maritime Transport Carbon Dioxide Emissions: An Environmental Impact Assessment

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IMSC Maritime transport accounts for a significant share of global carbon dioxide emissions. Around 80- 90% of world trade is carried by sea, making maritime transport a critical part of global logistics, but also a significant source of greenhouse gas emissions. According to the International Maritime Organization (IMO), maritime transport contributes around 2-3% of total global carbon dioxide emissions, which may seem like a small percentage, but given the total volume, it amounts to billions of tons of carbon dioxide per year. If current trends continue, emissions could increase by as much as 50% by 2050 due to increased demand for maritime transport. The largest polluters are cargo ships (especially container ships and tankers), as they consume large amounts of fossil-based fuels. This paper analyses the global environmental impact of the carbon dioxide emissions of the maritime transport sector using the available data and IBM statistics software. The results show the global environmental impact of maritime transport carbon dioxide emissions for the period 2019-2024 and the projected environmental impact in the future.

KEYWORDS

Maritime transport, Carbon dioxide, Emissions, Environmental impact, Assessment

Impact of the IHO Resolutions and Standards for ENCs on the Use of ECDIS

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The International Convention for the Safety of Life at Sea (SOLAS) requires certain ships to carry an Electronic Chart and Display System (ECDIS). In order to meet the requirements of the SOLAS Convention, the International Hydrographic Organisation (IHO) has developed a set of comprehensive standards for Electronic Navigational Charts (ENC). The aim of these standards is to ensure the uniformity, consistency and reliability of ENCs as well as the data protection and updating of charts. The production, publication and updating of ENCs is carried out in accordance with the work programme of the national hydrographic organisations (HOs) as members of the IHO and in accordance with the technical resolutions and standards of the IHO. The paper aims to analyse the current IHO standards and regulations and their impact on the production of ENCs in terms of accuracy, reliability and correct interpretation as well as the use of ENCs on ECDIS. During the analysis, the authors identified certain shortcomings in the production, updating and use of ENCs. These shortcomings could have an impact on the safety of navigation. In order to increase the safety of navigation, the authors propose the modification of certain practises and the standardisation of the production and updating of ENCs.

KEYWORDS

IHO resolutions and standards, ECDIS, ENC, Safety of navigation

Promoting ESG Principles and Healthy Nutritional Habits to Increase Competitiveness, Market Diversification and Effective Communication for Consumers in Adriatic-Ionian Aquaculture and Fishery Sectors

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Aquaculture and capture fisheries are the source of healthy and nutritional products for human consumption, rich in proteins, essential omega-3 fatty acids and bioavailable micronutrients. The Adriatic-Ionian region contributes around 3.4% of Europe's total fish and shellfish production with around 600 thousand tonnes produced in 2022, of which 52.8% was attributed by aquaculture. These sectors provide employment and economic benefits, setting strong foundation for the blue economy development in the region, however currently lack guidance and self-evaluation instruments that could facilitate adoption of environmental, social and governance (ESG) standards and strategic planning for sustainable operations.

Within project FISHIMPACT we aim to promote actions supporting the development and modernization of SMEs in the fish industry by introducing quality and sustainable requirements. The self-evaluation online tool will be built by collecting state of art information on the available labels and certification systems on national, EU and IPA markets, and developing a set of key performance indicators (KPIs) regarding ESG standards, sustainability, health and nutritional values of the aquatic products. In addition, importance of sustainable fishing practices, conservation of marine biological resources and the potential health benefits of consuming aquatic products will be communicated among all stakeholders. Training schemes for the industry about PEF/LCA, circular economy and environmental labels will be provided, as well as wide-range dissemination and capacity building for transferability in the entire Adriatic-Ionian region.

Project main outputs are set as: (i) Transnational pilot action to test developed toolkit dedicated to improving fishery and aquaculture SMEs' competitiveness, (ii) Guidelines for SMEs to facilitate the introduction of nutritional and sustainability requirements in fishery and aquaculture sectors, and (iii) Memorandum of Understanding on international cooperation in the Adriatic-Ionian region involved to ensure long-term sustainability to project outcomes. Project FISHIMPACT is co-funded by the European Union through the Interreg IPA ADRION programme.

KEYWORDS

Aquatic food value chain, Key performance indicators, Nutritional indicators, Sustainability, SMEs, Blue technology

The Impact of Shellfish Farming on Meiofaunal Composition

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This study analyzed 12 sediment samples collected near the Šibenik Bridge to investigate the impact of shellfish farming on meiofaunal composition. The total number of taxonomic groups was the same at the site below the shellfish farm and at the reference site, but the abundance of organisms was higher at the reference site (236.3 ± 90.4 ind. 10 cm²) compared to the site below the farm (179 ± 58.1 individuals per 10 cm²). Nematodes were the dominant group at both sites, with a slightly higher proportion at the site below the farm (62.94%) compared to the reference site (60.72%). Copepods were less represented below the farm (10.24%), compared to 12.03% at the reference site. The analysis of vertical distribution of organisms showed more organisms in the reference site sediment surface layer (155.2 ± 102.9 individuals per 10 cm²) compared to the sediment surface layer below the farm (115.7 ± 76.2 individuals per 10 cm²). These results suggest that shellfish farming may affect the abundance and distribution of meiofauna.

KEYWORDS

Meiofauna, Shellfish farm, Šibenik Chanel, Nematoda, Copepoda

Probabilistic Risk Assessment Perspective in Polar Region

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The "Polar Code" is an international code based on rules for ships operating in polar waters. It was developed by the International Maritime Organization (IMO) and entered into force in 2017. Its objective is to ensure safety and environmental protection in Polar Regions, and it includes regulations on ship stability, life-saving equipment, communication systems, navigation, ice protection, and waste management. It ensures that ships are adequately equipped and adapted to the challenges of polar waters. The Polar ship certificate applies to every ship operating in the Polar Region after an initial or renewal survey. The Arctic and Antarctic are different regions with different types of ice and climate. Appropriate training and knowledge are very important to avoid risks associated with operations in a Polar environment. The polar environment imposes additional demands on ship systems, life-saving appliances, main engines, environmental protection and damage control. Ships in the Polar Region may face dangerous scenarios, such as getting stuck in the ice and ship-ice collision due to various factors. Human factors (knowledge and skills, fatigue, stress), technological changes and deficiencies (Electronic Navigation Chart – ENC, inadequate use of equipment), weather conditions (fog, sea current), environment (glaciers, types of ice, ice maps) and rules and procedures (national and shipping regulations), and other risks are presented in this paper. Bayesian Network (BN) is a tool used to predict human error in maritime affairs by analyzing interactions between people, technology, and organizational and environmental factors while navigating in Polar Regions. The paper contributes to finding the worst combinations of influencing variables that can increase the risk of human error in extreme conditions. This approach aims to detect a combination of events that lead to an increased risk of human error. Knowing the limiting factors and their impact on ice navigation safety can contribute to timely decision-making.

KEYWORDS

Navigation safety, Polar Code, Operations in Polar Regions, Bayesian network

Comparative Analysis of Presumptions for the Application of Certain Systems of Liability for Loss of Life and Personal Injury to Swimmers and Other Persons in the Sea With Special Reference to the System of Liability for Damage Caused by Waterborne Craft

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An analysis of the phenomenology of injurious events resulting in the loss of life or personal injury to swimmers and other persons in the sea shows that the highest incidence of such events is caused by waterborne craft. However, due to the intensive development of the entertainment and recreation industry, there is a growing number of injurious events involving seaworthy devices that are not waterborne craft in the sense of the Maritime Code. Although, harm to swimmers can also be caused by other maritime objects and wrecks and sunken objects. The aim of this paper is to study the presumptions relevant to the application of certain systems of liability for damage. A legal position is taken on how to classify the presumptions and how certain doubtful legal issues should be interpreted in practice. The paper will use methods of teleological and linguistic interpretation of specific legal presumptions. The application of the comparative method will serve to determine their congruences, similarities and differences. Three systems of rules on liability for damage can be applied. The first system consists of provisions of the Maritime Code on non-contractual liability of the shipowner and ship operator, and liability for loss of life and personal injury. The second system is prescribed by the provisions of the Maritime Code on the recovery and removal of wrecks and sunken objects. The third system consists of provisions of the Civil Obligations Act on liability for damage. It is hoped that the classification and comparative analysis of the presumptions for the application of certain systems of liability for damage will contribute to improving the implementation of the law and to the correct selection of material law for concrete non-contractual liability for damage due to the loss of life and personal injury to swimmers and other persons in the sea.

KEYWORDS

Swimmers, Other persons in the sea, Waterborne craft, Loss of life and personal injury

Responsibilities of Maritime Transport Stakeholders for the Accuracy of Verified Container Gross Mass Data

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Resolution MSC.380 (94) of the International Maritime Organization, adopted in 2016, introduced an amendment to the SOLAS Convention requiring verification of the gross mass of packed containers. The verified gross mass data must be submitted before the container is loaded onto the ship at the port of loading. The obligation to determine the verified gross weight of the container and submit the data in a timely manner affects all parties in the shipping chain from the loading of the goods into the container to their loading onto the ship, so the participants have to cooperate to implement these rules in the best possible way. One of the objectives of this paper is therefore to review the role and responsibilities of each party involved, in particular the shipper and the ship master. In addition to the international regulations, the authors also analyze the legal regulation of the standard in the Croatian legal system. Particular attention is paid to the obligations of the recognized organization in the part relating to weighing equipment, as they must comply with the requirements of the country in which the equipment is used.

The paper also analyzes the court decision Stournaras Stylianos Monoprosopi EPE -v- Maersk A/S (Maersk Klaipeda) [2024] EWHC 2494 (Comm), which dealt with the issue of maritime carrier's responsibility for the accuracy of the data on the verified gross mass of a packed container.

The paper concludes with an assessment of the compliance of the Croatian legal system with international regulations on the obligation to provide data on the verified gross weight of containers, and the author's views on the position of individual parties in the transport process.

KEYWORDS
Verification of the gross mass of a packed container (VGM), Safety, Shipper, Master responsibility

Analysis of the Application of Digitalization in Nautical Tourism

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Digitalization of business is taking place in various fields, including nautical tourism. Unlike classic apartment accommodation, boats are still rented out by charter companies resulting in the fragmentation of the market. Through digitalization and digital transformation, efforts are being made to reduce business costs and achieve overall business excellence. Digital transformation is a notion that can be encountered in various fields of human life today. Digital transformation is specifically directed towards numerous sectors within the economy itself, including tourism. Everything is directed towards the area of implementing various digital technologies in order to accomplish certain advantages such as improving the business itself, facilitating business operations, but above all achieving financial benefits. Today, digitalization is being implemented in all types of tourism, including nautical tourism. Digitalization as such is necessary in order to compete with global market trends. The purpose of the paper is to explain and analyze the existing trends that are changing the tourism market, pointing out the importance of digital business transformation, defining the key factors for the success of digital business transformation, and explaining the specific benefits of the digital business models.

KEYWORDS

Digitalization, Nautical tourism, Digital transformation, Charter companies

Integration of Individual Systems in Maritime Industry – Standardization

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Standardization is pivotal in enhancing operational efficiency and reliability across various domains. In quality management, standards aim to improve productivity and reduce operational failures, while energy management standards focus on minimizing energy consumption. The rapid advancement of new technologies and the integration of information systems within the maritime industry have necessitated systematic monitoring and continuous investment by maritime companies to maintain competitiveness in an evolving market environment. Emerging research in digital twin technologies, increasingly adopted within the maritime sector, highlights the importance of standards such as ISO 23247 – Digital Twin Framework for Manufacturing. Furthermore, the adoption of Internet technologies emphasizes the relevance of ISO/IEC 27032:2023 – Guidelines for Internet Security, which has now entered its second publication. Standards like ISO 19030-1 – Ships and Marine Technology: Measurement of Changes in Hull and Propeller Performance are also instrumental in guiding the industry towards optimized energy efficiency and operational effectiveness solutions. The paper examines specific standardization systems and investigates the potential for integrating various systems to establish a cohesive framework. The analysis provides a foundation for recommendations aimed at advancing the integration and development of standardization practices within the maritime sector. Such integration has the potential to streamline operations, reduce costs, and improve compliance with regulatory requirements. Additionally, these efforts are critical in addressing environmental challenges by enabling the adoption of greener technologies and sustainable practices in maritime operations.

KEYWORDS

Maritime industry, Standardization, Energy efficiency, Information systems, Technological integration, Environmental challenges

Cruise Tourism in Split-Dalmatia County from 2021 to 2024

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Considering the importance and economic, social, and environmental impact of cruise tourism, this paper aims to analyse data on foreign cruisers in Split-Dalmatia County from 2021 to 2024. The Croatian Bureau of Statistics publishes reports on foreign cruise ship arrivals in Croatian internal sea waters based on monitoring of the Croatian Integrated Maritime Information System (CIMIS). The beginning of international cruise tourism in Split dates back to 2002 when 82 ships carrying 20,616 passengers visited the City. In 2021, 36 foreign cruise ships made 208 voyages with 193,911 passengers, spending 568 days in Croatian waters. Of the journeys, 27.4% were recorded in Split-Dalmatia County. The Port of Split, with 124 visits, was the busiest port in the county and the second busiest in Croatia in 2021, while Hvar, with 41 calls, was the second busiest port in the county and the fifth busiest in Croatia. In 2022, 32.4% of the 632 cruise journeys in Croatia were recorded in the county. The Port of Split was the second busiest port in Croatia in 2022, with 272 visits, while Hvar ranked fourth with 98 visits. In 2023, 26.9% of the 646 journeys in Croatia were recorded in the county, while Split ranked second with 300 visits and Hvar fourth with 110 visits on the list of most visited Croatian ports. In 2024, the number of journeys increased further to 736, of which 24.2% were recorded in the county. Split was in second place on the list of the most visited Croatian ports, with 331 visits, and Hvar was in fourth place with 118 visits. These figures demonstrate the sector's great potential, but it must be managed sustainably to reach its full potential and benefit the community.

KEYWORDS
Cruise, Tourism, Sustainability, Split-Dalmatia county, Croatia

Traffic Dynamics of Key Ferry Routes in Croatia

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Ferry services are an important part of regional connectivity as they facilitate the transportation of passengers and vehicles between coastal and island locations. The analysis of passenger and vehicle trends and dynamics is essential for the optimization of transport systems, particularly in regions with an indented coastline and an extensive coastal transport network. Such an example can be observed in the Republic of Croatia, where numerous ferries provide maritime transportation services along the coast, ensuring the connectivity and development of local island communities and their economies. This study examines passenger and vehicle data from seven key ferry routes, selected in the literature review, for the period from 2019 to 2023 and analyzes trends and descriptive statistics to gain insights into route performance and patterns. In particular, key ferry routes such as Valbiska-Merag and Split-Supetar proved to be highly frequented corridors for vehicles and passengers, respectively. While passenger volumes have increased significantly over the years, the vehicle data shows a more stable growth trend, except in 2020 due to COVID-19 pandemic. The results of the study demonstrate how ferry traffic varies on the different routes, even on the busiest routes, and how regional and local factors influence it. The observed evaluation provides insights for future efforts to optimize ferry routes and highlights the specific characteristics of each route. By comparing trends in passenger and vehicle traffic, a deeper understanding of the role of ferry traffic in mobility systems is provided. In a broader context, key routes need to be identified in order to gain the necessary knowledge that can be used for sustainable route optimization.

KEYWORDS

Ferry, Coastal maritime traffic, Transportation, Short sea shipping

Building the Circular Value Chain in the Port Industry for the Sustainable Blue Economy: Learning from the Circular Seaport Strategies

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The dual pressures of environmental challenges and global digitalization reshape port operations and management, prompting seaports to adopt circular economy (CE) principles and closed-loop economy strategies prioritizing long-term sustainability and operational efficiency. This study investigates a circular value chain in the port industry, including the interconnections between ports and their stakeholders within the circularity framework. It further explores practices for establishing circular ports and their positioning as circular hubs. Furthermore, the increasing waste generated by port operations and logistics forces authorities to embrace an integrated approach and develop innovative recycling strategies. These solutions necessitate collaboration among ports and their stakeholders to build circular value chains successfully. Digital technologies are vital for circular transformation, serving as powerful tools to virtualize, optimize, and interconnect port infrastructure and operations while improving environmental performance and monitoring of material flows. By integrating real-time data and intelligent decision-making, digital solutions contribute to operational efficiency, financial performance, and environmental sustainability while supporting the adoption of circular practices in waste management and energy transitions, including CO_2 reduction, renewable energy integration, and climate adaptation. Based on a case study method, this study proposes a model of a circular port strategically positioned to become a circular hub, focusing on building a digitalized recycling hub. The model integrates ports' CE strategies with economic and environmental performance, linking recycling practices to key indicators. It also examines the intersection of circular port strategies with broader green and digital transformation. The proposed model is a practical addition to a decision-making system in the blue economy regarding zero environmental footprints and represents a pivotal step toward fostering sustainable development. By aligning circular, green, and digital solutions, this research offers insights for developing resilient and sustainable port operations, driving innovation, and minimizing risks in the blue economy.

KEYWORDS

Circular port, Value chain, Recycling, Strategies, Blue economy, Sustainability

Sensor Technology and Its Applications in Augmented Reality

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The integration of sensor technologies and augmented reality (AR) is transforming the maritime industry, particularly in the context of autonomous ships. This article explores the application of sensor technologies such as LiDAR, radar, and computer vision systems alongside AR interfaces to enhance the operational efficiency, safety, and autonomy of maritime vessels. The sensors enable real-time data acquisition, providing autonomous systems with situational awareness to navigate and respond to dynamic maritime environments. AR technology further supports these systems by overlaying critical data onto real-world visualizations, improving operator decision-making and remote monitoring capabilities. The article reviews the current state of sensor and AR technologies in autonomous shipping, presents case studies of their application, and discusses the challenges of data integration, reliability, cybersecurity, and regulatory frameworks. Future research directions are also identified, including advancements in AI, sensor robustness, and cybersecurity to address existing limitations. Ultimately, the article underscores the potential of sensor and AR technologies to revolutionize maritime operations, paving the way for safer, more efficient, and fully autonomous shipping systems. In maritime applications, AR is implemented primarily through, smartphones, heads-up displays (HUDs), AR glasses, or tablet-based interfaces. These devices allow operators to view vital navigational data, environmental conditions, and vessel performance metrics without looking away from the operational environment. This paper proposes innovative way to merge sensor technology with AR display to enhance security and safety in shipping.

KEYWORDS

Sensor technology, Aaugmented reality, Maritime industry, Remote monitoring

Advancing Renewable Energy Solutions for Unmanned Marine Systems: Integrating Material Science and Computational Modeling

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Paper examines advancements in renewable energy technologies for application in unmanned marine systems, with the objective of enhancing energy conversion efficiency, operational durability, and resistance to environmental stressors such as temperature, humidity, and salinity. By integrating innovations in material science, computational modeling, and experimental validation, the study provides a comprehensive framework for improving energy harvesting and transmission systems. The research focused on the development and characterization of polymer- derived ceramics (PDCs) and conductive polymers (CPs), which were assessed for their magnetoelectric and physicochemical properties under marine conditions, with an emphasis on optimizing durability and performance. Advanced modeling and validation of thin-film deposition techniques, including chemical and electrochemical polymerization, were undertaken to enhance material efficiency. Simulations conducted using COMSOL investigated magnetic field distributions and the efficiency of energy transfer in marine environments. The study also developed and evaluated models for wireless energy transmission and mechanisms for harvesting kinetic energy from ocean waves, providing practical insights into system design. Furthermore, finite element method (FEM) analyses were employed to evaluate the mechanical strength of SiO_2 coatings on copper substrates, addressing challenges associated with thermal expansion mismatches and proposing solutions to improve coating adhesion and resilience. The findings of this phase demonstrate substantial progress in energy materials research and system modeling, establishing a robust foundation for the development of scalable renewable energy systems in unmanned marine applications. The results offer valuable pathways for future advancements and real-world implementation, addressing complex technical and regulatory challenges.

KEYWORDS

Renewable energy, Unmanned Marine Systems, Material science, Energy Harvesting

Communication Technologies for Remote Monitoring of Maritime Signaling Facilities: A Systematic Review Using PRISMA 2020

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Maritime signaling facilities are crucial for the safety of global navigation, but their remote locations and energy constraints often hinder the implementation of remote monitoring systems. This paper investigates communication technologies that enable reliable and efficient communication in maritime environments. Using the PRISMA 2020 methodology, relevant scientific literature from the past two decades was analyzed. The review includes an evaluation of various communication technologies in the context of their application to maritime signaling facilities. The results highlight the key advantages and limitations of the analyzed technologies, with a particular focus on their efficiency and compliance with international standards. Furthermore, the potential of the VHF Data Exchange System (VDES) is emphasized as a promising technology for the future. This research provides a foundation for the development of modern communication systems in the maritime industry.

KEYWORDS

Maritime signaling facilities, Remote monitoring systems, Communication technologies, VDES, PRISMA methodology

Data-Driven Black-Box Model of an Underwater Vehicle

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The paper presents the application of neural networks to model the behavior of an underwater vehicle. A reliable vehicle model is essential in the process of constructing an autonomy system based on artificial intelligence. This system cannot be designed based on a real vehicle because it would involve huge operating costs during system training. The paper presents several neural modeling solutions and presents their results obtained on real data. Neural models were also compared with the classical kinematic model. The comparison showed the superiority of neural models constructed in accordance with the data-driven approach over the classical model.

KEYWORDS

Neural networks, Underwater vehicle, Data-driven black-box model

Implementation of Artificial Intelligence Solutions in Maritime Transport: An Overview

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Implementing artificial intelligence (AI) solutions in maritime transport brings numerous benefits, including improved safety, efficiency and sustainability. The development of such solutions requires an interdisciplinary approach involving the maritime industry, IT experts and regulatory authorities. AI can be used to analyze real-time data and improve navigation safety, optimize ship routes and fuel consumption, autonomously navigate and avoid obstacles, improve port efficiency, maintain and monitor ship condition, monitor and comply with regulations, and monitor and record environmental pollution. For example, Rolls Royce Marine is a company specialized in ship design, integration of complex ship systems and the development of propulsion vessel systems and their equipment. In partnership with Intel, they begun testing the Intelligent Awareness System for ships, which consists of a large number of cameras, LiDAR (Light Detection and Ranging) and radars connected to a central AI software, with the aim of developing fully autonomous ships. This paper provides an overview of AI solutions in maritime transport, with an emphasis on the advantages and challenges of implementing artificial intelligence in maritime transport.

KEYWORDS

Implementation, Artificial intelligence, Solutions, Maritime transport

Estimation of Underwater Vehicle Speed Using Neural Networks

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The paper presents various neural network approaches for estimating the speed of an underwater vehicle, a key aspect in the development of autonomous underwater vehicles. Accurate speed estimation is essential for determining the position of the vehicle operating in underwater environments. This study compares the performance of several neural network models using data collected in natural conditions from low-cost sensors and vehicle parameters. The results are further compared with speed estimations obtained from the vehicle's onboard sensors, demonstrating that the neural network approaches are more effective.

KEYWORDS

Neural networks, Underwater vehicle, Speed estimation

Application of Artificial Neural Network for Steering Swarm of Underwater Autonomous Vehicles

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The paper presents the application of neural network for steering swarm consisting of underwater autonomous vehicles. There are many limitations in an underwater environment, one of the biggest being that communication between vehicles is severely restricted. Therefore, the use of fully autonomous vehicles capable of making decisions based on their own observations and the heavily constrained communication plays a key role in the development of technologies related to swarm management. The paper presents training and validation process of neural network for different variants of parameters values of low cost vehicles equipped only with cameras. Moreover additional test were conducted to test different camera inputs and methods of observation to improve swarm maneuverability and collision avoidance between swarm participants.

KEYWORDS

Neural networks, Autonomous underwater vehicles, Swarm

Diver Detection for Underwater Human-Robot Interaction

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Underwater human-robot interaction (U-HRI) establishes a significant advancement in cooperation between a diver and an underwater vehicle during demanding underwater tasks such as inspection, maintenance and exploration. Research has increasingly focused on visual gesture recognition since such cooperation remains challenging underwater due to electromagnetic wave attenuation and limited wireless options. However, a dependable communication system should consist of a diver detection and tracking module, an individual gesture recognition module, and a language module with grammar and syntax. This paper addresses the diver detection task, which constitutes the primary condition for establishing reliable communication. For this purpose, various neural network models have been deployed and analysed using real and synthetic images. The results suggest that the transformer architecture allows for precise detection, facilitating further adaptation for gesture recognition.

KEYWORDS
Autonomous underwater vehicle, Neural network, Transformer

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Sonar-Based Tracking System in AUV Swarms

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The article presents a sonar-based tracking system in a swarm of underwater vehicles to provide precise information about the position of the tracked object. The basic functions of the system include capturing environmental data with sonar, pre-processing the data, detecting and tracking the signature of the tracked vehicle, and transmitting its distance and heading information to the mission management system. Difficulties associated with the underwater environment, such as limited visibility and acoustic interference, underscore the critical importance of this solution for ensuring the autonomy of underwater vehicle swarms. The system's performance was verified in real-world conditions, where it successfully determined the position of the tracked object.

KEYWORDS

Sonar data processing, Underwater vehicle, Sonar-based tracking

A Bibliometric Analysis of the Underwater Hull Inspection Using ROV

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The reason for the underwater hull inspection could be threefold: firstly, it is an obligatory process to assess any possible damage and fatigue to the ship's hull, and therefore, it is done for safety reasons and classification societies prescribe it, secondly, it could serve as a detection process for biofouling serving as a vector for spreading marine invasive species, and thirdly, it could serve for security and anti-terrorism purposes, because underwater part of the ship's hull could serve as a hideout for various contraband, even weapons and explosives. Until recently, underwater hull inspections were done by professional divers in full, while lately, more and more inspections have been performed using remote-operated underwater vehicles (ROV) or autonomous underwater vehicles (AUV). However, technological advancements and related scientific research are not the same worldwide, some ports and areas use and study ROVs more than others. Therefore, it is important to identify research gaps and enable future studies to deal with emerging identified problems. With that aim, the authors used a bibliometric analysis to assess research trends, knowledge gaps, and collaboration patterns. Data was collected from the Web of Science (WoS) database, and publication trends, citation networks, key authors, and thematic developments were analysed using the VOSviewer software. Research gaps identified in this paper include the necessity for standardised training for ROV operators, the establishment of legal and regulatory standards concerning underwater hull inspection using ROV, and limited international collaboration. By addressing these gaps, future research can enhance ROV-based underwater hull inspections' efficiency, accuracy, and regulatory acceptance, ensuring safer and more sustainable maritime operations.

KEYWORDS

VoSviewer, Maritime safety and security, Sustainability, Marine robots, Bibliometric analysis, Underwater hull inspection

Different Methods for Measuring Exhaust Gas Emissions from Marine Engines

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New maritime regulations and directives regarding the marine environment tend to reduce greenhouse gases and harmful pollutants from maritime transport. Before implementing reduction strategies it is necessary to quantify the amount of emissions from ships. To achieve this goal the process of measuring emissions must be applied. The exhaust emissions depend on many variable factors such as operating engine load, ship speed, fuel type, combustion process and weather conditions, so these factors must be considered when choosing the measurement method. The main methods for measuring ship exhaust emissions are CEMS (Continuous Emission Monitoring System), onboard measuring equipment (exhaust gas analyzer), land-based measuring (port measuring equipment), and drone emission monitoring. For this research, the exhaust gas analyzer (Testo 350 Maritime v2) was used on one Ro-Pax vessel to measure the concentration of CO_2, NOx, O_2, and CO pollutants in the exhaust gases. The measuring methodology consists of installing the measuring equipment in the engine room, sampling process, and obtaining data. The measurement results are presented along with the advantages and disadvantages of each measurement method.

KEYWORDS

Ship exhaust emissions, Measuring methods, Marine engines, Exhaust gas analyzer

Feeding Two Birds With One Scone: The Application of Maritime Incident Case Studies in Developing Leadership, Managerial and Green Competencies

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Current literature on the efficiency of maritime resource management education and training indicates low effectiveness, particularly in real-life operations. Similarly, the efficiency of environmental education should be improved. Alternative teaching methods have the potential to address this issue. Student-centred, problem-driven learning (problem-based, project-based, and case-based) creates a more dynamic, engaging, and effective educational experience than teacher-centred/lecture-based learning. Case-based learning utilising real-world accidents may enhance maritime students' safety and environmental management competencies. Applying lessons from maritime incidents equips students with the technical and non-technical knowledge and skills needed to contribute to a strong safety culture and reduce the likelihood of accidents. Case-based learning is also an efficient approach to developing green competencies, particularly critical thinking and problem framing. This work aimed to evaluate the suitability of a case study approach for developing leadership and managerial and green competencies simultaneously. The selection of the case study provided to students was informed by a comprehensive analysis of maritime disaster and incident investigations. Structured prompts were used to guide students' attention to specific aspects of the case. The discussions revealed that students were able to develop a deeper understanding of both safety principles and environmental aspects. Moreover, video material stimulated emotional engagement among students, indicating a possible effect on intentions to behave pro-environmentally. The study results imply the increased potential of a case-based approach in comparison to lecture-based learning.

KEYWORDS

Leadership and managerial competencies, Green competencies, Case-based learning, Maritime accidents

Analysis of the Operation of the Me-Gi Two-Stroke Slow-Speed Diesel Engine in the LNG Tanker

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The development of technologies aimed at finding advanced solutions with the highest degree of fuel energy efficiency and minimal environmental pollution has resulted in the development of modern electronically controlled marine slow-speed diesel engines that use dual fuel systems, e.g. liquified natural gas LNG or compressed natural gas CNG, low sulphur heavy fuel oil LSHFO, heavy fuel oil HFO, marine diesel oil MDO or low sulphur marine gas oil LSMGO. The company MAN Diesel & Turbo has developed the ME-GI (M-type, Electronically Controlled, Gas Injection) type of marine engines, which operates according to the diesel process, where the liquified gas boil-off is compressed through the fuel gas supply system FGSS and injected into the cylinders at 300 bar and 45 oC, directly combusted in the cylinders. The main purpose of the FGSS is to supply fuel gas to the engine at the correct pressure, depending on the engine load. The operation of a dual-fuel engine first requires the injection of the pilot fuel, i.e. a small amount fuel oil which is self-ignited. As the combustion process starts, the secondary fuel (i.e. gas) is injected into the combustion chambers. Initially, the engine is always started on fuel oil. Once the engine operation on fuel oil is stabilised, the fuel supply can be switched to fuel gas. The engine runs both on fuel gas and fuel oil with equal efficiency. This paper analyses and discusses the ME-GI two-stroke slow-speed engine MAN B&W 5G70ME-C9.5-GI, installed on modern LNG carriers.

KEYWORDS

ME-GI, LNG, Dual fuel, Combustion, Fuel gas supply system

Laser Doppler Technique in the Diagnosis of the Fuel Injection Installation of Marine Diesel Engines

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Measurements of vibration parameters using laser Doppler vibrometry (LDV) is currently the method offering the best resolution regarding displacement and velocity measurements and is used in many fields of science. It enables the resolution of the femtometer amplitude (10-15 m), and also enables measurement in the range of very high sampling frequencies, currently up to 2 GHz. These properties are independent of the distance from which the measurement is made (within certain limits), therefore this principle is used both in microscopic operations and at large distances. The purpose of this article is to present a preliminary assessment of the use of laser vibrometry for reliable measurements of torsional vibrations of rotating shafts on floating units. The tests were carried out on a real object, which is a ship engine, but the measurement conditions differ slightly from the real ones due to the installation of the engine in the laboratory. In the future, it is planned to carry out measurements on board the ship. During measurements a RLV-5500 torsional vibration vibrometer was used. The principle of operation can be basically explained as follows: when vibration occurs, the frequency of the light wave changes. When the light source and its receiver come closer to each other, the frequency of the wave increases, resulting in the light changing color to purple. Similarly, the frequency decreases when the source and receiver are moved apart, and the light turns red. The information obtained in this way related to the surface vibration velocity can constitute the basis for further analysis and obtaining specific data regarding the vibration amplitude. In order to better understand the principle of operation, it is necessary to discuss the Doppler effect. During the measurements, the combustion pressure in individual cylinders was changed by simulating damage to the injection pumps. Such action has a significant impact on the change of torsional vibration parameters recorded on the rotating intermediate shaft. The recorded measurements were analyzed as a function of time and frequency. As a result, it was possible to determine the justification for using this type of measurement in the diagnostic process of the ship's propulsion system.

KEYWORDS

LDV, Torsional vibrations, Marine diesel engines, Diagnostic

How Artificial Intelligence Can Enhance Maritime Education and Training: Challenges and Opportunities

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Artificial intelligence (AI) has become a transformative element in maritime education, introducing innovative tools that enhance the effectiveness and efficiency of training processes. The increasing demands for competency-based education, aligned with international safety and operational standards, have highlighted the potential of AI-driven technologies to deliver significant advancements in this sector. This study explores the application of AI technologies to improve maritime education and training practices, with a particular focus on personalized learning, virtual and augmented reality (VR/AR) simulations, and automated performance evaluation tools. A systematic literature review was conducted to examine the implementation of AI-based tools in maritime education, drawing on case studies from institutions employing AI technologies for competency assessment, VR/AR-based simulators, and adaptive learning platforms aimed at optimizing seafarer training outcomes. Key findings reveal that AI-supported personalized learning platforms can dynamically adjust training content based on individual performance metrics, thereby improving skill retention and learning outcomes. Furthermore, VR/AR technologies have demonstrated effectiveness in simulating complex maritime scenarios, such as emergency responses and navigation challenges, within a controlled, risk-free environment. Automated assessment tools, driven by AI algorithms, offer real-time feedback and reduce instructor workload while maintaining high educational standards. The integration of AI technologies in maritime education holds significant potential to modernize training methodologies through enhanced personalization, increased efficiency, and global standardization of seafarer competencies. However, successful implementation requires careful planning to ensure a balanced approach that fosters technological innovation while safeguarding the core principles of educational quality and safety.

KEYWORDS

Artificial intelligence (AI), Maritime education, Personalized learning, Virtual reality, Augmented reality, Competency training

A Method for Estimating the Fuel Consumption Characteristics of Small Boats Sailing in Medium to High-Speed Range

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This research aims to develop application software to support energy-efficient operation for small boats in an easy, simple, and cost-effective way. Effective horsepower characteristics are basic and useful data to realize it. However, effective horsepower characteristics are not always provided for small boats. It is generally difficult to determine the effective horsepower characteristics of small boats of less than 20 tons in advance. Furthermore, the fuel consumption trend of a boat differs from boat to boat depending on the hull fouling and the amount of cargo carried. In order to develop an effective support tool for small boats, it is desirable that those characteristics can be estimated promptly after departure with a minimum of measuring equipment, without requiring the operator's intervention. A statistical survey of the relationship among ship speed, engine speed, and fuel consumption was conducted on a 19-ton small ship. It was assumed that the influence of wave-making resistance on energy consumption saturates at medium to high speeds, and frictional resistance becomes the dominant factor. Therefore, the fuel consumption trend was analyzed assuming it follows a fundamental physical law proportional to the cube of the ship's speed. As a result, a method was developed to estimate the fuel consumption trend at medium to high speeds range from the observed data that are available onboard during the voyage. Comparison of the estimated fuel consumption trend with actual voyage data showed a high degree of agreement for most of the data.

KEYWORDS
Energy-efficient operation, Small boats, Fuel consumption trend, Statistical survey

Achieving Environmental Sustainable Development Goals (SDGs) in the Maritime Industry

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Sustainable Development Goals (SDGs) are a global framework that was adopted by the United Nations in 2015. SDGs aspire to economic, environmental, and social sustainability. The maritime industry has a big impact on SDGs as a major transportation mode. Stakeholders of the maritime industry such as ports, shipowners, and charters should work together to achieve these targets. The maritime industry is making significant efforts to implement new regulations aimed at protecting the environment, especially for SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Action), and SDG 14 (Life Below Water) al which are directly related to environment protection. Despite strict rules and regulations in the maritime industry, achieving sustainability targets is a challenging process. This study aims to explore the current efforts of the maritime stakeholders to achieve SDG and to draw guidance to how to increase compliance and fitting with these goals. Qualitative research methods were utilized to collect data. The findings indicate that green ports, eco friendly ship design, renewable energy, alternative fuels, hybrid engines, new regulations about Energy Efficiency Existing Ship Index (EEXI) and Carbon Intensity Indicator (CII) for push lower carbon footprints, improvement of Ballast Water Treatment System (BWTS), installing on board a new Waste Treatment System which converts organic waste into biofuel, developing on board incinerator which disposes of non-recyclable waste while complying with emissions regulations. To achieve this, stakeholders of the maritime industry, strive to improve their practices. Finally, achieving constant sustainability requires collective action, additional measures, and greater commitment from all industry stakeholders.

KEYWORDS
Sustainable development goals (SDGs), Maritime industry, Environment, Sustainability targets

Strategic Climate Action in the Port Industry: Resilience, Adaptation, and Mitigation Practices

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This study aims to explore the strategic responses of ports to climate change through an analysis of key adaptation, resilience-building, and mitigation practices. As vital nodes in global maritime trade, ports face escalating climate risks, including sea level rise, severe storms, and coastal erosion. These impacts threaten port infrastructure, disrupt operations, increase costs, and strain global supply chains. Changes in marine ecosystems also endanger blue economy sectors such as tourism and fishing, along with the coastal communities that rely on ports. The study uses bibliographic analysis and case studies to explore how ports adopt climate-resilient infrastructure, deploy advanced technologies, and adapt operations to improve resilience. It also investigates mitigation strategies such as renewable energy integration, energy efficiency improvements, and alignment with decarbonization policies. While integrated adaptation and mitigation measures are becoming more widespread, many ports still face persistent barriers, such as limited funding, technical constraints, and regulatory complexity. The findings reveal emerging trends, innovative practices, and the growing importance of cross-sector collaboration in shaping effective and sustainable climate responses. Based on the research findings, this study proposes an analytical framework for ports' climate-related strategies and practices. Finally, this study contributes to ongoing discussions in maritime sustainability and climate governance by offering insight into the evolving role of seaports in global climate action.

KEYWORDS

Seaports, Climate change, Strategies and practices, Maritime sustainability, Adaptation, Mitigation

Navigating the Future of Maritime Education: the Role of Comprehensive English Training

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The Republic of Croatia is home to approximately 15,395 seafarers, including 7,922 deck officers and 7,473 marine engineers, according to EMSA statistics from 2022. Ranking sixth among EU nations in the number of shipmasters and officers, Croatia's maritime sector faces unique challenges due to its relatively small population and less developed shipping industry. To remain competitive, Croatia must continually modernize its maritime education system, particularly vocational training, to ensure that future seafarers acquire essential competencies. Many Croatian seafarers begin their careers in international shipping, emphasizing the need for an updated training system with a strong focus on professional and language skills. In maritime education, two primary approaches to teaching maritime English are used: an approach that satisfies the minimum STCW requirements and a more comprehensive approach that considers maritime English a critical subject. The paper supports the latter approach, arguing that effective communication skills cannot be cultivated through minimal standards alone. Although maritime English is standardized globally through the Standard Marine Communication Phrases (SMCP), these guidelines fail to fully address the dynamic and evolving demands of the profession. Research shows that experienced Croatian mariners find the current education system adequate but emphasize the need for a balanced integration of theoretical and practical knowledge. Such a balance is crucial not only for enhancing seafarers' competitiveness in the global job market but also for providing opportunities for shore-based employment.

KEYWORDS

Maritime English, SMCP, Theoretical and practical knowledge, Shore-based employment

Analysing the Application of the Leadership and Managerial Skills on Board Ships

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Nowadays, systems on ships are highly technologically advanced, but accidents at sea are still frequent. About 80% of accidents occur due to human factor, so there is a need to act on it and reduce the number of accidents caused by the human factor. According to the International Maritime Organization (IMO) requirements and the amendments to the STCW Convention A-II/2 and A III-3 from Manila in 2010, all deck or engine officers must be trained to use leadership and personnel management skills. This course enables crew members to develop the skills to manage a ship's crew successfully. Being a good leader means mastering the course guidelines, which include but are not limited to (i) skills and knowledge in the field of ship personnel management, (ii) understanding of international conventions, recommendations and national legislation, (iii) the ability to apply task and workload management, (iv) knowledge and ability to make decisions and (v) development, introduction and supervision of standard operating procedures. A good organisational culture means facing clear goals, having a strategy, and being open to new ideas. It also means adopting a trusting relationship among crewmembers to create a culture of belonging through the company's vision and mission. All this leads to development and responsibility among crewmembers at the support, operational, and management levels. This paper aims to determine how and to what extent seafarers use the knowledge they have acquired during training and identify the characteristics and effects of shipboard leaders. With that aim, a survey was developed, and the opinions of 71 experienced seafarers were collected and analysed. The study findings revealed that seafarers apply leadership and teamwork skills on board ships and consider their leaders competent with desirable characteristics and effects.

KEYWORDS

Leadership, Teamwork, Crew manning, Designated person, Communication

The Role of Logistics in the Maintenance of Ship Systems

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The maintenance of ship systems is critical to the safety, profitability and longevity of ships. The process includes corrective, preventive and predictive strategies to reduce failures and optimize operations. The integration of logistics, digitalization and remote technical support enables faster delivery of parts, lower costs and greater efficiency in the shipping industry. The impact of logistics strategies and technological innovations on the maintenance of ship systems analyzed in this paper focuses on three key aspects, namely inventory management, optimization of supply in ports and remote technical assistance. The results of the analysis show that logistics strategies and technological innovations bring numerous benefits, including reducing maintenance and repair costs, shortening vessel downtime, improving shipping safety and reliability, and optimizing the supply chain and speeding up the delivery of parts to the vessel. Applications of these strategies can be seen in shipping companies using IoT sensors to monitor the temperature of ship engines. Based on the data obtained from the sensors, the system can detect an elevated temperature at an early stage, indicating a possible malfunction in the engine's cooling system. This early alarm allows for timely intervention, such as cleaning or replacing damaged parts, preventing serious breakdowns and reducing repair costs and the risk of the ship being stranded at sea. In summary, the analysis confirms that the combination of technological innovation and logistical optimization significantly improves the efficiency, safety and cost-effectiveness of ship system maintenance, and makes the maritime sector more competitive and sustainable.

KEYWORDS

Maintenance, Innovations, IoT sensors, Failure prevention

Measures for Port Emission Reduction: A Comprehensive Study

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Global warming is already in its most calamitous stage, and the ports are practitioners of the emissions bonus that is responsible for the changes that are occurring. This paper comprehensively describes a number of approaches aimed at reducing the emissions associated with port-related operations. The measures require the need for establishing a regulatory framework, the need for operational optimization, technological improvements, and energy transition. The establishment of a functional legal and regulatory framework covers law, economy, and technology, which together seek to achieve sustainability without interfering with port operations. Proper energy-efficient, environmentally friendly, and cost-effective methods of optimizing the port operations will most probably lead to a drastic reduction in emissions. More advanced technologies, including microgrids, energy storage, cold ironing, and carbon capture, will also help to enhance emission control. In this regard, most likely progressive development needs a transition to the use of renewable energy sources, such as offshore wind power (OWP), solar photovoltaic (PV) power, biofuels, and tidal energy, along with the adoption of low-carbon fuels. Integration of regulatory measures, operational measures, technological measures, and energy measures is key to achieving significant reductions in port-related emissions. The aim of this paper is to offer users information that will be of help to the ports striving to implement best practices for green operations.

KEYWORDS

Emission reduction, Regulatory measures, Operational measures, Technological measures, Energy measures, Renewable energy, Alternative fuel

Utilization of Various PV Panels Technologies in the Maritime Sector

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In order to protect the sea environment and reduce fossil fuels consumption, energy requirements for the maritime sector are getting stricter, highlighting the significance of renewable energy sources. In this sense, photovoltaic (PV) technologies are increasingly present on vessels, along with their benefits, and some obstacles (limited deck space, bulky support structure for PV panels). PV panels are commonly produced with silicon solar cells. In 2023, silicon-based PV technology accounted for 97.4% of the total global production, out of which 96.6% were monocrystalline silicon PV panels. At the same time, thin film PV panels accounted for 2.6% (almost all Cadmium Telluride (CdTe)). Due to higher efficiency, monocrystalline technology has become the dominant over multi-crystalline technology that is phasing out. CdTe solar cells are more flexible which allows thinner and more narrow strips. Compared to crystalline silicon panels, CdTe panels have better electrical performance under lower solar irradiation and high temperature conditions. Considering PV panels efficiency and availability at the market, it can be concluded that for flat vessels surfaces, the most preferable solutions are monocrystalline panels, and for curved surfaces, CdTe panels. When choosing the most suitable PV panels technology for vessels application, except limited installation space, PV panels efficiency and price, also specific marine environmental conditions (wind, humidity, shading, corrosion, temperature, etc.) should be considered. In this paper, the PVsyst software will be used to simulate and compare the energy yield, efficiency, and performance of different PV panel technologies under specific marine environmental conditions. By modeling real-world operational constraints, the study aims to identify the most suitable PV panel technology for maritime applications based on energy output, space efficiency, and environmental resilience.

KEYWORDS

PV panel, PVsyst, Maritime sector, Ship emissions, Efficiency

The Impact of Teaching the Course Medicine for Seafarers on the Attitudes and Knowledge About Vaccination of Students of Nautical Science at the Faculty of Maritime Studies, University of Split

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Maintaining health while traveling requires adherence to medical guidelines, including risk prevention measures and vaccinations against infectious diseases. Yellow fever vaccination is mandatory under international regulations, while others, like meningococcal meningitis, depend on the destination country's requirements. To support disease control, health authorities issue an International Certificate of Vaccination in accordance with global vaccination regulations, serving as a crucial tool in controlling the cross-border transmission of infectious diseases. This study aims to investigate the attitudes and knowledge of Nautical Studies students regarding vaccination. Additionally, it seeks to determine whether there are differences in attitudes and knowledge between students who receive education on onboard healthcare and those without. For the purposes of the study, we developed a questionnaire consisting of three sections: knowledge about vaccination, attitudes, fear and anxiety related to other health conditions. The participants were undergraduate students of Nautical Studies at the Maritime Faculty of the University of Split. The results confirmed our initial hypotheses. Overall, students demonstrated a positive attitude toward vaccination, with an even more favourable outlook after completing the course Medicine for seafarers. Additionally, students' attitudes and knowledge about vaccination were not correlated with anxiety or fear related to other health conditions. By classifying their duties on board, a ship, seafarers spend part of their working life as second officers of the deck. The second officer or the master is the person responsible for the health of people on board, which includes access to the documentation and vaccinations. The negative attitude towards preventive medical interventions is not proportional to the quality performance of the set work tasks. The difference in attitudes toward vaccination based on education highlights the role of scientific understanding, trust in institutions, and informed decision-making in healthcare.

KEYWORDS

Vaccination, Attitudes, Knowledge, Education

Few-Shot Learning for Optical Navigation Near Shorelines

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This study introduces a GPS-independent navigation system tailored for autonomous surface and underwater vehicles operating near coastlines. The system leverages identifiable onshore landmarks—such as buildings and chimneys—as positional references. Upon surfacing, the vehicle captures images of these landmarks, which are then processed and labeled using a YOLO-based neural network. The spatial relationships of the detected objects are stored in a reference map. In subsequent surfacing events, newly captured images are matched against this map. By identifying at least three known objects, the system employs compass-derived bearings and optically estimated distances to triangulate the vehicle's position. This positional data informs the determination of optimal movement directions, facilitating navigation without reliance on GPS. To address the challenge of limited training data in real-world maritime environments—where acquiring extensive labeled datasets is often impractical—the system integrates a Few-Shot Learning approach. This methodology enables the model to recognize new object classes from a minimal number of examples. The approach utilizes two primary datasets: a support set containing a few labeled instances per class, and a query set comprising unlabeled images for classification. A ResNet-50 convolutional network serves as the feature extractor, forming the backbone of the model. Subsequently, a prototype network averages the extracted features to represent each class and performs classification by comparing query features to these prototypes. This combination of techniques demonstrates significant potential for enhancing autonomous navigation in maritime contexts where visual data is scarce or of limited quality.

KEYWORDS

Autonomous navigation, Few-shot learning, YOLO neural networks, ResNet-50, Triangulation