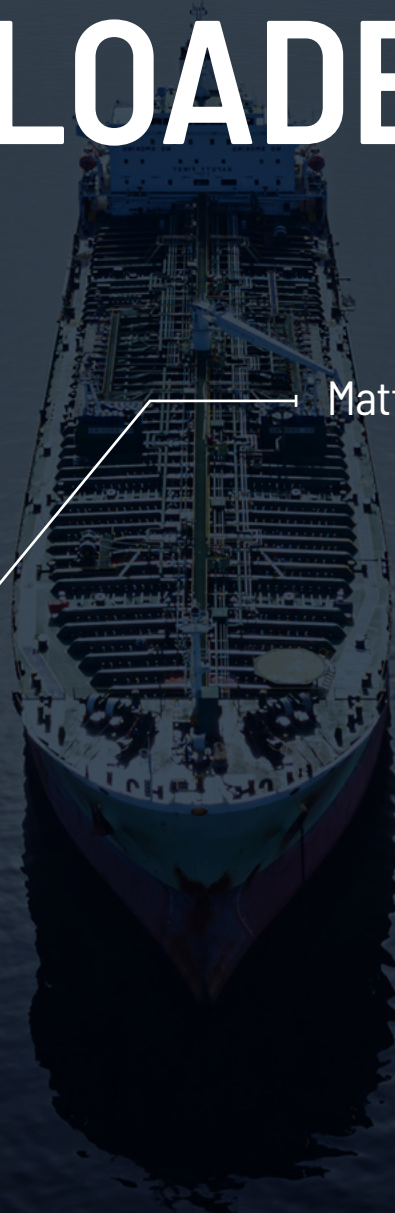


DECISION- OPTIMISED OR OVERLOADED?

Rethinking the use
of digital tools on a
digitalised bridge

Matt Stevens





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Foreword

The bridge has never been more capable. It has also never been more complex. Over the past decade, the maritime industry has digitalised rapidly, adding tools, data streams, and reporting requirements at a pace that has fundamentally changed what it means to work at sea. The question this paper asks is an important one: has that change actually made things better for the people responsible for operating these environments?

At OneOcean, we commissioned this research because we needed an honest answer to that question. As a technology provider, we are part of the landscape this paper examines. That means we share responsibility for whether the systems crews rely on reduce friction or contribute to it.

What the research found will not surprise anyone who spends time with seafarers. Fragmentation across systems, alert fatigue, cognitive overload, and crews routinely acting as the connective tissue between tools that were never designed to work together. The real question is whether the modern digital environment genuinely supports good decisions under real operational conditions, including when people are fatigued, under time pressure, and managing several competing demands at once.

This is something we see in our own work with customers. Earlier this year, our team travelled to Rio de Janeiro to work alongside Petrobras on a project focused on fleet-wide policy alignment and the implementation of digital workflows across their vessels. The three days we spent there were instructive because of what the conversations revealed about how people actually work.

The gap between what a system is designed to deliver and what crews experience day to day is often where the real challenge sits. Closing that gap means sitting alongside the people who use it, understanding their reality, and building implementation around that.



Elif Pitirli
Solutions Consultant
OneOcean

Organisations change when people change, and people change when technology is implemented with their reality in mind.

This is what shapes how we think about building and implementing our products. Integrated workflows rather than bolted-on tools. Adoption treated as seriously as deployment. Systems designed for the officer of the watch managing a difficult approach in poor conditions, not for the ideal user in a controlled demonstration. And continued investment in the kind of close, collaborative work we carried out with Petrobras, rather than simply handing over software and stepping back.

The findings in this paper point to a broader challenge for the industry as a whole. Shipowners, technology providers, regulators, and training organisations all have a part to play in whether the digital bridge environment of the future genuinely serves the people operating it. That will not happen by adding more capability. It will happen by asking harder questions about how existing capability is experienced in practice.

As the paper concludes, the best solutions come from the people at the sharp end. We hope this research helps ensure their voices are heard.

Executive summary

Digital navigation systems have improved the capabilities of modern bridge teams, but these improvements have changed the nature of bridge work.

The bridge is no longer only a navigation hub; it is now part of a wider digital operating environment that connects voyage execution, performance management, emissions reporting, compliance, and shoreside oversight. Digitalisation and the introduction of sophisticated tools onto the bridge are the reasons for this shift.

This report outlines that the main challenge for crews is not a lack of information; in many cases, crews now have more information than ever before. The central issue is whether that information is presented in a way that supports safe and effective decision-making.

As tools and systems become increasingly linked, crews are expected to monitor alerts, validate data, interpret system outputs, clear alarms, and handle discrepancies among tools. Although the bridge is more digitally capable than before, it is also far more cognitively demanding.

Bridge teams are dealing with more than just navigation, as alarms, disconnected systems, different interfaces, and extra reporting requirements all add to the workload. In the interviews conducted as part of the research informing this report, this came through most clearly in relation to the busiest parts of a voyage, such as pilotage, congested waters, poor weather, or when a system stops behaving as expected.

The report discusses how operational risk is no longer driven solely by traditional navigation difficulties but is now determined by how well crews interact with complex digital systems. If tools do not communicate effectively, crews become the link between them, underlining a dependence upon human experience to ensure digital tools work effectively.

Improving bridge operations is not about adding more technology. It is about making digital navigation environments easier to use, better connected, less noisy, and closer to how crews actually work.

Decision-ready systems will reduce noise, highlight what matters, support human decision making, and help crews manage complexity under pressure. For crews, shipowners, technology providers, and regulators, the priority should be to ensure that digital systems support the people who use them rather than adding more work and complexity to bridge operations.



Introduction

The modern bridge environment is becoming ever more complex, often due to the increasing number of technologies on board. Over the past decade, digital navigation systems, performance monitoring tools, compliance platforms, and ship-to-shore systems have become more capable and more widely used across the maritime industry.

These developments have improved vessel capability, with systems such as ECDIS, AIS, automation tools, route-planning platforms, and performance-monitoring systems strengthening maritime operations.

The benefits offered by these systems have changed the nature of bridge work as crews no longer only pilot the vessel. They now manage alerts, validate data, interpret system outputs, meet reporting requirements, and act as the integrator of information from tools which do not always communicate effectively.

This means that operations increasingly depend on the crew's ability to understand and manage a complex digital environment, rather than traditional seamanship skills. The challenge is not just that crews have more information available to them, but that this information often arrives via fragmented systems.

During high-stress situations such as berthing, sailing in congested waters, poor weather, or equipment disruption, this can increase cognitive load rather than reduce it.

Regulation has brought operational decision-making, emissions reporting, compliance, and voyage performance closer together. The bridge has become part of a broader digital operating environment in which navigation, safety, efficiency, and reporting are interconnected.

This report explores how bridge operations have developed, why digital systems can both assist and complicate decision-making, the effects of fatigue on crew, and what decision-ready systems should look like in practice.

Growing bridge complexity



A tanker approaching port called for the pilot, believing it was in the correct position, only to be told it was not.

When the bridge team checked, they found that the Electronic Chart Display and Information System (ECDIS) had a Global Positioning System (GPS) offset, and the vessel was about five miles further offshore than they had accounted for.

What made it more concerning was that no one on the bridge had noticed, despite having visual references, radar overlay, and routine position checks available. Alexander McDonald, a Coastal Tanker Master, recalled it as a mistake influenced by digital tools that has stayed with him.

For McDonald, the issue was not solely with the equipment, but also in what it revealed about modern bridge operations. Digital systems can be effective, but they can also create a false sense of security when bridge teams rely on them too much or fail to check what they are being told.

// The bridge has moved from a workspace built around tools focused on navigational aids to an environment where information is constantly generated and exchanged across multiple systems.

"I would have been embarrassed if it were me. I would have felt humiliated as a master if I didn't know where my ship was," said Alexander McDonald.

The last decade of bridge operations has seen a growth in digital technology alongside a fundamental shift in the operating reality. The bridge has moved from a workspace built around tools focused on navigational aids to an environment where information is constantly generated and exchanged across multiple systems.

The International Maritime Organization (IMO) frames e-navigation as being an ongoing transition, determined by changing user requirements and continuing technical development.¹ Similarly, ECDIS transitioned from being a specialist tool to a mandatory requirement as it was phased in from 2012 to 2018.²

The tools and technology used onboard the bridge have become more central to how vessels operate. For some experienced mariners, the gains are obvious. As Hristo Hadzhiev, Master Mariner at V.Group, put it; "now it is much easier. You can drive the vessel like a car."

However, ease of use in some areas does not mean the bridge has become simpler overall. The result is a bridge environment that is interconnected and more capable, but busier and more cognitively demanding than before. This raises questions about whether these systems consistently make it easier for crews to make decisions at sea or whether they also add new layers of difficulty to bridge crews' work.

1. International Maritime Organization (Accessed March, 2026) [E-navigation](#)

2. International Maritime Organization (Accessed March, 2026) [Electronic Nautical Charts \(ENC\) and Electronic Chart Display and Information Systems \(ECDIS\) increasingly using rely on data from onboard sensors, AIS, performance-monitoring consistent](#)

The digitalisation of bridge operations

Recent digital developments in bridge operations have improved crew capability levels. For example, tools like ECDIS have improved situational awareness, supported enhanced route planning, and enabled more effective approaches to collision prevention and voyage optimisation.

The shift of ECDIS, which has evolved from a specialist system to a standard feature on most vessels over the past decade, is evidence of a broader advance towards a digital-first bridge environment, where software systems sit at the centre of how information is presented and used.

Shravan Bhagra, Master Mariner, described the transition from paper charts to digital navigation as a quick and challenging shift for crews:

"It was a sudden shift from absolutely analogue work to digital work, when I transitioned, it was pretty scary because you don't understand the system."

// You cannot go without technology, but you also cannot fully rely on it. You have to balance both and use them as a tool."

Capt. Abhijit Arvind Mohite
HSSE Manager, a tanker operator,
and former Master Mariner

The IMO has made clear that ECDIS is not a simple tool and is a complex system with layers of information and varying levels of integration with other onboard systems. This is important because it highlights that digitalisation has not removed the need for seafarer judgement, but has altered its nature.

As Capt. Abhijit Arvind Mohite, HSSE Manager at a tanker operator and former Master Mariner, said, "You cannot go without technology, but you also cannot fully rely on it. You have to balance both and use them as a tool." Technology improves user effectiveness, but only when crews understand its limitations and actively check what systems are telling them.

For example, officers are expected to interpret systems, understand how information is structured, what tools they use, and the data they rely on. This is becoming increasingly important as digitalisation reaches beyond navigational tools.

Meaning that operational decisions are being shaped more by how well crews can interpret and validate what these systems are telling them. John Hissey, Senior Product Manager at OneOcean, spoke about how the role of the bridge team has changed as information has become more centralised. "The human was the processor," he said. "Now the difference is that information is provided there for you, and you need to know, is that right or not?"

The tools bridge teams use increasingly rely on data from onboard sensors, AIS, performance-monitoring tools, and connected ship-to-shore systems. Research into ship performance standards illustrates how valuable these data streams are for improving efficiency and how difficult it can be to preserve consistency due to data quality issues and fragmented system architectures.³

3. Science Direct (September, 2025) [A comprehensive review of data processing for ship performance analysis](#)



The bridge is no longer just a place for navigation. It is now part of a broader digital operating environment which connects voyage execution, performance management, emissions reporting, and shoreside oversight.

This expansion brings clear benefits but also places crews under pressure due to a more complex information ecosystem than traditional bridge designs accounted for.

Shravan Bhagra explained that while digital tools have reduced physical effort, they have increased the mental demands placed on crews. "The physical workload was more before, the mental workload was less. Now the mental workload is more, the physical workload is less," he said. "Digital systems have made some tasks easier, but they have not reduced the overall burden on bridge teams."

Pradeep Chawla, CEO at MarinePals, observed that "automation has brought about a much easier life, but what has not improved has actually gone worse, particularly when it comes to paperwork and pressure on crew time".

As Capt. Abhijit Arvind Mohite added, "there is enough data available, but interpreting it is the challenge." The issue is no longer access to information, but the ability to identify what matters in emergency situations.



// The issue is no longer access to information, but the ability to identify what matters in emergency situations.

The expanding regulatory environment

Evolving maritime regulations has added to the complexity that crews face in a bridge environment. Environmental and reporting requirements sit much closer to daily operations than they used to.

Systems on the bridge and, more generally, on a vessel do not just support navigation but also gather, process, and report data for compliance.

On a global scale, the IMO Data Collection System (DCS) has required ships of 5,000 GT and above to record fuel consumption and operational data since 2019, with this data feeding into the Carbon Intensity Indicator (CII) framework from 2023.⁴

In Europe, the extension of the EU Emissions Trading System (ETS) to maritime transport from 2024, alongside the introduction of FuelEU Maritime from 2025, has further integrated emissions monitoring and reporting into daily operations.⁵

These developments have begun to bring operational decision-making, data collection, and regulatory reporting into a single set of workflows. The complexity for modern seafarers is not just the number of regulations, but how they relate to one another.

The European Commission's FuelEU Maritime guidance highlights that the regulation is 'highly intertwined' with EU MRV (Monitoring, Reporting, and Verification) and the EU Emissions Trading System (EUETS), with overlapping requirements that must be managed together.

// The problem is not just that the amount of regulation has increased, but that the additional work has often been absorbed by the same number of people.

Crews now operate in a new digital environment where systems are expected to support safe navigation and compliance. The same data is often required to serve different purposes across evolving regulatory structures with varying requirements.⁶ As a result, compliance is no longer separate from operations as it directly influences daily decision-making on the bridge.

This move has increased the amount of information crews are required to manage and raised the stakes for what can go wrong, which helps explain why fatigue and workload are receiving more attention at a regulatory level.

As James Shaw, Master at a major ferry operator, outlined, new requirements are often layered onto existing workflows rather than replacing them. "There's a lot of policies and procedures, it becomes a bit overwhelming," he said, showing how additional demands increase workload without simplifying processes.

This indicates a widespread operational challenge across maritime, where new requirements are often layered onto existing systems rather than replacing them.

At the IMO's Human Element, Training and Watchkeeping (HTW) Sub-Committee in 2026, the Secretary-General and member states spoke regarding technological change and seafarer wellbeing, launching new work on fatigue and hours of rest.⁷ The discussions highlighted growing concerns about seafarer fatigue and were important because they recognised that, as vessels become more complex and regulations deepen, human factors such as fatigue affect safety, performance, and the adoption of new technologies.

The problem is not just that the amount of regulation has increased, but that the additional work has often been absorbed by the same number of people. As Pradeep Chawla explained, "with every new regulation we add some tasks for the seafarers, but we do not change the manning levels onboard."

4. International Maritime Organization (Accessed March, 2026) [IMO Data Collection System \(DCS\)](#)

5. European Commission (Accessed March, 2026) [Maritime transport in EU Emissions Trading System \(ETS\)](#)

6. European Commission (October, 2025) [Guidance on the FuelEU Maritime Regulation](#)

7. BIMCO (March, 2026) [HTW 12: IMO advances seafarer training and launches new fatigue management initiative](#)



Alert fatigue and information overload

This growing bridge complexity is most keenly felt by crews through the number of alerts received. Modern alert management systems are designed to draw crew attention to issues onboard, and to prioritise what matters.

Shravan Bhagra highlighted this, stating that “there are so many alarms going off, especially when you’re in constricted waters, guys are just going and acknowledging alarms”.

The IMO’s Bridge Alert Management (BAM) standard (MSC.302(87)) was developed to simplify alerts, improve their prioritisation and handling, helping bridge teams identify potentially fragile situations quickly and reduce unnecessary alarm-related distractions.⁸

Despite these efforts, the experience on board is often very different. As James Shaw explained from an operational standpoint, “when you are trying to concentrate on getting alongside the berth, it can be very distracting, the alarms are constantly going off in the background.”

“When you are trying to concentrate on getting alongside the berth, it can be very distracting, the alarms are constantly going off in the background.”

James Shaw

Master at a major ferry operator

John Hissey supported this, explaining that once systems are integrated, poor configuration can quickly turn into noise. “As soon as you put things into a digital platform, unless it’s really well configured, it will just ping at you,” he said. “You get so used to just silencing the button, you will miss the things that are important.”

Alert fatigue is not just a matter of quantity, but of whether systems showcase the right information in a usable way.

Repeated low-value alarms can train crews to stop properly engaging with them. As Alexander McDonald explained, “there might be that one in the middle which is a valuable alarm which nobody picks up on because it’s just acknowledge, acknowledge, acknowledge.”

Reflecting this, Matthew Bland, Chartered Master Mariner at Alton Marine Consulting Limited, observed that where alerts are not clearly differentiated, “they can’t prioritise them, and it leads inevitably to alarms being silenced or bypassed.”

Lloyd’s Register research has shown that alarm fatigue is a persistent issue.⁹ The report illustrates how high alarm volumes can impact situational awareness and response performance.

Speaking on the topic of unavoidable alarm load and alarms created by poor configuration, Robert Pogson, Deputy Harbour Master/VTS Manager at Belfast Harbour, stated, “people quote alarm fatigue, but then they don’t consider, well, you didn’t set the system up properly in the first place.”

From an operational perspective, Capt. Abhijit Arvind Mohite noted that “many pilots don’t like too many alarms because they become a distraction.” This reflects the issue that systems designed to improve awareness can end up competing for attention in already demanding environments.

8. IEC, (March, 2026) [Bridge Alert Management: an operational condition that can manifest](#)

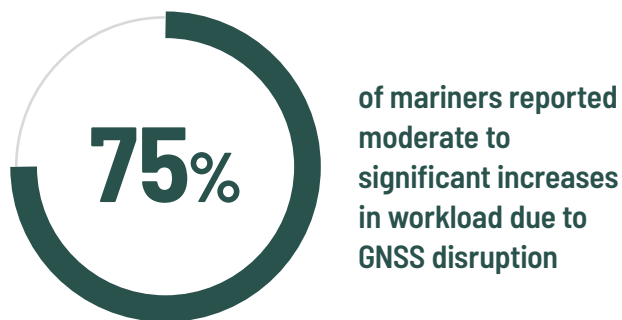
9. Lloyd’s Register (January, 2026) [Alarm overload is undermining safety at sea as new research shows crews face tens of thousands of daily alerts](#)

The challenges of alarm fatigue and information overload are more obvious when systems are interconnected. For example, Global Navigation Satellite System (GNSS) interference can trigger multiple alerts across a range of systems, including navigation and communication systems.

Barry Hooper, Head of Maritime Strategy at OneOcean, explained that the problem is not always one alarm, but the way alarms can build across multiple systems. “The danger isn’t a single alarm, it’s the cascade. When something really goes wrong, multiple systems alarm at once, and the volume of noise and competing alarms is enough that your body and brain can just freeze.”

Even where alarms are manageable overall, repeated nuisance alerts can still be frustrating in constrained waters. As Hristo Hadzhiev explained, “sometimes we have very annoying alarms, sailing in the Malacca Strait or Singapore Strait, we received that we are heading into danger where there is none.”

The Nautical Institute reported that only 25% reported little to no impact from GNSS disruption, with 75% of mariners reporting moderate to significant increases in workload.¹⁰ This shows that information overload is not just a design flaw but an operational condition that can manifest when systems fail or behave unexpectedly.



When the crew become system integrators

Something that was raised multiple times during Thetius’ conversations with industry professionals is that technology does not always eliminate work; it redistributes it. When tools do not communicate effectively, it is often left to crews to fill the gap.

As Matthew Bland noted, “you could describe them as being the APIs, human APIs really, in that there’s a manual process when you’ve got systems which don’t talk to each other.”

All too often, officers need to reconcile conflicting data across displays, interpret system inconsistencies, and determine which system to trust depending on the specifics of the situation.

Recent incident reports from CHIRP Maritime show that, even with advanced navigation systems in place, bridge teams often face challenges with system integration and correct application in real-world operations.¹¹ For example, there is an over-reliance on ECDIS and inconsistencies in system configuration.

As many vessels still operate with a mix of legacy systems, fragmented tool sets from a range of vendors, and add-on compliance platforms, the result is an environment where productive workflows are achieved through human effort rather than successful design.

10. The Nautical Institute (January, 2026)
[WAYPOINT - GNSS interference, workload and fatigue](#)
11. Chirp Maritime (Accessed, April, 2026)
[AIS and ECDIS offsets. - AIS and ECDIS offsets](#)





This is particularly true on older vessels, where new systems are often added one by one rather than designed to work together from the outset. Alexander McDonald noted, “things kind of come in individually, the older equipment won’t all talk to each other.”

That challenge begins with how systems are introduced. As Pradeep Chawla noted, “when we do newbuilding system design, we do not take into consideration the overall system.”

Operational resilience, therefore, depends on individual experience, and bridge teams act as mediators and facilitators between systems that do not communicate effectively.

Captain Amitvikram Chitnis, Head of Product at Inchcape Shipping Services and former Master Mariner, highlighted this, stating, “the main challenge is linking all those systems, and you are depending on a human to connect all the data points.”

In reality, this places pressure on crews who are already required to resolve conflicting information and make judgement calls under high pressure.

Operational resilience depends on individual experience, and crews act as mediators and facilitators between systems that do not communicate effectively.

The evolving role of the bridge crew

The role of the bridge team is being influenced by a number of factors. An officer of the watch remains responsible for safe navigation and collision avoidance, but they also must now monitor systems, manage alerts, validate data, and understand system behaviour under different conditions.

This means that complexity is no longer a by-product of progress, but a defining feature of modern bridge operations. While modern digital systems have improved capability, they have reshaped what bridge work looks like.

A central question is whether the more digital environment is genuinely supporting the people expected to operate it, or whether it is introducing new layers of complexity that make decision-making harder in practice.

Matthew Bland questioned how competence is assessed, noting that, “you would think that a newly qualified officer with a certificate of competency (COC) would be ready to go, but often they are not, and having a COC should demonstrate competence, but it often doesn’t.”

What decision-ready systems look like

More information on the bridge does not always lead to better judgement. Performance is often shaped by workload and attention, especially during busy voyages, high-pressure moments, and difficult manoeuvres. Crew members do not necessarily care how much a system can do, but whether it can help them in their daily routines.

Understanding cognitive load in maritime operations

A common key finding in human factors research is that more information does not always lead to better outcomes. Increased cognitive load, through workload and stress, can directly affect decision-making performance.

Cognitive load refers to the total demand placed on attention and decision-making capacity at any given moment. In a bridge environment, this demand is contributed to by a combination of navigation, communication, system monitoring, compliance tasks, and environmental conditions.

Research regularly shows that decision-making quality depends on the tools available and the operator's state of mind. Under high workload, crew members are more likely to simplify decisions, overlook information, or delay action.¹²

This challenges the commonly held view that human performance is inconsistent. A decision-ready system is not about providing people with more to look at. It should be about making things simpler and presenting the right information in the right way, so people can make decisions quickly and confidently.

This challenge is most visible in the transition from training to voyages. As James Shaw explained, "rather than someone passing out of college and being sent on ship straight away, they need some time as a supernumerary, so they get used to being on board first."

// A decision-ready system is not about providing people with more to look at. It should be about making things simpler and presenting the right information in the right way, so people can make decisions quickly and confidently.

12. Lloyd's Register (January, 2026) [Alarm overload is undermining safety at sea as new research shows crews face tens of thousands of daily alerts](#)

The reality of bridge operations

The importance of cognitive load is often highlighted when considering real-world operations. Fatigue has been recognised as a safety risk to crew members for a long time. IMO guidance under the STCW Convention, furthered through the 2010 Manila Amendments, sets minimum rest requirements, including 10 hours in any 24-hour period and 77 hours over seven days.¹³

Maritime operations are 24/7, and fatigue tends to accumulate in ways that regulations alone cannot prevent. Recent research, including UK Department for Transport studies on seafarer fatigue, found an ongoing gap between regulatory frameworks and operational realities.

A decision-ready bridge environment needs to reflect changeable and volatile conditions, not perfect ones. It needs to assume that operators manage multiple competing demands while fatigued or under time pressure.

It also hinted that workload does not tend to occur evenly, but rather in clusters. That pattern is familiar to many operators. As Pradeep Chawla “if they have touched more than two or three ports in the past one week, everybody is shattered.”

This is important as it shows how fatigue is often driven by repeated cycles of intense operational demand. For example, traffic, adverse weather conditions, busy port operations, unexpected administrative tasks, and bridge system issues can all occur simultaneously. Newer risks, like GNSS interference, can further increase pressure by causing sudden system disruptions.

A decision-ready bridge environment needs to reflect these changeable and volatile conditions, not perfect ones. It needs to assume that operators manage multiple competing demands while fatigued or under time pressure.

This involves recognising that bridge workload rarely builds in a neat, linear way, but rather in layers. A bridge team approaching port may be handling traffic, pilot communications, company reporting, checklist completion, changing environmental conditions, and multiple active systems simultaneously.

When another complication is added, whether GNSS interference, a last-minute course change, or a number of alarms in tandem, the task moves beyond navigation and becomes about managing attention under pressure.

This is where the quality of system design matters most. Systems might work well in normal conditions but become distracting in busy conditions. The test is whether they help crews stay focused during busy operational periods.

As James Shaw explained, “they are an issue at the times when you want maximum focus”, highlighting how poorly timed alerts can undermine crew attention in important moments.

That includes recognising how fatigue and interruption are built into life on board. As Amitvikram Chitnis noted, “people normally sail for anywhere between 4 weeks to 3 months, by the time you adapt to the systems, it’s time for you to move on.” This makes continuity and handover harder than shore-based system designers envision.

13. International Maritime Organization (Accessed April, 2026) [Seafarers hours of work and rest](#)

Technology layering and system integration difficulties

One reason digital systems can fail to reduce workload is that they have evolved incrementally, without a structured approach to their adoption. For example, new regulations lead to the introduction of new reporting tools, new optimisation goals bring in new platforms, and legacy systems remain in place alongside newer ones.

This layering effect is not just technical but commercial. Alexander McDonald argued, “they don’t want their equipment to talk to another manufacturer’s,” highlighting how vendor incentives can work against integration onboard.

Over time, this leads to vessels accumulating tools that might be effective in isolation but fail to integrate. The difficulty stems from how they interact; crews must navigate between complex platforms and understand how different processes connect.

For the officer of the watch, this often means moving between systems that were never designed to work together. One platform may display navigation data one way, another may present alarms differently, while a third may require separate manual input for reporting or performance monitoring.

Even where information is technically available, it may not be easy to compare or interpret. This creates additional work, as systems can require bridge teams to verify, translate, and reconcile information before they can act on it.

In this kind of environment, safe performance depends heavily on individual familiarity and experience, which makes the operation more fragile than it appears.

As Marco Vatteroni, Secretary General of Shipdex, explained in relation to technical manuals and documentation, “today, data is exchanged in an unstructured format. Every maker, every shipyard has a different format.” This helps explain why technical documentation can remain difficult to integrate into digital workflows, even when the underlying systems function well.

“Today, data is exchanged in an unstructured format. Every maker, every shipyard has a different format.”

Marco Vatteroni

Secretary General, Shipdex

Even when each individual system is functioning well, this lack of a centralised view tends to introduce ambiguity and increase the chance of misinterpretation. The IMO’s e-navigation strategy recognises this challenge and underscores the need for harmonised, integrated systems across ship and shore environments.¹⁴

However, other research into maritime digitalisation continues to identify fragmentation and a lack of standards as key blockers, leading to a layered system architecture which only increases the complexity bridge teams face.

Marco Vatteroni also described a more basic issue regarding how the industry treats information. As he put it, “they say, ‘For us, PDF is enough.’ But PDF cannot be enough.” Many shipping workflows still rely on digital documents that behave like paper, rather than structured data that can move easily across systems.

The challenge is organisational and technical, as different systems are often introduced by different stakeholders, including equipment manufacturers, software providers, regulators, and internal performance teams, each with their own priorities.

This disconnect tends to start during the design phase. Amitvikram Chitnis explained, “most of the systems you have teams giving the concept to the IT team. Now the IT team has never had the operational experience.”

In these situations, potential problems do not only include system failure but also the crew’s ability to maintain situational awareness under pressure. A design that seems straightforward for an IT native may not be easy to interpret in a real-world, busy shipping environment.

14. International Maritime Organization (Accessed March, 2026)
[E-navigation](#)



When digital tools create new risks

Digital tools can also introduce new risks. For example, while automation is effective for routine tasks, it can lead to reduced engagement and delayed response when human intervention is required.

Matthew Bland highlighted, “in the past people understood the implications of what they were doing and the process, whereas now that is seen as a waste of knowledge, and people are expected to just know what to do rather than why they are doing it.”

This creates a situation where systems perform well most of the time, and users get used to that way of working, making it harder for operators to re-engage quickly when something goes wrong. As Capt. Abhijit Arvind Mohite stated, “over-reliance on equipment is a real hazard, especially when people don’t understand its limitations.”

Robert Pogson discussed a subtler risk whereby there has been a gradual loss of manual navigational confidence as bridge teams become increasingly dependent on digital tools. On this issue, he emphasised how “there is definitely a risk for skills fade within the labour pool.”

Risk is compounded by the way digital tools can hide weak practice until a vital moment. Alexander McDonald observed, “the digital systems are so good in many ways that they can mask a lack of competence until a point where it becomes a little bit critical.”

This reinforces concerns that automation can negatively affect engagement if not paired with strong operational understanding. In a bridge setting, where timing is so important, this can lead to slower reactions, misreading of system messaging, and a general over-reliance on automation.

The problem is exacerbated by cross-system dependencies, with many platforms relying on common inputs, such as GNSS, so that when these inputs are disrupted, multiple systems can be affected simultaneously.

“The digital systems are so good in many ways that they can mask a lack of competence until a point where it becomes a little bit critical.”

Alexander McDonald

A Coastal Tanker Master at a shipping company





Designing systems around human capabilities

The IMO's human-centred design guidance argues that tools ought to align with the characteristics of the intended users and their tasks, rather than requiring users to adapt to the system.¹⁵

That gap between design intent and operational reality was a recurring theme in the interviews conducted for this report. As Amitvikram Chitnis put it, “any system which is designed without keeping the people at the centre never works.”

IMO's human-centred design guidance also outlines the need to design systems that account for human limitations and support safe operation across changing conditions, especially when operators are more vulnerable to error.

The IMO's Bridge Alert Management (BAM) standard states that information should be minimised to what is necessary to assess the situation.¹⁶ This means that decision-ready systems should present the most relevant information first, suppress low-value noise, make system status and mode changes as clear as possible, and integrate related tasks into workflows rather than scatter them across disconnected systems.

Good design should not overwhelm operators with every possible input, but rather it should highlight what is relevant in context. It should make system status and mode changes obvious, reduce the number of steps needed for routine actions and avoid forcing bridge teams to remember workarounds or inconsistent logic under pressure.

For Barry Hooper this means technology providers need to remember the real conditions in which systems are used. “There are tired humans on the bridges of our ships, and we shouldn't be overcomplicating their lives. Their job is to get a ship safely and efficiently from A to B, our job is to make that easier for them.”

They should focus on handling routine, repetitive data tasks that make life easier for crews, while still keeping people firmly in control of safety-critical decisions. Just as importantly, these systems need to be tested under real bridge conditions, not just signed off as technically sound.

Improving bridge operations is not about adding more layers of intelligence or more tools. It is about building systems that actually work for the people using them, recognising their limits, supporting their strengths, and fitting into the realities of daily life at sea.

15. International Maritime Organization (July, 2015) [Guideline on software quality assurance and human-centred design for e-navigation](#)

16. International Maritime Organization (May, 2010) [Adoption of Performance Standards for Bridge Alert Management](#)

Improving digital navigation environments

The challenge is no longer about whether ships are becoming more digital. It is about whether these environments are designed to support operational resilience.

Improving digital navigation environments is not dependent on adding more tools or increasing system capabilities. It is about reducing friction between systems, harmonising technology with real operational workflows, and ensuring that digital capability translates into better decisions in practice.

This process entails a shift in focus, with the industry needing to ask itself how technology is actually used onboard, and whether it supports or hinders the people responsible for operating it.

From fragmented tools to integrated workflows

Modern bridge operations rely on how effectively information can flow between systems, users, teams, and operational workflows. To lessen operational friction, the industry needs to move toward more integrated digital environments.

Navigation, compliance, performance monitoring, weather routing, and operational planning should be integrated into connected workflows instead of isolated systems. Often, these isolated systems end up competing for crew attention and require manual workarounds across multiple platforms.

The IMO's e-navigation strategy reflects this focus through its emphasis on coordinated data exchange and better integration between shipboard and shore-based systems.¹⁷ This would involve reducing duplicate data entries, improving interoperability across platforms, and ensuring that operational information can be accessed through a unified operational picture.

A better-integrated bridge environment would allow crews to spend less time managing systems and more time on operational decision-making. Systems should present navigational, compliance, and performance data in ways that support prioritisation and swift decision-making amid pressure.

This highlights a broader operational challenge onboard: the issue is often not a lack of data but the burden of interpreting it in real time. Capt. Abhijit Arvind Mohite underlined this, explaining that "it is up to the user how to interpret data, with interpretation being the central challenge."

17. International Maritime Organization (Accessed March, 2026) [E-navigation](#)



Better-integrated systems could reduce the need for crews to mentally combine information from multiple disconnected sources while operating under pressure.

Our interviewees discussed how this can be supported through standardisation across equipment manufacturers, shared data environments, and the adoption of interfaces that present information consistently across platforms.

For example, Matt Bland explained that there should be “commonality between systems, with the user interface being intuitive, and it should be obvious what you’re meant to do.”

Involving operational personnel earlier in the system design and testing process could help ensure that systems are built around real bridge conditions rather than assumed workflows.

Rather than evaluating systems under controlled settings or against technical performance criteria, technology developers and operators should assess how technologies perform in high-workload operational situations, such as pilotage, congested waterways, heavy traffic, degraded GNSS conditions, port arrivals, and alarm-heavy environments.

Moving towards a more grounded approach to system development could involve simulator exercises, onboard trials, and scenario-based usability testing. This approach would help assess a system’s technical functionality, as well as whether it remains usable under pressure, reduces unnecessary interactions, and supports prioritisation during periods of fatigue and high workload.

These concerns were closely linked to broader interviewee calls for greater standardisation. As Shravan Bhagra argued, “standardisation would make things better for people,” because crews are ultimately “doing the same thing” across different vessels and companies.

Achieving this requires alignment among equipment manufacturers, software providers, regulators, and shipowners on shared interface principles, alarm structures, and data formats.

Interviewees frequently described the operational burden of adapting to unfamiliar systems and workflows when joining new vessels or transitioning between equipment types.

For example, Shravan Bhagra described repeatedly transitioning between different ECDIS manufacturers and software systems during his career, arguing that officers are often expected to become operational on unfamiliar systems after only limited training.

// Integration should be judged by whether it reduces workload, improves clarity, and supports safer operational decision-making onboard.

More consistency across systems would help create more intuitive operating environments and reduce the cognitive effort required from seafarers to manage multiple disconnected platforms.

This is particularly important during high-workload situations, when crews may have limited time to adjust to unfamiliar interfaces. At such moments, operational resilience depends less on the volume of available information and more on whether systems help crews identify what matters most while limiting unnecessary interaction with onboard systems.

Integration should be judged by whether it reduces workload, improves clarity, and supports safer operational decision-making onboard.

Reducing cognitive load through system design

While greater integration can reduce fragmentation, system design determines how the crew experiences information. As discussed, cognitive load is a leading limiting factor in decision-making.

Increasing the volume of information alone does not improve performance unless the additional information is properly structured and prioritised. The IMO’s guideline makes it clear that systems should be designed to meet users’ needs and support their tasks, ensuring usability, safety, and effective performance in real operational conditions.¹⁸

This reinforces the need to design systems around how work is actually done onboard, not how it is assumed to be done.

Successfully reducing cognitive demands should start with how information is presented. Interfaces should reflect operational workflows, not technical structures, by grouping related information, reducing unnecessary steps, and ensuring that systems present information consistently and predictably.

18. International Maritime Organization (July, 2015) [Guideline on software quality assurance and human-centred design for e-navigation](#)

Inconsistent interfaces increase the effort required to interpret information and can lead to errors, notably under pressure. Alert design is another central factor.

The Bridge Alert Management standard emphasises prioritisation and relevance, ensuring that alerts enable rapid recognition of abnormal situations. Despite the guidance, many systems still generate high volumes of alerts that do not clearly indicate the next action the crew should take.

This can lead to the crew having to filter information themselves, increasing cognitive load when attention should be focused on decision-making. Alerts should be contextual, highlighting what matters in a given situation rather than presenting all available information equally, allowing crews to prioritise and respond more effectively.

This is important because cognitive load is not shaped solely by major failures or incidents. It is also shaped by the accumulation of small design frictions.

A system that requires multiple steps for a routine action, presents too many similar alerts, or forces users to move repeatedly between screens adds mental effort even when nothing is going wrong. In low-pressure situations, this might be manageable, while in high-pressure situations, it becomes a risk factor.

Designing for lower cognitive load should involve removing unnecessary mental work wherever possible, so that crews have more capacity available for the moments that genuinely require judgement.

Automation also helps reduce workload, especially for repetitive tasks like data entry and reporting. However, automation should be implemented carefully, as research shows that excessive reliance on it can lead to complacency and limited situational awareness.

This balance between support and over-reliance remains a practical concern onboard. Capt. Abhijit Arvind Mohite warned that “you cannot fully go with technology. You have to balance both and use it as a tool.”

Effective system design requires balance, and automation should reduce workload without removing visibility. Bridge teams should understand what systems are doing, particularly when conditions change or systems behave unexpectedly.

Reducing cognitive demands does not involve the total removal of complexity. It is about managing complexity in a way that supports human decision-making. Systems should make it easier to understand what is happening, what matters, and what needs to be done next.





The future of digitally enabled bridge operations

As maritime operations become more connected and data-driven, the industry is moving away from isolated systems towards integrated digital environments which better support onboard and ashore decision-making.

Integrated operational platforms are likely to become more prominent as they aim to bring together navigation, performance monitoring, compliance, and communication into a single environment, reducing fragmentation and improving situational awareness.

Advances in decision-support systems and predictive analytics also provide potential. By combining historical and live data, these systems can identify trends, highlight emerging risks, and provide recommendations to support operational decisions.

However, these developments depend on strong data foundations; without consistent data quality, standardisation, and integration, more advanced systems risk adding complexity rather than reducing it.

There is also a need to sustain a balance between automation and human control. Research into automation in safety-critical environments shows that excessive reliance on automated systems can reduce situational awareness and delay responses in emergencies.¹⁹

// The success of digital navigation will not be defined by how advanced the systems are, but by how well they support the people who use them.

This is a central issue on the bridge, where timing and judgement are central to effective operations. Future systems should be designed to support, not replace, human decision processes.

This includes upholding transparency in system behaviour, training crew to understand system restrictions, and preserving the ability to intervene when required. Hristo Hadzhiev explained how the biggest improvement now would come less from adding new systems and more from improving preparation before crews join the vessel.

He argued that “it is good to have better training before joining the vessel, simulators in particular are very useful”. The IMO’s e-navigation framework points towards a better-connected digital ecosystem, centred on the consolidation and exchange of data between ship and shore systems.

If implemented successfully, this could facilitate a shift from fragmented tools to integrated, decision-ready environments. The success of digital navigation will not be defined by how advanced the systems are, but by how well they support the people who use them.

That points back to culture, trust, and how companies support the people at sea. As Pradeep Chawla said, “the best solutions always come from the people at the sharp end.”

The goal should not be more technology, but rather better alignment among systems, workflows, and human abilities. This would help create a bridge environment that improves safety, reduces workload, and supports consistent decision-making throughout operations.

Robert Pogson underlined how one of the biggest practical issues for crew is how little time they get to adjust to new technology. “It is probably one of the biggest cold starts you will ever get in your career, and some of this equipment you have never seen or touched in your life,” he said.

19. Department of Industrial Engineering Texas Tech University (Endsley (1995); Parasuraman et al. (2000)) [Automation and Situation Awareness](#)

Conclusion and recommendations

Digital navigation systems have improved bridge teams' capabilities and have also increased the complexity of the bridge environment. The issue is that technology has often been added in layers, creating more systems, more alerts, more data, and more interactions for crews to manage.

Modern bridge teams are operating in an environment where navigation, compliance, performance management, reporting, and shoreside oversight are increasingly connected. This has created obvious operational benefits in isolation, but it has also increased the cognitive strain placed on crews.

The risks facing modern bridge operations are no longer driven only by traditional navigation problems. They are also affected by how crews interact with complex digital systems, how information is presented, how alerts are prioritised, and how well different tools work together.

When systems are fragmented, crews are often required to act as the link between them, interpreting conflicting information, moving between interfaces, validating system outputs, and deciding which data to trust under pressure.

This results in functional resilience becoming dependent on individual experience rather than good system design. The evidence gathered for this report indicates that improving bridge operations calls for a shift in focus.

Digital progress should not be measured by how many systems are installed, how much data is available, or how advanced individual tools appear to be, but rather by whether those systems help crews make better decisions in real working conditions.

The main aim should be to reduce complexity, not add to it. To achieve this, four recommendations have been identified.

01 Design bridge systems around operational realities

Technology providers and operators should begin by understanding how crews work at different points of a voyage. Interviewees told Thetius that alarms and system notifications are valuable at times but unnecessary at crucial moments, such as berthing, as the crew are already aware of the dangers they warn of.

Systems also need to be tested in real bridge conditions, including pilotage, congested waters, bad weather, equipment disruption, crew fatigue, and under time pressure. Systems tend to be designed around technical capability or compliance requirements rather than real-world operational use.

This can create tools which work in isolation but do not fit well inside daily routines on board. Bridge systems should reduce the number of steps required for routine actions and support the way crews already make decisions.

Essentially, good design should ensure work is made easier during busy periods, not only during normal conditions.

02 Integration over adding new tools

It is the responsibility of shipowners and technology providers to focus on connecting existing systems before adding new ones. Modern-day bridge environments already have sufficient data; the challenge is that it is commonly fragmented across several platforms, displays, formats, and reporting tools.

Greater integration across systems would reduce the need for crews to manually interpret and connect information from multiple sources. It would also improve situational awareness by providing bridge teams with a better and more reliable operational picture.

Integration should not be treated solely as a technical ambition, but rather as a means to reduce workload, reduce fatigue, increase clarity, and support better decision-making onboard.

03 Reduce alert fatigue and information overload

There should be a review of how alerts are configured and presented to crews, especially during high-pressure moments. Alerts must highlight what requires action, not simply increase the volume of information competing for attention.

Poorly configured or low-value alarms can lead crews to acknowledge alerts without thoroughly comprehending or engaging with them. This creates genuine operational risk, especially when important alarms appear alongside repeated non-essential alerts.

Bridge alert systems should be contextual and designed to support attention during high-workload periods. The aim should be to help crews understand risk, changes, and what needs to be done next.

04 Keep people at the centre of bridge operations

The future of bridge operations should not involve removing people from the decision-making process. It should be based on giving crews better support and information, reducing workloads and fatigue, and on systems which recognise and support human limitations.

Automation and decision-support tools can reduce workload, but they should not reduce crew engagement or understanding. Crews need to fully understand which systems are in place to support safety and know when human control may be required.

Shipowners, regulators, and technology providers have a central role to play in guaranteeing that bridge systems support human decision-making rather than replace or overload it. Training, familiarisation, usability testing, and crew feedback should all be essential elements of digital system design and implementation.

Improving digital navigation environments is not about more technology. Rather, it is about capable technology which improves operations, with improved levels of integration and a better understanding between systems and the people who use them. Modern bridge tools should help crews manage complexity rather than asking them to manage more of it.

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