

## **Navigating the Digital Wave: A Systematic Literature Review on Digital Leadership in the Maritime Industry (2020–2025)**

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### **Abstract**

The maritime industry is currently facing two major transformations, namely digitalization and decarbonization within the framework of “Shipping 4.0,” which demand fundamental changes in leadership practices. Although the adoption of technology is advancing rapidly, the human role remains a key factor in ensuring the successful implementation of these transformations. This study aims to examine the evolution of digital leadership in the maritime sector through a systematic literature review of scientific publications from 2020 to 2025. The method employed is a systematic literature review of 30 relevant primary sources, involving a process of selection, analysis, and thematic synthesis of findings. The results indicate a shift from traditional hierarchical leadership models toward more adaptive, data-driven, and socio-technical leadership. Digital leadership is identified not only as a technical competence but also as a strategic necessity capable of integrating autonomous systems, cybersecurity, and sustainability. This study also proposes the conceptual framework of the “Maritime Digital Triad” as a theoretical contribution to understanding the complexities of leadership in the digital age. In conclusion, digital leadership plays a crucial role in bridging the challenges of technology and human resources while opening avenues for further research, particularly in the adaptive and sustainable management of maritime human resources.

**Keywords:** Digital Leadership; Shipping 4.0; Maritime Transformation; Decarbonisation; Cyber Resilience; Human Element.

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## **INTRODUCTION**

The global maritime industry has underpinned over 80% of world trade; for decades, it has been known as a sector that tends to be conservative, with hierarchical organisational structures and rigid operational processes (Ali, 2025). This model has proven effective in maintaining stability, maritime safety, and compliance with strict international regulations. However, on the other hand, this approach has also led to a slow adoption of innovation and new technologies (Gavalas et al., 2022). In an increasingly dynamic global competitive landscape, these conservative characteristics are beginning to be viewed as obstacles that must be overcome to ensure the industry remains relevant and competitive.

The period from 2020 to 2025 marks a significant turning point for the transformation of the maritime industry. The global COVID-19 pandemic has accelerated the need for digitalisation, particularly in terms of operational automation, remote monitoring, and the integration of cross-border logistics systems (Chua et al., 2022). Furthermore, increasing pressure for decarbonisation and environmental sustainability is driving shipping companies to adopt technology-based solutions to improve energy efficiency and reduce carbon emissions. This transformation has subsequently given rise to the concept of “Shipping 4.0”, which

emphasises the comprehensive integration of digital technology across the maritime value chain, from ports to vessels (Sanchez-Gonzalez et al., 2019).

In this context, digital leadership has become a key factor determining the success of the transformation. Digital leadership is not merely about the ability to use technology, but also encompasses the capacity to manage organisational change, foster a culture of innovation, and harmoniously integrate human and technological aspects (Zeng et al., 2025; Bach & Sulíková, 2021). This is becoming increasingly important as digital transformation often causes internal disruption that requires an adaptive and visionary leadership approach. In other words, leaders do not merely act as decision-makers, but also as agents of change within the organisation (Zulu et al., 2024).

Unlike traditional maritime management approaches, which focus on control and procedural compliance, digital leadership demands flexibility, collaboration, and data-driven decision-making. Leaders in this era are required to understand how technologies such as Big Data, Artificial Intelligence (AI), and the Internet of Things (IoT) can be optimised to enhance operational efficiency whilst maintaining safety and sustainability (Rane, 2023). Furthermore, the ability to translate data into appropriate strategies is also a key competency that modern leaders in the maritime sector must possess (Müller et al., 2024).

However, the adoption of digital leadership in the maritime sector is not without its complex challenges. One of the main issues is the digital skills gap among the maritime workforce, the majority of whom are still accustomed to conventional systems and have limited exposure to cutting-edge technology (Alamouh & Ölçer, 2025; Jacobs & Goedhals-Gerber, 2026). Furthermore, cybersecurity concerns are a serious issue as reliance on digital systems which are vulnerable to attacks continues to grow (Djenna et al., 2021; Yogamalar & Samuel, 2019). Other challenges include resistance to organisational change, limited investment in technology, and the lack of uniform global standards for digitalisation implementation.

These conditions highlight an urgent need for a comprehensive understanding of how digital leadership is evolving within the maritime industry. Such understanding is crucial not only for identifying best practices that have been successfully implemented but also for uncovering research gaps that require further exploration. Consequently, a literature-based review serves as a relevant approach to mapping trends, patterns of development, and research directions in the field of maritime digital leadership.

This literature review aims to explore the evolution of digital leadership in the maritime sector during the period 2020–2025, by identifying shifts in leadership paradigms and the factors influencing organisational transformation. Furthermore, this study seeks to examine how the integration of digital technology and the human role shapes new leadership models that are more adaptive, collaborative, and sustainable. This analysis is expected to provide a more systematic overview of leadership dynamics in the digital age.

Ultimately, this research is expected to make a conceptual contribution to understanding the dynamics of digital leadership in the maritime industry, whilst serving as a foundation for the development of human resource management policies and practices that are more responsive to

the demands of the digital age. Furthermore, the findings of this study are also expected to serve as a reference for practitioners and academics in designing effective digital transformation strategies. Thus, the maritime sector is expected not only to adapt but also to become a pioneer in sustainable and inclusive global digital transformation.

## **METHOD**

This research employed a Systematic Literature Review (SLR) approach, adhering to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure a systematic, transparent and replicable process. Data collection was carried out through a comprehensive search of major academic databases, namely Scopus, Web of Science, ScienceDirect and IEEE Xplore. The sources used were limited to peer-reviewed publications in English, including journal articles, conference proceedings, and official industry reports published between January 2020 and January 2026.

The literature selection process was carried out in stages through the screening of titles, abstracts, and full-text reviews to ensure alignment with the research focus. Inclusion criteria focused on studies addressing digital leadership within the maritime industry context, particularly those related to technological and organisational transformation. Irrelevant, duplicate, or substandard sources were eliminated during this process, ensuring that only the most relevant literature was analysed further.

The analysis was conducted using a thematic approach based on three main aspects: leadership competencies, socio-technical systems, and digital governance. Leadership competencies encompass the skills required in the ‘Shipping 4.0’ era; socio-technical systems highlight the interaction between humans and technology; whilst digital governance focuses on the role of leadership in cybersecurity and sustainability. Through this qualitative synthesis, the research was able to identify patterns, trends, and gaps in the development of digital leadership within the maritime industry.

## **RESULT AND DISCUSSION**

### **Thematic Findings: The Evolution of Maritime Leadership**

#### **a. From Hierarchy to Agility**

The results of the literature review indicate a significant shift from traditional hierarchical models of maritime leadership towards more adaptive and collaborative approaches (Trilasmana et al., 2025; Zakiah et al., 2025). The concept of “Master-under-God”, which positions the captain as the sole authority on board, is undergoing transformation alongside the advancement of digitalisation and automation (Wiśnicki et al., 2024). The presence of Shore Control Centres (SCCs) in the operation of autonomous vessels has redistributed leadership roles and responsibilities (Dybvik et al., 2020). In this context, the digital leader no longer acts solely as the primary decision-maker, but as an “orchestrator” who coordinates interactions between the ship’s crew, automated systems, and shore-based analysts within an integrated network.

#### **b. The Green–Digital Nexus**

Findings also indicate that most recent research highlights the concept of the digital and green as the primary direction for the maritime industry (Mietule et al., 2025; Quimba et al.,

2023; Alterio, 2025). Digitalisation is no longer viewed as an end in itself, but rather as an enabler for achieving environmental sustainability. Digital leaders utilise real-time data to optimise fuel consumption, route planning, and operational efficiency. This demonstrates a close interconnection between digital literacy and environmental management, where data quality and adaptive leadership capabilities are key determinants of success. Conceptually, this relationship can be formulated as follows:

$$\text{Sustainability Efficiency} = f(\text{Data Quality} \times \text{Leadership Agility})$$

c. Cyber Resilience as a Leadership Responsibility

Furthermore, a significant rise in cyber threats has also shifted leadership perspectives within the maritime sector. The literature indicates a surge in maritime cyber incidents, making cybersecurity a strategic issue rather than merely a technical concern (Saskia & Agussalim, 2023). Digital leaders are now required to integrate cyber risk management into operational strategies and foster a culture of cyber security within the workplace. This is crucial given the increasing reliance on interconnected navigation, communication, and propulsion systems, meaning that vulnerability to cyber disruptions can have a direct impact on safety and the continuity of operations.

**Comparative Analysis: Ports vs. Vessel Management**

The analysis results indicate that the implementation of digital leadership is not uniform across the maritime supply chain, but varies according to individual operations. These differences are clearly evident between leadership in smart ports and leadership on ships and fleets, in terms of objectives, technologies used, leadership styles, and the challenges faced.

**Table 1.** Comparison of Digital Leadership in Ports and Ships/Fleets

Features	Smart Port Leadership	Ship & Fleet Leadership
Primary Objectives	Ecosystem Integration & Capacity	Operational Safety & Fuel Efficiency
Key Technologies	Digital Twins & Blockchain	AI Navigation & Remote Monitoring
Leadership Style	Collaborative Stakeholder Management	Flexible Socio-Technical Coordination
Key Challenges	Data Silos & Standardisation	Technostress & Outdated Mindset

Source: Processed by the author from reviewed articles (2026)

**Discussion: The Maritime Digital Triad**

A synthesis of the 30 sources analysed in this study led to the formulation of a conceptual framework referred to as *the Maritime Digital Triad*. This framework emphasises that the success of digital leadership in the maritime industry is determined not only by the adoption of technology, but by a balanced integration of three key pillars: technological literacy, a human-centred approach, and strategic governance. These three elements are interrelated and form the foundation that determines the effectiveness of digital transformation in “Shipping 4.0”.

The first aspect, technological literacy, is a key prerequisite for leaders in understanding the complexity of the evolving digital architecture within the maritime industry. It is no longer sufficient for leaders to possess merely operational understanding; they must also be able to

interpret, analyse, and utilise technologies such as autonomous systems, data analytics, and digital platform integration. The literature indicates that a lack of this understanding often leads to a gap between technological potential and on-the-ground implementation, thereby hindering the optimisation of organisational performance.

However, this research also emphasises that a human-centred approach plays an equally vital role. Digital transformation often gives rise to the phenomenon of *technostress*, namely the psychological pressure resulting from adapting to new technologies. Therefore, digital leadership must be able to create a supportive working environment, including fostering a sense of psychological safety, enhancing competencies through training, and encouraging the workforce's active involvement in the change process. This approach is crucial to ensuring that technology is not only accepted but also utilised optimally by human resources.

Furthermore, strategic governance is a key element in aligning digital initiatives with the industry's long-term objectives, particularly regarding sustainability and decarbonisation. Leaders are required to integrate technological investment with global environmental policies, such as the mandates of the International Maritime Organization (IMO). This demonstrates that digital leadership is not only focused on operational efficiency, but also on environmental responsibility and the industry's overall sustainability.

Furthermore, recent literature highlights the dangers of *techno-optimism*—an overly optimistic view of technology's capabilities that fails to account for human factors and organisational culture. Many studies show that the failure of technology implementation is not caused by system limitations, but rather by a lack of cultural and psychological readiness among the workforce. Therefore, effective digital leadership must be able to balance technological innovation with the management of human change, so that digital transformation can proceed in a holistic and sustainable manner.

## CONCLUSION

The maritime industry is undergoing a critical transformation driven by digitalization and decarbonization, rendering traditional hierarchical leadership models insufficient for addressing the complexities of a digital and low-carbon environment. A review of literature from 2020 to 2025 highlights digital leadership as a strategic necessity, requiring adaptive, data-driven competencies and the ability to integrate technological and human dimensions, with future leaders acting as “dual citizens” in both physical and digital contexts. The study underscores the need to reform maritime education by incorporating digital governance, cybersecurity, and data ethics into curricula aligned with international standards such as “STCW,” alongside encouraging shipping companies to adopt more flexible and communicative organizational structures to enable agile, data-informed decision-making. These efforts are essential to enhance workforce and organizational readiness for the “Shipping 4.0” era and to ensure long-term sustainability and competitiveness. Future research should focus on empirically evaluating the effectiveness of digital leadership development programs and educational reforms in improving operational performance and resilience within the maritime sector.

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