Understanding the Drivers, Solutions and Enablers within the Shipping Industry

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INTRODUCTION

The shipping industry is going through significant change, driven by the need for it to be a cleaner, greener industry and the explosion of digitalisation and technology that has opened new opportunities for shipping companies and supporting organisations, such as hydrographic offices, to evaluate and develop fresh solutions.

This whitepaper explores the key drivers/issues that are influencing the shipping industry from a customer/end-user perspective and the solutions and enablers which are being developed to address these drivers.

A driver, solution and enabler can be defined as:

- **Drivers:** an internal or external pressure that shapes change to an organisation or industry, such as changes to regulation, or a business strategy or its operations.
- **Solutions:** an initiative or product/service designed to address a particular problem or need.
- **Enablers:** a person or thing that makes something possible.

EXECUTIVE SUMMARY

Two drivers have been dominating the shipping industry in recent years and will continue to dominate in the future: shipping companies seek to reduce emissions and improve operational efficiency through investing in technological tools to forensically monitor their fleet.

Shipping companies seek to achieve this through optimisation in the short- and medium-term and using alternative fuels in the long-term. Examples where optimisation will benefit the customer/end user: better voyage planning and execution, post voyage review, reviewing vessel and fleet performance and negotiate better charter party terms.

For optimisation to be successful, it is imperative that the vessel receives real time secure data feeds, with increased internet connectivity, having sufficient cyber security, and supported with appropriate training.

Drivers	Solutions	Enablers
• Environmental accountability • Improve operational efficiency	• Environmental initiatives • Alternative propulsions & fuels • Optimisation • Autonomous Navigation	• Increased internet connectivity to support real time data feeds • Cyber security • Training & simulators

DRIVERS

These are addressing the industry environmental impact and shipping companies desire to improve operational efficiency to maximise financial returns.

Environmental Accountability

The shipping industry emits around 3% of global greenhouse emissions and without intervention these emissions will continue to increase, given the growing demand for global trade. Many shipping companies are looking at become carbon neutral and promoting its green credentials by publicly reporting their carbon emissions, via the greenhouse gas protocol. Whilst emission publication is not mandatory today, it is anticipated that it will be in the future, meaning companies will need to highlight shipping's emission contribution in the supply chain.

There are many industry initiatives to address the industry's emissions.

International Maritime Organisation (IMO) – overall targets

IMO's initial greenhouse gas strategy (GHG) calls for emissions to peak as soon as possible, to fall at least 50% by 2050 and for at least a 40% reduction in the carbon intensity of international shipping by 2030 (vs. 2008 levels).

MARPOL

The IMO's Marine Environment Division is the IMO's senior technical body on marine pollution related matters. The original focus of its work was the prevention of marine pollution by oil, resulting in the adoption of the first ever comprehensive anti-pollution convention in 1973. Since then, MARPOL has changed to include a wider range of measures to prevent marine pollution coming from chemicals, other harmful substances, garbage, sewage, and other emissions from vessels.

Poseidon Principles

The Poseidon Principles are the world's first sector-specific, self-governing climate alignment agreement amongst financial institutions and established a global framework for assessing and disclosing the climate alignment of ship finance portfolios. The four principles are Assessment of client alignment, Accountability, Enforcement and Transparency, and are consistent with the policies and ambitions of the IMO's GHG strategy. Signatories include global banks and other financial institutions and, combined, represent a global shipping bank loan portfolio of more than US$185 billion, nearly 50% of the global ship finance portfolio. It is committed to improving the role of maritime finance in tackling shipping's climate impact.

Carbon Intensity Indicator (CII)

The Carbon Intensity Indicator is a rating system the IMO has developed and is a mandatory measure under MARPOL Annex VI. The measure will impact all cargo, RoPax and cruise vessels above 5,000 gross tonnage and trading internationally. The CII measures how efficiently a vessel transports goods or passengers, based on grams of CO_2 emitted per cargo-carrying capacity and nautical mile. The vessel is then given an annual rating ranging from A to E, with A being the best score. Vessels with poor ratings (D or E for three consecutive years) are required to submit a corrective action plan to improve performance and get to the required index rating of C or above. These rating thresholds will become increasingly more stringent in the next 10 years.

Government pressure

It is probable that all countries will set emission reduction targets and have initiatives to address it. Some governments are considering applying an actual financial cost to CO_2 emissions to encourage shipping companies to act.

- **European Union:** approved the inclusion of shipping in its emissions trading system (ETS). The move will impact vessels above 400 gross tonnage and offshore vessels. Polluters are expected to pay for their share of greenhouse gas emissions during voyages within the bloc and half of the journeys outside the EU until 2027. From 2027, all vessels sailing in and out of EU ports will automatically be included in the carbon market system. The EU's "Fit for 55" package aims to reduce greenhouse gas emissions by at least 55% by 2030 (vs. 1990 levels) and achieve net-zero emissions by 2050.
- **China:** propose to set up an upper and lower CO_2 emissions level for each vessel, based on the vessel's upper and lower 'C' rating boundaries as set out in the CII rating guidelines, the vessel's capacity and actual distance travelled in a calendar year. A shipping company is penalised when its vessel emissions exceed the upper CO_2 level and rewarded when the emissions are below the lower CO_2 level.
- **Japan:** propose to implement a carbon tax where shipping companies pay $56 per tonne of CO_2 emitted between 2025 to 2030, and this fee increases every five years. The monies raised will go into the development of zero-emission vessels.

Improved Operational Efficiency

Technological developments driven by digitalisation have given shipping companies the tools to forensically monitor their fleet to improve its operation and maximise the financial return. Examples includes:

- Reducing fuel consumption through fuel optimisation and monitoring.
- Having the vessel working at its optimum level through vessel operations performance monitoring and analysis on equipment condition, engine performance, bunker planning etc.
- Improving the route planning by avoiding adverse weather, monitoring currents and tides, and berthing at ports immediately on arrival to avoid port service costs and delays.
- Optimising the fleet so shipping companies making the best use of all the assets it owns.
- Vessel utilization optimization e.g., demand or freight price forecast.
- Being environmentally compliant to prevent fines and gain access to green finance.
- Cargo tracking and monitoring.
- Supporting the welfare and wellbeing of its crew.

A report published by Inmarsat in May 2020 demonstrates the interest shipping companies have in digitalisation to improve operations. The "Digitalisation Uncovered" report surveyed 186 respondents and key findings were:

- Shipping companies' primary drivers for digitalisation were for cost reduction and operational efficiencies reasons, followed by regulatory compliance.
- Vessel performance monitoring and fuel optimisation/monitoring were the most widely deployed solutions, followed by engine performance monitoring and analysis, and emissions monitoring.
- Going forward, 83% of those planning to deploy more fleet and vessel performance solutions said they wanted to deploy fuel optimisation and fuel monitoring applications within 24 months. Digital navigation solutions followed, accounting for between one-fifth and one-quarter of the applications being deployed or tested.
- When asked to identify challenges to implementation, 37% included a 'lack of or little evidence of value for money' as a top 3 reason.

Source: Inmarsat 2020

SOLUTIONS

Environmental Initiatives

Initiatives set up by governments and regulatory bodies to curb emissions in geographical areas (protection zones) or to encourage environmental consideration.

Emission control areas (ECA) *Protection zone*	Under Annex VI of MARPOL (air pollution from vessels), IMO member states agree to abide by fuel emission standards that are about three times more stringent within ECA's, covering nitrogen and sulphur oxides, and particulate matter. Existing ECAs are around the Baltic Sea, North Sea, North America (most of US and Canadian coast) and US Caribbean; with the Mediterranean set to become an ECA, a significant development considering the volume of shipping that travels through it.
Marine Protected areas (MPA) *Protection zone*	Pockets of oceans, bays, and estuaries around the world are designated as MPAs. Examples include the Florida Keys and Australia's Great Barrier Reef. Governments establish MPAs to help protect marine ecosystems, to protect underwater archaeological sites, shipwrecks, and other historically important places, provide areas for scientific study, help local tourism, and set responsible fishing practices.
Mammal migration pathways	It is anticipated that the industry will develop a greater understanding in mammal migration (whales, porpoises etc), and this will be factored into future voyage routing operations.
Green corridors	It is likely that there will be more interest in green corridors in the future despite it having no formal definition. Green corridors do not appear to be a routeing scheme. The use of the word 'corridor' is not meant as a defined navigation route from port A to port B but indicate that the ports at either end of the corridor support a range of green measures to assist shipping and shore-side activities.

The Customer / End user perspective

Shipping companies need to be aware when they are entering ECAs or other protected zones and apply the right operational rules to ensure they meet the regulations and prevent financial penalties.

Green corridors sounds more of a PR initiative than something more concrete. However, if these corridors meet green credentials that benefit both shipping companies and the ports, this could generate more activity along these routes. Smaller ports may use green corridors as an opportunity to differentiate themselves from their competitors.

Whilst environmental initiatives are led by governments or regulatory bodies, the following solutions are driven by shipping companies, with the aim to be more operational efficient and to maximise revenues and profits, as well as addressing environmental obligations.

Alternative Propulsions and Fuels

An immediate solution shipping companies can deploy is to install alternative propulsion on vessels, such as sails, kites and Flettner rotors. Of the three, Flettner rotors are leading in terms of development and deployment, given they are of modular design, almost fully automated and they could be retrofitted onto many vessels. All three are only suitable in windy conditions so they are a part-solution rather than the whole-solution to tackling emissions. The challenge for these alternative propulsions is whether there is a compelling business case to install this propulsion vs. the fuel savings/reduction in emissions.

Longer term, cleaner emission fuels are seen as the main pathway for the shipping industry to reduce carbon emissions and other pollutants. Today, there are established fuels that can reduce or eliminate these pollutants (low-sulphur marine fuel, biofuel, liquified natural gas, methanol), and there are active trials of new fuels (hydrogen, ammonia). The short-term challenge shipping companies face is the cost in converting existing vessels to the new fuel (if that is even a practical option). For new vessels that already use alternative fuels, shipping companies need to consider the port infrastructure the vessels visits – does the port have alternative fuel refuelling facilities and is the supply reliable?

The Customer / End user perspective

With many developments happening on many fuels, which fuel will win out and becomes the 'fuel of the future' has yet to be determined. The worst-case scenario for a shipping company is to invest in an alternative fuel, only for that fuel to get superseded by another and become redundant. Alternative fuels will play a role in reducing emissions, but it is a future solution. In looking for a solution today, we need to be looking at optimising the performance of the vessel, improve route planning and making the port call operations more effective and efficient.

Optimisation

As alternative fuels continue to be developed to tackle emissions, they can only be seen as a long-term solution. For the short and medium term, data driven solutions such as optimisation are required if shipping companies are to meet CII targets and become more operationally efficient. It is anticipated that alternative fuels will be more expensive than traditional fuels, so any data-led solution today that demonstrates to a shipping company how it can reduce its fuel consumption is a positive thing.

There are three defined areas of optimisation: vessel, voyage, and port-call. Only two (voyage and port-call) appear to use any form of navigation data and use it for its intended purpose - to plan and validate safe and legal routes. Whatever type of optimisation is taken, all three require the gathering of data (ideally a real time data feed), analysing it and reacting accordingly. This reaction may be automatic i.e., vessel correcting its engine output based on current sea conditions, or require a human to adjust i.e., a person evaluates the optimisation tool recommendation to change routeing course and then reacts, or somewhere in between.

Types of optimisation

Vessel	Making improvements to the physical, mechanical, and electrical aspects of a vessel such fuel efficiency or reducing hull friction and have no role for navigational purposes. • Vessel dynamics optimisation: optimising the performance of the vessel (including engine and power optimisation, hull performance, cargo / ballast management). It also considers factors such as sea state and can include real-time monitoring and correction. • Fleet optimisation: following on from above, uses comparative analysis and information between vessels in a fleet to optimise the overall efficiency of the fleet.
Voyage	Making improvements to the route of a vessel to take account of dynamic external factors such as weather, waves, and currents. In addition to the services Hydrographic offices provide i.e., confirming safety of a route. • Weather routing: optimising oceanic voyage based on forecasted weather, sea state and ocean information. Sophisticated tools also consider the characteristics of the vessel for more accurate predictions. • Routing improvements: identify shortest navigational route and speed, estimated time of arrival, the optimum feasible time for a vessel to reach the port to maximise cargo value, passenger comfort, the safest route in terms of piracy risk, terrorism, conflict, achieve the lowest overall cost and/or the highest margin.
Port-call	Making improvements to the interface between vessel and port, such as improving estimation of vessel arrival times; supporting just-in-time arrival; tracking vessels and the cargos they carry; improving the support and service the port and its support services can offer vessels. Solutions are maturing and offered by several organisations. There is demand for these types of solution and they aim to deliver tangible benefits to their users such as supply chain resilience, fuel savings, contributing towards decarbonisation and sharing information between vessel and the shore. • Just in time arrival (JTA): looks to avoid waiting time outside ports by sharing information on berth availability with the vessel, to enable it to optimise its speed on route and to arrive at the agreed time. • Port-call optimisation: closely related to above, this ensures the streamlining of delivery of services and load/unload operations, to make the time in port for any vessels as short and as predictable as possible. • Dynamic under keel clearance (DUKC): integrates real-time measurement of tides and waves, with modelled vessel motions to maximise port efficiency and safety.

The Customer / End user perspective

The phrase 'optimisation' tends to be used by vendors and suppliers of products and services i.e., voyage optimisation. The end user tends to use the term performance i.e., fleet performance or vessel performance and have a holistic view – they are interested in the vessel, the voyage, and the port-call solution at the same time if they are to operate the fleet at the optimum level. For example, if the hull or propeller is not in good condition or the engines are not functioning properly, then the vessel's ability to complete the voyage efficiently and effectively is impaired and the voyage may take longer to complete and therefore use more fuel.

For large and medium shipping companies, operators, and charterers, the voyage decision making tends to be done jointly between the vessel bridge and shoreside support teams, with the Master having final decision. This means other parties may influence the decisions onboard. For example, the shipping company may demand the vessel performs to a certain performance envelope of speed and time of arrival to reduce wear and tear on the vessel and its engines, while the charterer may want to save fuel or arrive faster.

In recent years, the industry has seen the software market explode with the number of vessel software vendors increase from around 170 in 2017 to over 550 today[1]. Without the benchmarking of different applications in relation to their operational benefits, there is a risk that shipping companies may make poorly informed decisions and compromise the efficiency gains they are trying to achieve from this software.

[1] Source: Arkevista 2022

Autonomous Navigation

Autonomous navigation is when a vessel can plan and execute its voyage without human intervention. This is achieved by training or programming the vessel with data about the vessel behaviour in various sailing environments, driven by intelligent analytics based on machine learning algorithms. Its overriding purpose is optimisation of the vessel by adjusting to the internal and external environment, such as internal operations (engine power, emission control etc) and changing the passage routeing to avoid adverse weather, strong currents etc.

The path to the adoption of autonomous vessels is expected to follow a similar path to the adoption of autonomy in other transport sectors, i.e., increasing adoption of intelligent decision support and task automation tools across the board with a few early adopters testing the water to provide evidence to the rest of the industry of its economics and safety. Autonomous navigation does not automatically mean a vessel will have no crew onboard. The navigation team on a large vessel is a small proportion of the overall crew, so unless all systems on the vessel are autonomous there will need to be a human presence on board overseeing other operations such as the maintenance of the vessel and the safety of the cargo. Additionally, human intervention can also occur via a remote-controlled solution.

Benefits	Challenges
• Keeping operational expenses as low as possible to facilitate efficient international trade (optimum operational performance and route planning) • Reducing environmental impact and emission of greenhouse gases • Addressing the shortage of skilled mariners • Improving the safety of vessel operations	• No global regulations exist (currently fragmented) • Lack of a compelling business case • Lack of infrastructure to support autonomous vessels and the cost of implementation • Human and organisational inertia and lack of a single coordinated approach • Understanding the new risks and liability • Lack of skilled personnel to operate remote-controlled vessels and monitor autonomous vessels • Technology & ethical issues • Coexistence with staffed vessels

Timeline	Adoption stages
2020 Remotely operated local vessel Reduced crew with remote support and operation of certain functions **2025** Remote controlled unmanned coastal vessel **2030** Remote controlled unmanned ocean-going vessel **2035** Autonomous unmanned ocean-going vessel	**Stage 1: Coexistence** See a small number of autonomous vessels operating alongside staffed vessels. Likely to be high-tech shipping companies who are likely to have existing modern, well-automated fleets with well-paid crew on board and can afford the new technology. **Stage 2: Separation** In this stage, the increase in autonomous vessels and areas of operation will lead to the emergence of new shipping lanes and geographical regions where autonomous vessels will be primarily used. It would be natural for certain water areas and traffic separation systems to be designated as "only for autonomous vessels" as this will reduce any risks associated with autonomous vessels interactions with unpredictable or poorly controlled crewed vessels. **Stage 3: Predominance** Since transportation by autonomous vessels will be cheaper and safer, older vessels will naturally move to niche regions where autonomous vessel use is likely to be impossible or economically unprofitable. These may include areas with a small volume of traffic or have extremely unpredictable weather and climatic conditions.

The Customer / End user perspective

The first autonomous vessel journeys are likely to be vessels that go to and from the same port every day, on the same route. For example, commuter ferries and small container vessels. It is likely that a navigational crew will still be required in busy ports and shipping lanes due to regulatory requirements and this will continue until most vessels become autonomous.

Key issues shipping companies need to consider are:

- *The commercial business case - whether it is the costs involved in purchasing new autonomous vessels or retrofitting existing vessels to unmanned vessels.*
- *What are the operational changes required to adopt these vessels – a larger onshore operational team, and on what routes can these vessels operate on?*
- *Overcoming the human and organisational inertia – what education and training is required to overcome this? If there is a navigational crew on board to monitor and react when required, clarity on areas of responsibility need to be defined i.e., when does a mariner overrule the computer?*

ENABLERS

Fundamental to optimisation is the need for real time data feeds so mariners onboard or the shoreside team can assess the information immediately. For this real time transfer of data, a strong and reliable internet connection is required. Just like on land, vessel data is at risk of malware or being hacked, so strong cyber security is required. Finally, training needs to be implemented for mariners onboard and/or the shoreside team to understand all this data, to then make the right decision.

Increased internet connectivity to support real time data feeds

Historically the primary driver for communications between vessel and shore has been the safety of the crew and passengers and seen as a requirement. With the advent of the internet and connectivity, different communications have developed – to optimise operations i.e., route planning, and crew and passenger welfare and entertainment. This has become possible with the move away from analogue to digital and connecting the vessel to orbital satellites via a VSAT (Very Small Aperture Terminal). Research conducted by the UKHO, surveying mariners and fleet managers, found that over 70% said they have full access to the internet anywhere in the world and not just on coastal waters. When asked what it is used for, the majority said for both vessel operations and crew social use. These numbers were similar regardless of the type of vessel, although the numbers decline in older vessels (over 15 years old).

Cyber security

Today, vessels have many digital systems for both navigational and operational reasons and deploy sensors to deliver this. As such, cyber security has become critical on vessels to protect itself. Naturally, we think that cyber-attacks need to be sophisticated. It doesn't - if appropriate security procedures are not followed by the crew to protect against malware or viruses, then the uploading of files onto EDCIS is a risk that could attack all bridge equipment. Fortunately, the industry recognises this risk. According to a recent Global Maritime Forum survey, cyber-attacks and data thefts was viewed as the 2nd highest issue where the industry is least prepared (1st was autonomy), and the 3rd most likely issue to occur over the next 10 years. Below are recent examples of collaboration within the industry to address security:

Research	• The Singapore Maritime Institute has signed a series of memorandum of understandings with Kongsberg Digital, RightShip and Wärtsilä, to cooperate on the Maritime Artificial Intelligence (AI) R&D Programme to address gaps and concerns arising from automation such as data quality and integrity, systems security, and integration.
Guidance	• The International Association of Ports and Harbors (IAPH) announced the launch of its Cybersecurity Guidelines for Ports and Port Facilities. Assists ports and its facilities to establish the financial, commercial & operational impact of a cyber-attack.
Audit & Certification	• DNV has awarded its D-INF(P) and Cyber secure SP1 certifications to Kongsberg Digital's Vessel Insight and its end-to-end data infrastructure and cybersecurity.
Technology	• Marlink has released a latest version of CyberGuard Threat Detection, its cloud-based system for vessel protection and recovery in the face of cyber threats, Including technology to retroactively explore whether any newly identified threat might have attacked the vessel.

Source: Arkevista 2022

Training & simulators

Training needs to evolve if it is to remain relevant to modern technologies on vessels and more importantly, able to connect with the next generation of mariner i.e., other training approaches beyond the classroom. Novel approaches may need to be adopted i.e., virtual, mixed, and augmented reality training. With the emergence of VR, AR and MR (see table below for definitions), there has been the development of simulator-based training, which allows mariners to accrue new skills and competencies without endangering their or anyone else's safety.

Virtual reality (VR)	Allows a person to interact within a computer-generated, artificial three-dimensional environment. An example of virtual reality is Sony PlayStation's VR games that are played wearing a headset to immerse the player in another world.
Augmented reality (AR)	Overlays or adds digital objects or elements into a real-world live view. Examples include Ikea's mobile app 'Place,' which allows you to view their furnishings in your own home, or Pokémon Go app.
Mixed reality (MR)	Combines the real world with a virtual world to create a unique environment that includes both real and digital objects. Not only can these objects co-exist, but they can also interact in real time. An example of MR is the OnSight software which was developed by Microsoft in conjunction with NASA which allows scientists and engineers to virtually 'walk' on Mars.

The Customer / End user perspective

For optimisation to work, real time data feeds are required. Today with internet connectivity via satellites, this is possible. The biggest challenge the industry needs to address is on cyber security so it is protecting its assets; and providing sufficient and relevant training so mariners onboard and/or the shoreside team can interpret the data and make the correct decision to maximise fleet and vessel operational efficiency.