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The significance of trust in maintaining safety during digital transformations in the maritime industry

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Digitalization is rapidly transforming maritime operations, reshaping both technical systems and everyday work practices on board vessels and within shipowner organizations. This paper investigates how the introduction of digital tools such as automated machinery and sensor-based monitoring systems, as well as information technologies for data processing and communication affect maritime work and safety. While the adoption of these technologies is driven by efficiency demands, environmental requirements, regulatory pressures, and the need for real-time operational insight. Crews benefit from improved access to operational data and enhanced connectivity, yet they also face increased workloads due to manual data entry, duplicate reporting, and insufficient integration between systems. This has an impact on the sociotechnical system and hence, the safety of the operation. This is not recognized in the development of technology. Drawing on sociotechnical research, the study highlights the role of technology design, usability, and integration in shaping safe and efficient operations. Despite the potential for digital tools to support operational resilience, findings indicate that current systems are primarily developed from a functional, control-oriented perspective. A central challenge identified in the study is the lack of collaboration and trust between shipowners and technology suppliers. Conflicts around data ownership, integration costs, and vendor lock-in limit cooperative development. Trust is shown to be essential for successful partnerships and for the development of digital systems that genuinely support maritime operations. The paper is based on a qualitative study of 16 focus group interviews with shipowners and senior crew members from Norwegian maritime companies. The findings demonstrate that building stronger, trust-based supplier relationships is crucial for developing digital tools to improve safety, efficiency, and the resilience of maritime sociotechnical systems.

Keywords: Trust, Digital technology, Safety, Maritime industry, technology development, sociotechnical systems

1. Introduction

Digital technology has become an increasingly important part of ship operations in the maritime industry. This encompasses both Operational Technology (OT), such as automated machinery and control systems, including advanced monitoring sensors that track onboard conditions and equipment performance —and Information Technology (IT), which includes data processing systems and communication platforms.

The adoption of these technologies is driven by multiple factors. Efficiency improvements and demand for environmentally sustainable solutions are key motivators. Additionally, growing regulatory demands and the increasing need for real-time information to customers and stakeholders have accelerated the implementation of digital technology.

A common consequence of this technological shift is its impact on the work of maritime professionals. Professional work, performed

in a complex sociotechnical system, affects both safety and operational efficiency. Whether technology will have a positive or negative impact on safety depends on several critical factors, including: The design and usability of the technology, the effectiveness of its integration into maritime organizational structures, the quality of ongoing maintenance and updates.

The importance of applying a sociotechnical approach to safety in complex high risk systems have been shown by many researchers (Antonsen & Le Coze, 2023).While many of these factors can be managed by shipowners and onboard personnel, several of the most important elements are determined by the technology manufacturers and suppliers. These include system design that aligns with professional needs, the usability of the technology, and its ability to adapt to evolving operational requirements.

In the maritime industry, the influence of technology design on safety has been examined from several perspectives. Research on user interfaces for safety-critical systems—such as radar and electronic charts—has highlighted the value of open industry standards and intuitive design (Bjørneseth et al., 2012; Mallam & Nordby, 2021; Nordby et al., 2019). User interfaces that help operators concentrate on essential tasks and allow different systems to be used in a consistent, familiar way improve safety and reduce workload in critical situations.

Another important viewpoint concerns how digital systems enforce standardization and thereby reshape work practices and safety conditions. Almklov and Antonsen (2019) discuss this through the lens of work as imagined—as represented in procedures and digital systems—versus work as done, which is inherently adaptive, situational, and time-dependent. They show how digital technologies can restrict the flexibility required for safe, real-world operations. Related discussions of the relationship between work as imagined and work as done in safety critical operations can be found in Haavik (2014) and Hollnagel (2017). Digital technologies also influence what different actors focus on during operations. For example, remote monitoring and sensor-data logging enable shipowners to evaluate and control operational parameters that affect performance and economic outcomes. Such technologies facilitate standardization, increase classification and accountability, and can reshape how operations are perceived and understood However, they may also introduce increased managerial control, shifting the focus from operational safety toward meeting performance indicators and strategic targets (Almklov et al., 2014). Overall, it is essential to recognize how digital transformation affects operational practices and safety, and to ensure that these consequences are understood by operators and all involved stakeholders. Ensuring that digital systems are designed with the user in mind and that they function as intended is therefore essential. Achieving this requires close collaboration between shipowners, crew, and technology suppliers. However, such collaboration is more complex than it may initially appear. Digital systems can be expensive to develop, representing significant investments in research and engineering for manufacturers. For shipowners, adopting a new system also involves substantial costs related to procurement, training, and implementation.

The success of new technologies additionally depends on their ability to integrate with existing systems, which often requires manufacturers to make technical adjustments or customizations. Meaningful collaboration between manufacturers and customers is therefore necessary to ensure effective integration and usability. Yet collaboration itself hinges on trust between the involved parties (Blomqvist et al., 2005). In particular, integrity-based trust has been shown to be crucial for maintaining relationships that support innovation and joint problem-solving. The development of such trust is further influenced by the historical relationships within value chains, making its establishment both gradual and inherently challenging (Hastings et al., 2016). As a

result, the potential for new digital technologies to improve safety in the maritime industry is closely tied to the quality of the relationship between shipowners and technology suppliers.

The aim of this paper is to study digital tools influence on work and work systems onboard ships and in ship owners' offices and how the relationship between ship owners and suppliers influence the possibilities for developing digital tools that support safe operations.
These issues are investigated through a qualitative study involving 16 focus group interviews with shipowners and crew members onboard their vessels.

2. Teoretical foundation

Technology and technological failures have been central concerns in safety science since the industrial revolution. Today, technology plays an even more important role, as digital tools shape work and sociotechnical systems in increasingly complex ways (Antonsen & Le Coze, 2023). This complexity is evident in modern accident investigations, where a systems perspective—one that considers interactions among humans, organizations, and technology—is essential for understanding how accidents occur (Carayon et al., 2015).

Following the systems perspective in safety science, the development processes behind complex technologies become relevant. For example, Roe and Fortmann Roe (2023) discuss how technology developers influence a system's ability to recover from failures. Designing technology that support resilient sociotechnical systems requires a theoretical foundation that extends beyond traditional functional development approaches, even those found in human centered design.

One important step toward such a foundation is Haavik's (2014) concept of sensework. Sensework offers a constructionist perspective for understanding safety in sociotechnical systems—particularly in settings where users must interpret sensor data to make sense of critical operational situations. It draws on Science and Technology Studies (STS) and Actor Network Theory (ANT) to explain how meaning is collaboratively produced in complex, data driven environments.

A second relevant perspective is found in Woolgar's (1990) Configuring the User. Woolgar shows how designers and developers shape assumptions about who the user is, how they behave, and how they are expected to interact with technology. Instead of treating users as pre-existing and independent, he argues that technologies are built around imagined users, effectively "configuring" them through design decisions.

A related but distinct contribution comes from Orlikowski (1992), who uses Giddens' (1984) structuration theory to conceptualize the relationship between technology and organizations. In structuration theory, structures both enable and constrain human action, and these structures are themselves produced through repeated human practices. Humans are reflexive, drawing on rules and resources in their interactions, and thereby reinforcing institutionalized organizational patterns—what Giddens calls the duality of structures.

Orlikowski extends this idea to propose the duality of technology: Technology is created and changed through human action—through processes of design, interpretation, and modification. Then again: Technology shapes human action by enabling certain practices and constraining others.

She further argues that technology is interpretively flexible, meaning its use and significance depend on the actors involved and the sociohistorical context of development and use.

Given these complexities, effective technology development requires close collaboration between developers and customers. Such collaboration depends on the ability to build a shared understanding of user needs and the sociotechnical system the technology will support. Trust therefore becomes a critical factor. Research has shown the importance of trust for innovation in interorganizational relationships such as those between customers and suppliers (Grant & Baden-Fuller, 1995).

An organization's willingness to engage in initiatives with uncertain outcomes is strongly influenced by the level of trust it has in external partners. These relationships may form through supply chains, business to business arrangements, or research and development partnerships. Interorganizational trust is well recognized as a key factor in business performance. Zaheer et al. (1998), for instance, demonstrate that interorganizational trust and interpersonal trust are related but distinct.

Despite its importance, defining interorganizational trust remains difficult. Connelly et al. (2018) note the challenges involved, and Seppänen et al. (2007) identify 24 different dimensions associated with the concept, with reliability and credibility among the most common. The concept is difficult to isolate because it overlaps with its antecedents and consequences—such as collaboration and communication—which complicates simple causal models.

Some studies also suggest that trust matters only when customers have genuine alternatives. In "lock in" situations caused by technology or market structures, trust does not significantly influence the customer–supplier relationship (Sako & Helper, 1998). As a result, using trust as a predictor of collaborative success or competitive advantage is more complex than it first appears.

One way to address this complexity is by distinguishing between competence based trust and integrity based trust (Connelly et al., 2018).

•Competence based trust reflects confidence in a partner's skills, expertise, and experience (Lee, 2004).

•Integrity based trust reflects beliefs about a partner's motives, honesty, and character (Svare et al., 2020).

Studies show that these forms of trust affect relationships differently. Integrity based trust often has a stronger impact on relationship performance (Connelly et al., 2018), while competence based trust plays a major role in partner selection (Shazi et al., 2015). In long term contractual relationships, integrity based trust becomes especially important and functions as a complement to formal contracting.

Trust and contracts have been examined across various interorganizational settings—including supply chains and R&D collaborations. In many of these contexts, trust plays a critical role because formal contracts cannot provide sufficient flexibility. R&D collaborations in particular rely heavily on trust to support the delicate, knowledge intensive processes required for innovation (Blomqvist et al., 2005). Together, trust and contracts operate as mutually reinforcing elements that guide relationship governance (Blomqvist et al., 2005; Cao & Lumineau, 2015).

At the same time, research warns against assuming trust is always beneficial. High levels of trust can reduce partners' efforts in negotiations, potentially leading to poorer outcomes (Jeffries & Reed, 2000). Excessive trust may also harm innovation performance: overly trusting relationships can reduce monitoring, increase vulnerability to opportunism, and limit exposure to new ideas (Xavier Molina-Morales et al., 2011).

To use trust effectively, organizations must therefore maintain a strategic balance—leveraging trust while incorporating safeguards. Explicit contracts are identified as one of the most important mechanisms for mitigating the "dark side" of trust (Villena et al., 2021). This supports the broader conclusion, emphasized by Blomqvist et al. (2005), that trust and contracts together form two complementary sides of effective relationship governance.

3. Method

The data used in this article is part of a larger project investigating the use of digital technologies in the maritime industry. The project was a collaboration between NTNU, Sintef, Blue maritime cluster and the Norwegian Shipowners association. The data was gathered by conducting a total of 16 focus group interviews. The focus groups consisted of either onshore management teams or the senior officers from one vessel. This allowed viewpoints from both onshore and offshore within each company. The companies consisted of Norwegian

shipowners and was strategically selected from participants in a workshop on digital transformation in the Norwegian maritime industry. The participants were known to focus on the implementation of digital tools and were thought to have valuable information for the study. The data was recorded and transcribed before thematically analyzed using Nvivo.software version 15.2.2. A thematic analysis was chosen as it is considered flexible and direct and require no specific theoretical foundation (Braun & Clarke, 2006). An overview of the thematical analysis is shown in figure 1, describing the coding process and chosen categories.

Figure 1. Result of the thematical analysis

4. Figures and Photographs

The results of the tematical analysis is presented according to the main categories identified.

4.1. Impact on work and safety

All informants acknowledge that digitalization has influenced their daily work. However, the extent of this influence varies significantly across shipowners. Offshore and passenger transport vessels experience a greater impact from digital tools than deep sea cargo shipping.

Onshore personnel report that the amount of available ship data has increased substantially, especially through digital sensors. They also note that the way information is obtained has changed. Previously, onshore staff had to request specific data and hope the crew would remember to send it. Now, much of this information is stored in cloud databases, and the crew enters data as part of their routine work. This shift, however, introduces a challenge: quality control. When crews manually prepared reports, they typically checked their own data. With automated routines, responsibility for quality control now falls to the onshore staff. As one technical manager explains:

"Now it is much easier. We have the data available instantly, instead of emails going back and forth. The quality of the data is not good enough; we try to follow it up and try to make them (the offshore crew) double check but in the end, it is up to us."

Crew members onboard also observe changes in their workflow. They appreciate the benefits of increased sensor data and automated logging but point out that many tasks still require manual data entry. In fact, manual reporting has in some cases increased because digital systems require additional contextual information or inputs from other systems. Some crew members must also submit data to their clients' systems, resulting in duplicate reporting. As one chief engineer states:

"This is the big minus of digitalization, it often means double or triple reporting. The ship owner has his systems, the customer his systems and they all want information."

Overall, the crew sees both positive and negative aspects. They value the improved information access and automation while recognizing that it requires greater focus and discernment. One captain explains:

"Yes, but that's something you learn over time, I'd say… I think you do get better at filtering out what isn't really necessary. That you instead focus on things that are more relevant and important."

A major change in work practices—both onboard and onshore—has been the widespread adoption of video communication tools. Introduced during the COVID 19 pandemic, these digital platforms have remained central in the maritime industry:

"We have now decided that we will have regular digital meetings between the offshore operations and the onshore organization… So, it gives us a much better tool for following up on priority issues, boat by boat, shift by shift, and for actively working on things together… Teams together with Starlink, it's a revolution in shipping."

4.2. Sociotechnical challenges

New technology demands new competencies, a reality recognized by both offshore and onshore personnel. Onshore staff note that IT knowledge has become increasingly important, particularly as some shipowners who previously outsourced IT services are now re internalizing them. They also emphasize that collecting large volumes of sensor data is only valuable if that data can be interpreted—requiring analytical skills.

Onboard crews similarly recognize shifting competence requirements. One chief engineer humorously noted:

"I know of one guy in the technical department that has asked for an Excel course for 15 years."

Another challenge is the slow transition away from paper based systems. Despite digital solutions, some countries still require physical copies of certificates, procedures, and licenses.

Digital transformation is also costly. Beyond procurement and implementation expenses, several informants describe operational disruptions caused by new digital tools. Many onboard personnel express frustration with insufficient training and poor implementation processes:

"Whenever the company introduces new tools… we don't have enough time to learn… They just send us instructions on board… But not all can get to learn these new tools."

"Sometimes they introduce new tools and… I was on vacation during the implementation… And then when I go on board, this tool is new for me. And then there's nobody on board who can teach you how to use it."

4.3 Trust and supplier Relations

Managers frequently report tensions with suppliers regarding data ownership. Shipowners generally believe that operational data belongs to them, while suppliers often charge for processing and transforming that data into usable information. This disagreement can hinder cooperation. One technical manager describes a recent development project:

"It requires us to collect a lot of data, and we have to share it with the suppliers… We also had a discussion… regarding newbuilds—whether the designer should get exclusive access to our data. We said no to that."

Another challenge in the ship owners office is the difficulty of establishing efficient workflows across different digital tools. Departments often use specialized software, but sharing information between them is complicated. Many feel they lack the competence to articulate to suppliers how tools should support integrated workflows. There is also anticipation of future digital solutions, perhaps using artificial intelligence, that can improve the ability to use the increased amount of data for strategic decisions and business intelligence systems.

From the crew's perspective, however, increased connectivity has major benefits—particularly when suppliers can access systems remotely for troubleshooting. As one chief engineer notes:

"Previously you had to go to shore to fix something you were unable to fix yourself. Now they can just log on, that's a huge difference."

The informants from management also mentions the challenges with data transfer between systems from different suppliers. This is something the suppliers charge for and they also seem to be reluctant to do in many cases. From the ship owner's perspective this is taken as an attempt to make them stick to one supplier.

5. Discussion

This study shows that digital tools have significantly changed work practices both in shipowners' offices and onboard vessels. The increased ability to collect operational and equipment-performance data has created more opportunities for monitoring, comparison, and performance optimization. However, much of this data is currently used mainly for reporting and optimization purposes. While crews recognize the benefits of greater data availability, they also experience the added burden of manually entering information that is not automatically captured. It is unclear whether this shift has increased managerial control, as suggested by Almklov and Antonsen (2019), but digitalization has clearly moved attention away from operations and toward data collection for reporting and optimization by onshore management and customers.

The findings also suggest that digital tools have been developed primarily from a functional, control-oriented perspective. Although these tools offer many advantages, the benefits appear to accrue mainly to management and customers. Little attention has been given to how these technologies influence the broader sociotechnical system or how they might support operational

resilience. Such potential benefits are neither recognized nor experienced by the informants.
Furthermore, the study reveals limited collaboration between technology developers and shipowners. Although shipowners acknowledge that greater collaboration could improve operations, they struggle to initiate and structure such partnerships. This lack of collaboration also constrains innovation, as highlighted by Blomqvist et al. (2005) and Grant and Baden-Fuller (1995).
The absence of collaboration also contributes to low levels of trust between suppliers and shipowners. Ongoing disputes regarding data ownership and costs associated with processing and interpreting data weaken these relationships. Challenges related to system integration are often perceived as attempts by suppliers to "lock in" customers, which further undermines trust.

6. Conclusion

The discussion on technologically influenced work practices shows how digital tools can impact safety in operations. The lack of trust between suppliers and shipowners is a significant barrier to collaboration and to the development of digital tools that genuinely improve maritime operations. Building trust—starting with competence-based trust and ideally extending to integrity-based trust—would be a valuable step for the industry. Stronger trust relationships would enable more effective collaboration, support the development of digital tools that benefit the entire sociotechnical system, and ultimately enhance operational performance.

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