Journal of *Marine Science and Engineering*

MDPI

Editorial

Novel Maritime Techniques and Technologies, and Their Safety

Eduardo Blanco-Davis *, Sean Loughney and Zaili Yang

Liverpool Logistics Offshore and Marine Research Institute (LOOM), Faculty of Engineering, Liverpool John Moores University, Liverpool L3 3AF, UK; s.loughney@ljmu.ac.uk (S.L.)
* Correspondence: e.e.blancodavis@ljmu.ac.uk

Due to the convergence of decarbonisation imperatives, digitalisation, automation, and safety assurance, the maritime sector is undergoing an unprecedented transformation, redefining how ships are designed, operated, and regulated. From the widespread introduction of low-carbon propulsion systems to the deployment of AI-driven optimisation tools and autonomous control technologies, the industry is faced with the challenge of balancing rapid innovation with maintaining, or indeed strengthening, the safety foundations upon which maritime transport depends. This Special Issue, *Novel Maritime Techniques and Technologies, and Their Safety*, collates recent research that exemplifies the diversity of responses to that challenge from both scientific and engineering perspectives. Collectively, the papers within reflect a strong emphasis on integration—between technology and human operators, between data and decision-making, and between sustainability objectives and the practical realities of ship operation.

Across the fourteen contributions to this Special Issue—eleven research articles and three reviews—a clear narrative of progress toward intelligent, resilient, and environmentally responsible maritime systems emerges. Several studies demonstrate how **digitalisation** and **machine learning** can enhance operational safety and efficiency. Artificial intelligence-based models for trim optimisation and sea-spray-icing prediction have shown how data-driven techniques complement physical understanding, providing operators with adaptive decision-support tools capable of responding to changing environmental and operational conditions. Similarly, risk-based simulations have been applied to automatic mooring systems, quantifying reliability levels and critical failure modes to prioritise design improvements where they will yield the greatest safety benefits.

The contributions devoted to **automation** and **autonomy** highlight the importance of robust modelling and communication frameworks in the next generation of maritime operations. Comparative studies of system-based and CFD-based manoeuvring models show that accurate hydrodynamic prediction is vital to the safe deployment of Maritime Autonomous Surface Ships (MASSs). Complementary to this, research on 6G-enabled multi-radio access networks explores how the simultaneous use of satellite, UAV, and terrestrial channels [1] can ensure uninterrupted data connectivity, vital for autonomous navigation. Together, these works illustrate the emergence of a new research frontier that integrates naval architecture, control theory, and telecommunications engineering.

Another category of submissions advances our understanding of **cyber resilience** in the maritime domain. These papers, detailing the development of attack-tree frameworks for shipboard systems and comprehensive reviews of cyber-risk evolution, reveal how vulnerabilities propagate through increasingly connected shipboard networks. They show that cybersecurity is not merely a technical issue but a fundamental component of maritime safety management. The relevance of the IMO's *Guidelines on Maritime Cyber Risk Management* [2] is particularly evident here, as it forms the regulatory backbone for many of the strategies

check for updates

Received: 4 November 2025
Accepted: 6 November 2025
Published: 24 December 2025

explored in these studies. These findings echo the wider industry shift from compliance-based approaches to proactive risk engineering, where threat modelling, human-factor analysis, and continuous monitoring are components of a unified resilience strategy.

Decarbonisation remains relevant; several studies in this Special Issue examine **alternative fuels and energy-efficiency technologies** to reduce the emissions of various types and scales of vessels. Investigations into hydrogen-fuelled and fuel-cell-powered systems demonstrate how the hybridisation of clean fuels with advanced power electronics can replace traditional auxiliary engines, reducing both greenhouse gas and local pollutant emissions in port environments. Research on AI-assisted trim optimisation, life-cycle assessments of hydrogen supply chains, and low-cost monitoring for small and medium-sized vessels collectively underscore the multidimensional nature of the maritime energy transition—technological, operational, and economic. The results point to a developing consensus: that decarbonisation is inseparable from digitalisation, and that real-time data acquisition, performance modelling, and adaptive control will be indispensable for achieving net-zero targets.

Safety, efficiency, and sustainability are also increasingly being evaluated through **quantitative risk and performance methodologies**. Studies employing data-envelopment analysis, Monte Carlo simulation, and fault-tree or failure-mode assessments illustrate the power of mathematical modelling to reveal systemic weaknesses and optimisation opportunities. When applied to port logistics, such models quantify how technical efficiency and spatial connectivity evolve under geopolitical and economic pressures, providing decision-makers with evidence-based pathways to enhance resilience. Likewise, network-reliability analyses of maritime energy transport systems identify critical nodes—such as major straits and ports—whose disruption would have disproportionate impacts on global trade and energy security. These methodological advances highlight the growing role of quantitative safety and reliability engineering in maritime policy formulation.

From a broader systems perspective, the included review on **short sea shipping** captures the policy and economic dimension of sustainability. Despite decades of promotion, the modal shift from road to sea has not progressed at the anticipated rate. By analysing policy outcomes alongside technological readiness, the authors argue that automation, digital integration, and greener propulsion could reinvigorate the sector—provided that regulatory frameworks evolve to support innovation while maintaining fair competition. The European Commission's *Greening Freight Package* [3] exemplifies this ongoing policy transition, seeking to balance modal competitiveness with carbon neutrality goals. This synthesis bridges macro-economic insight with technological foresight, reinforcing the importance of interdisciplinary collaboration.

Together, these diverse contributions form a coherent picture of a maritime industry in transition—one that is embracing **novel techniques and digital tools** not as ends in themselves but as enablers of safer, more sustainable, and more intelligent marine systems. They also reveal persistent gaps; foremost among these is the need for holistic frameworks capable of integrating human, technical, and environmental dimensions of safety. As systems become more autonomous, it is critical to ensure that algorithmic decision-making is characterised by explainability, transparency, and trust The transition to alternative fuels, while technologically promising, demands further research into life-cycle emissions, onboard storage safety, and global fuel-supply logistics. Cyber resilience must advance beyond detection to autonomous defence mechanisms capable of adaptive responses. Finally, as connectivity extends into the 6G era, research must continue to address latency, spectrum allocation, and secure data exchange across the maritime–satellite continuum.

Future research should prioritise three interrelated directions: **First**, the creation of integrated digital-twin ecosystems that unify design, operation, and maintenance across

a ship's life cycle, enabling predictive safety management and optimisation. **Second**, the establishment of internationally harmonised standards for data governance, cybersecurity, and autonomy, ensuring that technological innovation aligns with regulatory and ethical principles. **Third**, the continued coupling of environmental and safety objectives through life-cycle-based assessment frameworks, so that decarbonisation strategies inherently support risk reduction and operational resilience.

The collective work presented in this Special Issue reflects the commitment of the maritime research community to bridge the gap between innovation and assurance. The editors wish to thank all contributing authors, reviewers, and the editorial staff of *JMSE* for their effort and dedication. Their contributions not only advance scientific understanding but also chart a course toward a maritime industry that is safer, cleaner, and more intelligent.

Funding: This research received no external funding.

Acknowledgments: The editors gratefully acknowledge all authors, reviewers, and technical editors who contributed to the success of this Special Issue. The authors would like to also thank Milad Armin for his initial assistance in the conception of this Special Issue.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

List of Contributions:

1. Seyfi, H.; Hitchmough, D.; Armin, M.; Blanco-Davis, E. A Study on the Viability of Fuel Cells as an Alternative to Diesel Fuel Generators on Ships. *J. Mar. Sci. Eng.* **2023**, *11*, 1489. https://doi.org/10.3390/jmse11081489.
2. Wang, J.; Wang, X.; Feng, Y.; Cao, Y.; Guo, Z.; Liu, Z. Assessing the Connectivity Reliability of a Maritime Transport Network: A Case of Imported Crude Oil in China. *J. Mar. Sci. Eng.* **2023**, *11*, 1597. https://doi.org/10.3390/jmse11081597
3. Knight, M.; Blanco-Davis, E.; Platt, O.; Armin, M. Life-Cycle and Applicational Analysis of Hydrogen Production and Powered Inland Marine Vessels. *J. Mar. Sci. Eng.* **2023**, *11*, 1611. https://doi.org/10.3390/jmse11081611.
4. Kim, S.; Kim, H.; Jeon, H. Development of a Simplified Performance Monitoring System for Small and Medium Sized Ships. *J. Mar. Sci. Eng.* **2023**, *11*, 1734. https://doi.org/10.3390/jmse11091734.
5. Kim, M.; Chun, K. A Comprehensive Review on Material Compatibility and Safety Standards for Liquid Hydrogen Cargo and Fuel Containment Systems in Marine Applications. *J. Mar. Sci. Eng.* **2023**, *11*, 1927. https://doi.org/10.3390/jmse11101927.
6. Koo, H.; Ryoo, C.; Kim, W. Simultaneous Utilization of Multiple Radio Access Networks in Ubiquitous 6G Connectivity for Autonomous Ships: Opportunities and Challenges. *J. Mar. Sci. Eng.* **2023**, *11*, 2106. https://doi.org/10.3390/jmse11112106.
7. Batista Santos, P.; Santos, T. Short Sea Shipping in the Age of Sustainability, Autonomous Navigation and Digitalization. *J. Mar. Sci. Eng.* **2024**, *12*, 252. https://doi.org/10.3390/jmse12020252.
8. Matthews, N.; Joiner, K.; Smith, W. Stability Assessment of a Catamaran Using Sea Trials. *J. Mar. Sci. Eng.* **2024**, *12*, 1436. https://doi.org/10.3390/jmse12081436.
9. Sundsbø, P.; Deshpande, S. An Investigation into Using CFD for the Estimation of Ship Specific Parameters for the SPICE Model for the Prediction of Sea Spray Icing: Part 2—The Verification of SPICE2 with a Full-Scale Test. *J. Mar. Sci. Eng.* **2024**, *12*, 1866. https://doi.org/10.3390/jmse12101866.
10. Deshpande, S.; Sundsbø, P. Investigation into Using CFD for Estimation of Ship Specific Parameters for the SPICE Model for Prediction of Sea Spray Icing: Part 1—The Proposal. *J. Mar. Sci. Eng.* **2024**, *12*, 1872. https://doi.org/10.3390/jmse12101872.
11. Kim, K.; Kwon, S.; Choi, M. Optimization of Production Scheduling for the Additive Manufacturing of Ship Models Using a Hybrid Method. *J. Mar. Sci. Eng.* **2024**, *12*, 1961. https://doi.org/10.3390/jmse12111961.

12. Kašpar, J.; Mauro, F.; Biot, M.; Rognoni, G.; Kyaw Oo D'Amore, G. A Design-Oriented Model for Transmission Loss Optimization in Marine DOCs. *J. Mar. Sci. Eng.* **2024**, *12*, 2358. https://doi.org/10.3390/jmse12122358.
13. Locaitienė, V.; Čižiūnienė, K. Assessing the Logistics Efficiency of Baltic Region Seaports Through DEA-BCC and Spatial Analysis. *J. Mar. Sci. Eng.* **2025**, *13*, 50. https://doi.org/10.3390/jmse13010050.
14. Keskin, O.; Lubja, K.; Bahsi, H.; Tatar, U. Systematic Cyber Threat Modeling for Maritime Operations: Attack Trees for Shipboard Systems. *J. Mar. Sci. Eng.* **2025**, *13*, 645. https://doi.org/10.3390/jmse13040645.

References

1. International Telecommunication Union. *IMT-2030 Framework for 6G Mobile Communications*; ITU-R M.2160-0; International Telecommunication Union: Geneva, Switzerland, 2023.
2. International Maritime Organization. *Guidelines on Maritime Cyber Risk Management*; MSC-FAL.1/Circ.3/Rev.3; IMO: London, UK, 2025.
3. European Commission. *Greening Freight Transport (COM(2023) 440 Final)*; European Commission: Brussels, Belgium, 2023.