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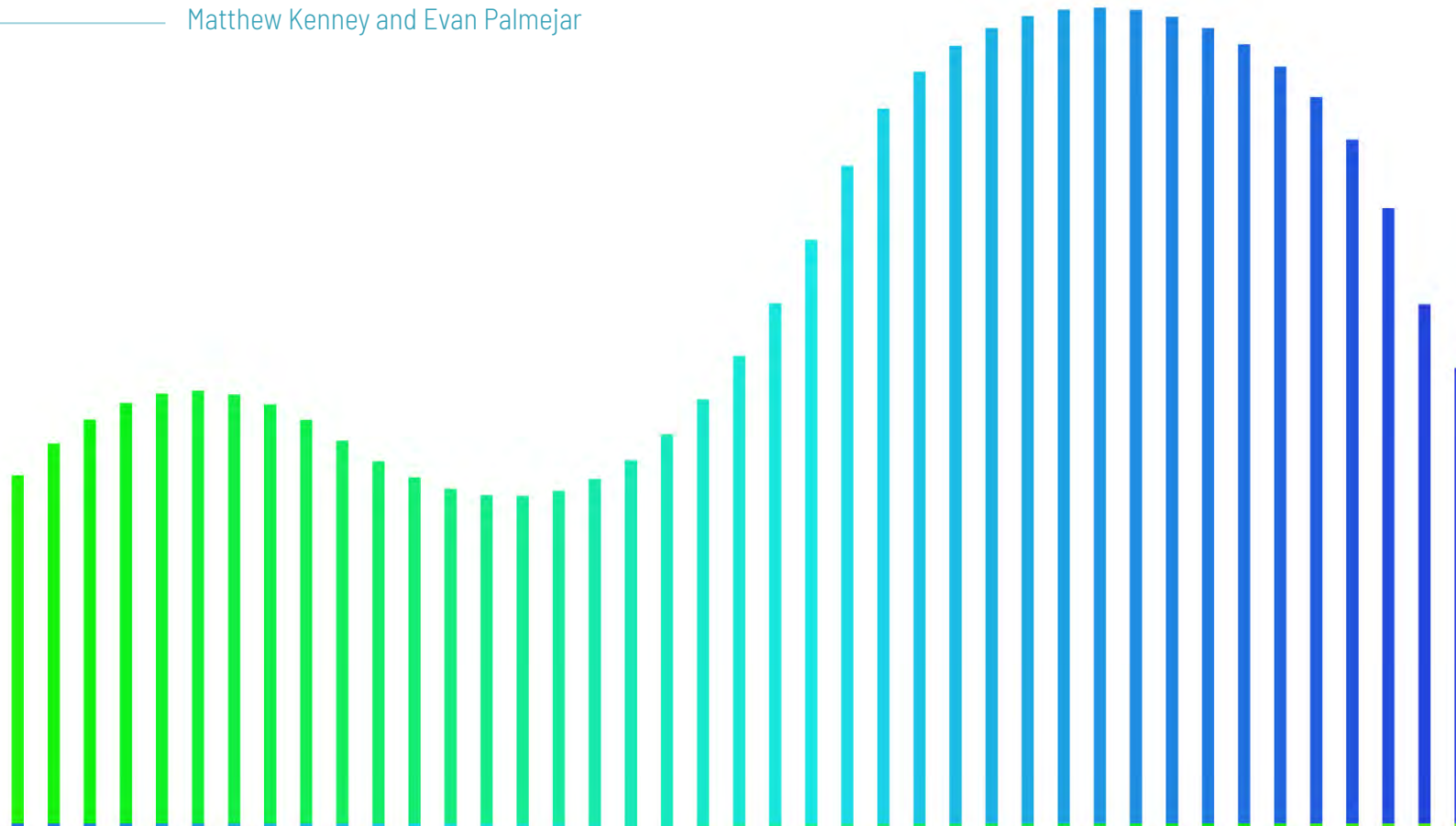
DECARBONISATION TOOLKIT

A PRACTICAL GUIDE FOR DECARBONISING THE MARITIME INDUSTRY FOR A BETTER, GREENER FUTURE.

Matthew Kenney and Evan Palmejar



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FOREWORD

Against a backdrop of evolving environmental regulations, decarbonisation is about more than just compliance – and shipping companies that have taken a proactive approach are already reaping the rewards.

In 2018, the International Maritime Organization (IMO) set sector-wide objectives for the reduction of greenhouse gas emissions. The targeted measures that followed – including the Carbon Intensity Indicator (CII) and Energy Efficiency Existing Ship Index (EEXI) – have brought into focus the threat that outdated processes pose if vessels are rated for environmental performance in ways which can affect business continuity and asset value.

Rather than seeing the motivation to decarbonise as deriving from a fear of the consequences of non-compliance, therefore, shipowners should look to seize the opportunities that sustainable operations present by embracing a responsible and proactive approach based on data. The same data that is collected, analysed and shared for compliance purposes can help shipping companies to take ownership of their energy transition – to lead and not simply to follow.

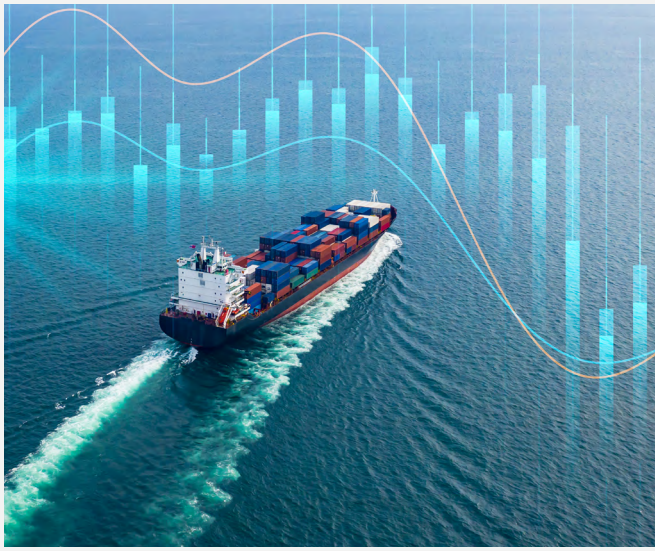
Indeed, data is key to harnessing the full potential of digital optimisation tools, which, along with other green solutions such as energy-saving devices and cleaner fuels, are gaining traction throughout the maritime industry. Companies that have taken the initiative with these technologies are already reaping the rewards of their investment – minimising their carbon footprint while saving time, effort and money at the voyage, vessel and fleet levels.

It is such achievements that maritime innovation consultancy Thetius examines in the enclosed report. Drawing on a selection of success stories from international shipping, Decarbonisation Toolkit – Decarbonising the Maritime Industry for a Better, Greener Future provides an accessible blueprint to realising a more efficient and environmentally friendly ocean freight sector.

As the report demonstrates with real-world examples, operational decarbonisation can be achieved through voyage and port-call optimisation; collaboration and data exchange; and green corridor schemes.

Ultimately, the key to a successful decarbonisation strategy is implementing a practical, data-backed plan for the application of solutions that support greener, more efficient shipping companies today and for decades to come. As a long-standing technology partner to the international maritime industry, Inmarsat remains committed to supporting businesses in overcoming their challenges, seizing their opportunities and achieving their decarbonisation goals.

Ben Palmer, President, Inmarsat Maritime



INTRODUCTION

Regardless of size and scope, all shipping companies who are looking to stay compliant, maximise their relevance and remain competitive in the years ahead now need to put ideas into action and build an effective energy transition plan.

It is overly simplistic to confine decarbonisation to a compliance issue alone. While it is true that regulations will become harder to comply with over time, thinking of clean shipping in this way shrouds the bigger picture. Imagine greenhouse gas emissions regulations like a snowball rolling down a hill. It might be possible to anticipate how big the ball will get by measuring the accretive effect of regulatory compliance alone. But that would ignore other important factors. Consumer demand, shifting sentiment in finance and capital markets, the economics of global energy, liner consolidation, industrial R&D, investment in shore-based energy infrastructure, and the strengthening of political will, are all adding to the snowball which is rapidly getting bigger.

The first Carbon Intensity Indicator (CII) report is due some time before March 2024 and until that data is understood, it is difficult to render a 'live' picture of the rate of decarbonisation in international shipping. Alignment forecasts to 2030 and 2050 involve significant uncertainty, largely because they rely heavily on economic growth factors.

But, it is clear that inertia is building in the system. Like a spring in compression, investments and developments in efficiency, optimisation, energy-saving devices (ESDs), and cleaner fuels are building momentum. Results are revealing themselves in isolation. Those companies which have responded to decarbonisation as the biggest opportunity since the standardised shipping container are already reaping returns on their investments. Carbon footprints are being reduced at voyage, vessel, and fleet levels, and with them, fuel costs and wasted time and effort.

This report examines some of these achievements and maps out an accessible blueprint to success. Through our research, we suggest a three-by-three model consisting of three phases of transition, each containing eight action steps. These are distributed throughout three transition domains, under which the most impactful tools of decarbonisation are explored. The examples in this report help by reverse-engineering success, sharing blueprints which spark ideas and share inspiration across the ocean freight sector.

"Extracting value from data is now critical to the profitability and sustainability of shipping companies the world over."

Ben Palmer, President of Inmarsat Maritime, Speaking at Singapore Maritime Week, May 2023

THE MARITIME ENERGY TRANSITION

The IMO has set global ambitions on Greenhouse Gas (GHG) reduction since 2018, becoming the first global regulator to do so on a sector-wide basis. But decarbonisation and the digital infrastructure needed to achieve it, means so much more than conforming with IMO targets.

The same data that is already gathered, analysed and shared by shipping companies for compliance purposes, can be used to take more agency of their energy transition journeys. To lead and not just to follow. This is true regardless of the size or influence of a given carrier and tangible progress toward mandated 2030 and 2050 goals can be achieved relatively quickly in many cases.

For businesses of all sizes operating within the global shipping industry, the need to embrace a responsible and proactive approach to decarbonisation is rapidly moving beyond optional. Measures like carbon credits, the Carbon Intensity Index (CII), and Energy Efficiency Existing Ship Index (EEXI), have brought the environmental impact of outdated processes and technology into sharp relief as threats to business continuity and asset values.

Pressure to bring about change and accelerate decarbonisation efforts in shipping come from both the supply and demand side of the industry. Significant pressure is building from charterers, cargo owners, and financiers as factors such as scope 3 emissions reporting and tighter environmental, social, and governance (ESG) policies become embedded into the money supply. Speaking at the Inmarsat Shaping Connected Future event at Singapore Maritime Week 2023, Sarah Greenough, Head of Maritime Sustainability at mining company and prominent dry bulk charterer, BHP, remarked, “We are seeing shareholders not only demanding value, but also sustainability credentials as well. We see both of these elements as two sides of the same coin.”[1]

But with any change comes opportunity. The maritime industry can choose to take the reins and develop effective action plans which will deliver them from present, to target states of digital and sustainable readiness. This opportunity is widely recognised by ship operators according to the Global Centre for Maritime Decarbonisation (GCMD). The action and research organisation recently surveyed 130 ship owners and charterers representing about 13,000 vessels, and found that 70% now believed decarbonisation to be very important to their business.[2]

This report considers the approaches taken by some of the most proactive businesses in the maritime industry to spot the patterns and features common to effective energy transition programs. The result is a “three-by-three” framework which can be applied to any maritime business with a need to take action. Within this framework are a number of tools which, together, makeup the decarbonisation toolkit.

Our first journey takes us through three phases of learning, insight, and execution, to move from business as usual, to taking action and seeing results.

1 Inmarsat Breakfast Event (April 25, 2023) Conference Transcript: Shaping Connected Future. More information is available at https://www2.inmarsat.com/SMW_Inmarsat_breakfast_event_2023

2 IBID (1)

THE THREE PHASES OF MARITIME ENERGY TRANSITION

Dividing complex projects into manageable phases is a good way of making progress. This approach helps businesses to identify challenges and map them spatially (i.e. where do the problems exist), and temporally (i.e. when are the problems likely to be encountered or by when will solutions be needed?).

It's clear that decarbonising the shipping industry is a very complex project. But while each business will have its own unique challenges and timelines, every project can be understood using three phases of transition. These span the process from defining the problem to implementing solutions, multiplied across three transition domains – the operation; the asset; and the human element.

One size does not fit all, but readers should find this framework helpful for understanding the fundamentals of maritime decarbonisation and arranging the tools needed to tackle their own decarbonising efforts. The three phases and their action steps are:

- **Discover**
  - Define
  - Gather
  - Analyse
- **Understand**
  - Diagnose
  - Tool
  - Connect
- **Execute**
  - Plan
  - Implement

Here we use the example of rectifying a non-compliant CII rating as a typical decarbonisation problem, but this framework is designed to be applicable to a wide range of other issues.

PHASE 1: DISCOVER

This phase consists of three actions designed to set out the problem, gather the information required to begin solving it, and put in place tried and tested techniques to turn data into understanding. This is a critical first step for any successful energy transition.

DEFINE

Confronting decarbonisation means different things to different companies. To many, decarbonisation represents an opportunity to operate a leaner and more efficient fleet at a reduced cost. To others, it is necessary to access more lucrative contracts, or better finance rates. For a few, a minimal compliance approach might suffice in the short term.

Defining a route to decarbonisation requires businesses to know their desired outcomes

in detail. Ask probing questions and commit to honest answers: Does the company still want to be operating ships in 2030 and beyond? If so, which ships? Which trade routes? Which charterers, cargo owners, trade partners, port states, financiers, and insurers does the company need to work with to remain competitive? What effects are emerging regulations, policies and laws likely to have on current fleet renewal programs and asset values?

Try to distil this learning into a single short statement which defines the decarbonisation challenge from a company-centred perspective.

"One of the biggest opportunities we have in the maritime sector is to use the data we already have. There are large amounts of interesting data not being used and dying on paper or in spreadsheets in email inboxes."

Arnaud Dianoux, Founder and Co-Founder at Opsealog

GATHER

Once the desired outcomes of the decarbonisation program have been established, the next action step is to gather raw data. This means measuring as much as possible as accurately as possible. Vessel operators who contend with CII, EEXI, EU ETS, MRV, IMO DSC etc. will already be familiar with the growing importance of collecting data from their ships and operations.

It is important to remember that the data already gathered for compliance purposes may also provide the key to making improvements to safety, efficiency, cargo throughput, and profitability. Many conventional sources of ship data are likely to be recorded already in one way or another. These include vessel position, course, speed, trim angles, weather, sea state, and tidal conditions, engine parameters such as fuel flow, power and load settings, exhaust gas temperatures, propeller revolutions-per-minute, roll, pitch, yaw, surge, and sway parameters, berth or gantry crane productivity, idle time, and others.

But the most effective decarbonisation strategies look beyond obvious data sources to uncover more "speculative" data. This is data which may not have a pre-established relevance, but could yield new insights or avenues of understanding. This data could include generator load demands, cabin temperatures and humidity, deck lighting configurations, typical handling strategies for responding to bad weather and counter currents on passage, fuel consumptions at anchor or while awaiting port services such as tugs and pilots.

It is important to recognise two key factors in data collection: accuracy and consistency. A powerful way to ensure both of these conditions are met is to consider which data could be collected and recorded digitally.

While it is likely that noon reports will continue to provide a vital data link with vessels at sea, some operators augment this with high frequency data streamed directly from sensors. This dramatically increases the amount of data points gathered (known as "resolution"), without placing additional demands on officers and crew. Where this is implemented, it is vital to ensure that data quality is considered. Your software or platform provider should provide a robust mechanism for identifying erroneous data in automated data streams.

ANALYSE

Analysing data in complex problem solving is a specialist field of expertise. However, the basic principles are simple and taking a structured and logical approach is the most important thing.

Visualisation is perhaps the most powerful tool when analysing data. A graph which plots a parameter over time, or collelates it with a related parameter (for example, a speed – consumption curve) can be a simple but effective way of spotting trends. Use the mission statement produced in step 1 (define) and consider the range of data identified in step 2 (gather) to decide what insights could be generated during analysis.

FOCUSSED GAP ANALYSIS

It is now possible to conduct a gap analysis. This method builds a picture of the "present state" and "target state", revealing the gap between them. For example, comparing an attained CII rating with a required CII rating for a particular vessel will show the gap between compliant and non-compliant. Calculating a 'D' or 'E' rating will require a corrective action plan and this alone provides a specific goal (produce a corrective action plan) and a defined timeline (1 – 3 years depending on the rating).

"A useful mechanism for breaking down behaviour factors in projects with big goals like decarbonisation is to break it into increasingly focussed 'why' questions until you uncover the true reasons behind certain actions. Only then should you look at the systems."

Karin Staal, Founder and Director, Staal Maritime

PHASE 2: UNDERSTAND

Gaining understanding is about realising the root causes of a problem in order to set about finding the right solutions. The purpose of this is to ultimately avoid wasted effort and convert learning into action. This begins with a systematic diagnosis in order to select the right tools to apply.

DIAGNOSE

Once the data analysis is completed, the present and target states defined, and the gap between them established, the next step requires a diagnostic analysis, otherwise known as a root cause analysis. Where a gap analysis answers "what" and "where" questions, the root cause analysis poses "why" questions. In fact, a popular technique for launching a root cause analysis is the "five whys" approach.

ROOT CAUSE ANALYSIS AND THE FIVE WHYS APPROACH

Continuing the example above, the analysis revealed that a vessel is misaligned with CII, so a diagnosis or root cause analysis is required to understand why and identify the corrective actions that need to take place. Studying the Annual Emissions Ratio (AER) closer will provide major clues and corrective actions are likely to become apparent since there are a limited number of variables.

The vessel in this example will need to find reductions in energy consumption for the same amount of work done, or find operational efficiencies which increase the amount of work done for given consumption. In all cases, it would be useful to group the analysis into two: **actual problems,** where the influence is in evidence, and **potential problems,** which could represent influencing factors, even if the evidence is incomplete or unclear.

Let's take a look at a basic example of a Five Whys approach to the problem above:

- **Why has the vessel failed to attain a rating of C or above?**
  - Because the carbon intensity was too high over the reporting year.
- **Why was the carbon intensity high?**
  - (one reason) Because port waiting times were high, leading to increased idle time emissions.
- **Why were port waiting times high?**
  - Because the vessel made best speed voyages to each safe port / safe berth, regardless of berth availability.
- **Why did the vessel proceed at best speed?**
  - Because it was contractually obliged to do so under the charter party agreement.
- **Why does the charter party agreement stipulate best speed?**
  - Because dynamic demurrage or just in time clauses have not been negotiated with the charterer.

This simplified example demonstrates a logical approach to finding reasons for the vessel failing to achieve a compliant CII rating. In this case, a potential course of action to address the problem is identified: seek to negotiate a charter agreement that is better aligned with just in time port arrivals in order to reduce the impact of 'sail fast, then wait', which is known to erode CII rating performance.

TOOL

During a Riviera Maritime Media Webinar on the subject of improving CII compliance ratings, a panel consisting of fleet operators and ship technologists described several strategies for improving CII. These included implementing a just in time (JIT) arrival mechanism to facilitate speed reductions, reducing energy demand on board, retrofitting ships with energy saving devices such as air lubrication, switching to lower-carbon fuels, and implementing "cold ironing" where available.[3]

Selecting and prioritising the most appropriate tools for decarbonisation depends entirely on the diagnosis and the tools available to the operator in light of certain factors. The following questions could help to identify these factors:

- Is the identified solution technological, behavioural, or contractual in nature?
- Is it a process, procedure, condition, or culture that needs to change?
- If the solution is technical, how mature is the readiness and availability of the technology? Is there an off-the-shelf solution?
- What budget can be assigned to solving this problem? Can we expect a return on investment?
- Which other resources – both internal and external – would the solution need for implementation?

CONNECT

Once solutions have been found and prioritised for each problem, it is vitally important to zoom out to take a macro view. How do these problems and solutions relate to each other? Is there a single solution which could solve more than one problem? How might one solution impact another? If so, what is the balance of risk versus reward?

It isn't just problems and solutions which need to be joined together, it is the three core domains too – the operation, the asset, and the human element.

Imagine that our CII improvement problem requires a speed reduction solution rooted in human behaviour. Building habits among captains and deck officers to seek opportunities to sail slower and reduce engine loads might start with a company seminar where ideas are generated and shared among seafaring staff. This addresses the human domain. But building these new habits might also benefit from technology-based decision support tools. One example is placing a consumption indicator at the throttle lever on the bridge which provides efficiency

3 Riviera Maritime Media (25 January 2023) Webinar: How ship owners can improve their CII compliance rating. Retrieved from https://www.rivieramm.com/webinar-library/how-ship-owners-can-improve-their-cii-compliance-rating

information to the operator in real time. If the engine is being pressed to accelerate harder than is necessary, the operator is given a warning and can take the decision to adjust the engine power demand accordingly. This solution falls into both the asset and operations domains but acts as a supporting measure to a human element solution.

"We have built and improved models for our vessels over time, so we know which speed is optimal under defined circumstances. This is backed by high frequency data, collected hourly from flow meters and other sensors onboard our ships, which is combined with daily noon reporting data to keep a dynamic picture of vessel performance throughout the voyage."

Natalia Walker, Project Analyst at Carisbrooke Shipping

PHASE 3: EXECUTE

Writer, philosopher and polymath, John Ruskin (1819 – 1900) once wrote, "It is far more difficult to be simple than to be complicated; far more difficult to sacrifice skill and easy execution in the proper place, than to expand both indiscriminately."

What Ruskin describes is the result of effective discovery and understanding prior to planning and taking action. If undertaken effectively, phases 1 and 2 should highlight the simplest and most efficient route to success. Therefore, creating a plan and putting that plan into action represent the final phase in a well considered maritime energy transition.

PLAN

Arguably, everything up to this point has constituted 'planning', but the plan referred to here is one that can be actioned directly to achieve the aims of the decarbonisation program, within the specified time frame. It might be surprising at first to note that creating a plan for decarbonisation isn't the first thing to do, coming in at step 7, but when we consider the body of information gathered and questions raised in preceding phases, this makes sense. An actionable plan needs to contain solutions, not questions.

By consolidating the baselines, gaps between present and target states, the options and tools, and desired strategic outcomes, the plan can now set out a procedure for action, complete with timescales, budgets, roles, responsibilities, and taskings.

How this plan is formalised and shared is less important than making sure that it is actioned, but the SMART goals approach offers a familiar framework, by making sure that the plan is:

- **S**pecific
- **M**easurable
- **A**chievable
- **R**elevant, and;
- **T**imebound

IMPLEMENT

The success of phase 3 is reliant on the outputs from the two preceding phases. As such, it is useful to remember at each phase that eventually the business will be investing real time and money putting a decarbonisation plan into action.

The implementation phase is both the endpoint and starting point for a well-executed decarbonisation strategy. Its actions close a cycle of learning and open a cycle of change. In every case, implementing change will require a loop back to the beginning. The decarbonisation strategy may need redefining, new data can be gathered and analysed. The gap between present and target states will have shifted – hopefully for the better – and all of these considerations will need reassessment.

THE THREE DOMAINS OF MARITIME ENERGY TRANSITION

A successful decarbonisation strategy will find solutions to a range of problems. Ship operations and management is a complex industrial sector, so it helps to group problems and their respective solutions into categories.

Three domain areas – the operation, the asset, and the human element – are useful groupings for maritime decarbonisation. These can be likened to three drawers in a toolbox, where each drawer contains specialist tools for a given application. Where a real toolbox might contain mechanical, electrical, and carpentry tools, the decarbonisation toolbox contains tools for decarbonising ship operations, the fabric of the ship as an asset, and the human element which forms the connective tissue between asset and operation.

Let's explore each domain (or tool drawer) and consider examples where certain tools have demonstrated a degree of success in decarbonisation. While these examples are not exhaustive, they are selected to show a general direction of travel. Please note, where figures are cited, these have been taken on trust from source statements.

TRANSITION DOMAIN 1: OPERATION

Maritime operations are naturally carbon intensive. Making maritime operations more efficient and thus conserving wasted energy and ultimately saving fuel, is a powerful way of decarbonising the global merchant fleet.

Over the past 12 months, results have been announced from several pilot programs which demonstrate tangible reductions in GHG emissions. Every maritime energy transition project requires tools for execution. The best tools for the task depending on which improvement is being sought and in which domain it falls. Here, we explore the most impactful tools for decarbonising domain 1: the operation.

THE TOOLS OF OPERATIONAL DECARBONISATION

VOYAGE OPTIMISATION

In September 2022, Wallenius Wilhelmsen announced its intention to become the first global shipping company to adopt a fully AI-based voyage optimisation system throughout its 120+ vessel fleet. This announcement followed results from an 18-month trial of DeepSea Technologies' performance routing software Pythia, which achieved a 6.9% improvement in vessel efficiency, predicting a 170,000 tonne reduction in emissions on a fleet-wide roll out. In an interview with gCaptain in March 2023, Wilhelmsen CEO Lasse Kristoffersen stated that climate change is the biggest challenge the company faces. As a result, he announced the establishment of a dedicated climate task force – the Orcelle Accelerator – to help speed up their transition to zero-emissions end-to-end transport services by 2027.[4]

Kristoffersen concluded by saying, "Shipping and logistics need to be zero emission... we want to be a 'shaper' in the fight against climate change."

Allied with voyage optimisation, route and cargo optimisation is also potentially impactful. At the end of the third quarter of 2022, Stena Line reported an 11% reduction in carbon intensity and a 4% absolute reduction in total ship emissions compared to pre-COVID operations by improving utilisation rates and switching to 100% renewable energy during port operations and lay time.[5]

Carisbrooke Shipping has developed an approach to voyage optimisation which over the course of 2022 resulted in a 600-ton reduction in CO2 emissions across their 28 vessel fleet. The saving was achieved in part by using Wärtsilä's Fleet Optimisation Solution (FOS).[6]

Natalia Walker, Project Analyst at Carisbrooke Shipping, told Thetius that, "After extensive development with Transas and Wärtsilä, including setting base lines from flow meters and torque meters and conducting trials with other software providers, Carisbrooke formalised its fleet optimisation centre in 2021 and 2022 became our first full operational year."

Walker continued, "We use AI-enabled software to compare baseline voyage performance data from previous years to model outcomes. Sometimes the margins are tight, especially if voyages are already close to optimised anyway and not every voyage can be improved upon."

Data flow is a vital component: "We have built and improved models for our vessels over time, so we know which speed is optimal under defined circumstances. This is backed by high frequency data collected hourly from flow metres and other sensors onboard our ships, which is combined with daily noon reported data to keep a dynamic picture of vessel performance throughout the voyage."

The operations centre at Carisbrooke compliments a proactive fleet renewal program: "Carisbrooke has consistently been interested in efficiency improvements and decarbonisation. Our strategy is based around operating modern vessels incorporating state of the art technical developments in ship design and construction. In our most recent new building program, we built a series of green ships which were, on average, about 34% more efficient than the market standard."

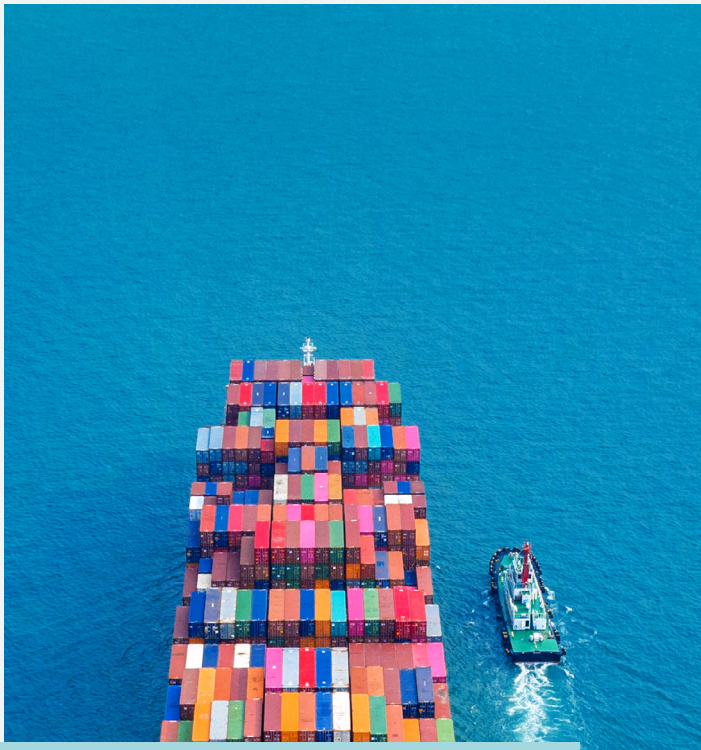
4 GCaptain (March 30, 2023) Wallenius Wilhelmsen Reveals New Company Structure Focused on Decarbonization. Retrieved from https://gcaptain.com/wallenius-wilhelmsen-reveals-new-company-structure-focused-on-decarbonization/

5 Stena Line (August 24, 2022) Stena Line reports 11% reduction of carbon emissions. Retrieved from https://news.cision.com/stena-line/r/stena-line-reports-11--reduction-of-carbon-emissions,c3618532

6 Wärtsilä (15 November 2022) Carisbrooke Shipping significantly reduces CO2 emissions with Wärtsilä's fleet optimisation solution. Retrieved from https://www.wartsila.com/media/news/15-11-2022-carisbrooke-shipping-significantly-reduces-co2-emissions-with-wartsila-s-fleet-optimisation-solution-3185143

COLLABORATION AND DATA EXCHANGE

Orchestrating something as complex as a sector-wide energy transition requires unprecedented levels of cooperation. As Inmarsat President of Maritime, Ben Palmer, told an audience in Singapore in May 2023, "At this stage, what is needed is an industry wide shift in mindset with a long term commitment to open collaboration; the adoption of a more transparent, more collaborative open systems mindset. Shipowners, equipment suppliers and connectivity providers need to work together to realise more efficient processes and new business models. Ultimately, that collaboration across the supply chain will be critical to shaping a connected maritime future that is both sustainable and profitable for all the actors in it."

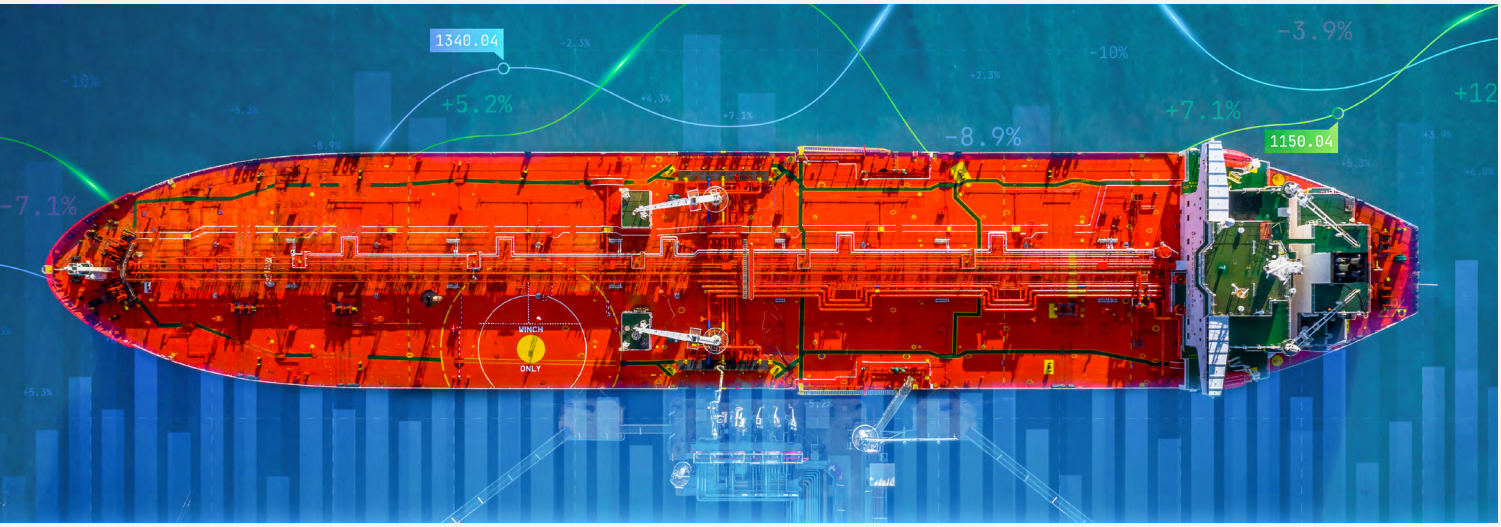


"We are looking at all opportunities to share data. From more accurate orchestration of multi modal port traffic, to providing accurate cargo data in real time, we see an opportunity for €400 million of benefits to users of the Port of Rotterdam alone. A single delay might seem insignificant, but each delay accumulates over the entire supply chain, adding up to a decarbonisation and efficiency opportunity of significant size and scope."

Saskia Mureau, Director Customer Digital at Port of Rotterdam

Data sharing and collaboration can be thought of as existing on two scales; micro and macro. On the micro scale, data can be shared between people, departments, regional offices, and suppliers and trade partners. Use cases are likely to be deeply subjective to a business or an operation. For example, a charterer and shipowner might collaborate via a data sharing platform to make mutual efficiency gains.

On the macro level, businesses and service sectors collaborate to bring about market-wide



change. The approaches needed to make these micro and macro collaborations successful are very different since widespread change such as selecting alternative fuels requires the coordination of far more moving parts and ultimately needs widespread consensus.

Commenting on the importance of effective data sharing and collaboration for decarbonisation, BHP's Sarah Greenough, told a 2023 Singapore Maritime Week audience that, "BHP's decarbonisation strategy really has two critical enablers that are fundamental to our success. The first one is our ecosystem partnerships and how we strategically partner with people to deliver on future fuels, onboard innovation, or enhancing our chartering choices for example. The other critical enabler is certainly data democratisation and the technology we use to enable that."

Greenough described how collaboration will be necessary to harness rapidly increasing sophistication in maritime technology, particularly for efficiency and decarbonisation use cases: "I think we're at a tipping point where we're going to be overwhelmed with the power of AI, IoT sensors, and process automation. We haven't seen the full capability of them and we're not fully aware of their power. Historically, we've used data and analytics quite successfully in the safety space, for example, predicting an incident before it occurs, or using data and insights to better predict an ETA and manage variability. But I think now we're heading into a space where sustainability credentials are coming into their own. Being able to use cost, safety, and sustainability data and really look at those three elements when making more informed chartering choices, is as important as how we are measuring our emissions to meet our 2050 goals."[7]

Greenough's fellow conference panellist, GCMD CEO Lynn Loo, was also asked about the key opportunities for collaboration and partnership. Drawing comparisons from the global fuel supply chain, Loo highlighted the importance of data collaboration for developing traceability in alternative fuels infrastructure. Commenting on the number of times fuel quality data is synthesised, allowing for errors to creep in, she said, "This becomes problematic when you're dealing with drop-in green fuel replacements that command a green premium. How do you know what you're paying for is what you're actually getting? Assurance on the quality and quantity of the fuel – and ultimately, the abatement potential – becomes really important. This is where data becomes vital."

7 IBID (1)

Loo believes that data sharing and collaboration provides the key to developing a robust framework for green fuels traceability and assurance, concluding, "Having methodologies that enable you to get the data required to make it transparent what you're buying and what you're paying for, will be increasingly important. This will also require collaboration and partnership across the ecosystem for it to happen."

DATA STANDARDS AND NOMENCLATURE

Collaborative digital data is heavily reliant on common units of measurement and frames of reference. For example, in speed measurement, one 'nautical' mile-per-hour (1 Knot) is very different from one 'statute' mile-per-hour (1 MPH). In fact, 1 MPH is about 15% faster than 1 knot. Confusing these velocities could cause a sizable cumulative error in the data, unless naming conventions and definitions (known as "nomenclature") are agreed and understood between senders and receivers from the outset.

One practical example of standards development has recently developed in noon reporting. While noon reports remain the de facto standard for ships at sea, digital high frequency data is gathering momentum as a transformative method of gathering larger amounts of data.

Progress in satellite connectivity over recent years is making this paradigm a reality, but noon report data will likely continue to be the standard for some considerable time to come. One advantage of noon reporting data is that it provides a focal point for data quality monitoring. For example, if one noon report gives a position which is impossibly distant from the previous report, it provides a clear indication that an error has occurred.

As seafarers shoulder more complex tasks at sea, digital noon reporting offers shipping companies a way of sending key voyage information more frequently without increasing burdens on officers and crew. The other major advantage is that digital noon reports can easily and instantly be shared with the stakeholders that need it, such as charterers and terminal operators.

In February 2023, the Smart Maritime Council launched their "Standardised Vessel Dataset (SVD) for Noon Reports". This simple, but impactful list of standard data points is offered for use by any maritime stakeholder and is aimed at standardising the data collection, sharing, and analysis of noon report information. Making sure that interoperability and compatibility is maximised across the supply chain is a vital step towards making automated digital data exchange work well for the sector.

The dataset is the brainchild of a proof of concept process involving ship managers OSM, Thome, and V.Ships, with additional support from Stolt Tankers. Lloyd's Register participated as the data analysis partner and as part of their input, suggested adding timestamped metadata alongside standard data points to " improve the potential for that data to be used to create actionable insights in the longer term."[8]

Chairman of the Smart Maritime Council, Rob O'Dwyer, said, "The maritime industry as a whole, stands to significantly benefit from widespread adoption of standard formats in the collection of vessel operational data, reducing the time and resources wasted in converting each ship operator's own data into the variety of different formats required by application providers."

NOTES ON DATA OWNERSHIP AND CONTROL

Alongside interoperability standards, there is the topic of data ownership and control. From a legal perspective, data "ownership" is a complicated term and depends upon factors such as the "data value cycle". This describes how in business – particularly complex, cross-border trade – the involvement of numerous stakeholders makes it difficult to determine who could or would be entitled to claim ownership of a particular piece of data. Data sets are often compound and there could be several potential claimants to component data points.

8 Smart Maritime Network (N.D.) Standardised Vessel Dataset (SVD) Noon Reports. Available for download at https://smartmaritimenetwork.com/standardised-vessel-dataset-for-noon-reports/

In the Smart Maritime Council "Best Practice Guidelines for Data Ownership and Access in Maritime", this issue is tackled by seeking to establish three pillars of data ownership and access, summarised as follows:[9]

- The raw data produced by shipboard equipment belongs to the equipment owner and that ownership conveys certain rights.
- Equipment manufacturers should not place unreasonable limitations on the equipment owner's ability to access this raw data.
- Equipment manufacturers should provide owners with access to the means of decoding and understanding the raw data, for free or at a reasonable cost, to enable the owner to use the data for other purposes.

This approach sets out a stall similar to that posed by the EU Commission in February 2023, with their proposal for a new EU Data Act. According to the EU, the volume of commercial and industrial data is rising exponentially within the bloc, and is forecasted to rise from 33 zettabytes per year in 2018, to a hefty 175 zettabytes per year in 2025. As a result, it will address legal, economic, and technical issues that lead to data underutilisation. The result for shipping will be a similar paradigm to the one set out by the Smart Maritime Guidelines, mandated into EU law. The rules are anticipated to create an additional €270 billion in European gross domestic product (GDP) by 2028.[10]

PORT TRAFFIC SYNCHRONISATION AND SPEED REDUCTION MEASURES

One of the key benefits to enhanced data sharing and collaboration is the possibility to better organise port arrivals and departures to support more efficient sea voyages for all ships. The traditional system of "sail fast, then wait" is the legacy of competitive maritime trade, where cargo owners were keen to place some contractual control over ships which invariably disappeared over the horizon for weeks or months at a time. Global communications have radically improved visibility and today ships no longer need to disappear at all, even when crossing remote ocean regions.

Harnessing the benefits of ships connected by technology and through contracts, The Blue Visby Solution has designed a neutral, independent, and collaborative platform which has the potential to bring about impactful reductions in global GHG emissions by synchronising ships to arrive at pilot stations at the optimal time, while maintaining a fair and equitable order of arrival.

In essence, the Blue Visby system seeks to eradicate the "sail fast, then wait" paradigm by offering ship owners, operators, charterers, and cargo owners a voluntary mutual association through which all members benefit and all members have

9 Smart Maritime Network (N.D.) Data Ownership and Access in Maritime – Best Practice Guidelines. Available for download at https://smartmaritimenetwork.com/data-ownership-and-access-guidelines/

10 EU Commission (22 February, 2023) Data Act: Commission proposes measures for a fair and innovative data economy. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1113

"In order to progress beyond 'sail fast, then wait', we need to recognise conflicting interests, or what economists term 'split incentives'."

Haris Zografakis, Partner at Stephenson Harwood LLP and leading member of The Blue Visby Solution

responsibility for running fairly. The Blue Visby Solution gives structure to the concept of collaborative decarbonisation.

The concept comprises a contractual framework which includes an the element of "mutuality" that is inspired by the structure of a P&I club; an operational system which monitors specific voyage parameters such as vessel specifications and performance; port congestion; weather and current related conditions; a proprietary algorithm for calculating speed reductions and controlling the order of arrivals; and a sharing mechanism inspired by the concept of general average which enables stakeholders to share the cost and benefit of involvement in the program.

Partner at Stephenson Harwood LLP and leading member of The Blue Visby Solution, Haris Zografakis, told Thetius, "In order to progress beyond 'sail fast, then wait', we need to recognise conflicting interests, or what economists term 'split incentives'." He continued, "We need to do something together to solve the problem of 'sail fast, then wait', which is the biggest carbon inefficiency in world trade. How do we address the obstacle of split incentives? The answer is that we devise a sharing mechanism where the shipowner, the charterers, and the cargo interests share the financial consequences of the system. Fuel saving is one consequence, and there are others."

The Blue Visby Solution is focussed on eradicating "sail fast, then wait" and helping all members arrive at their destinations at more optimal times, thus making speed reductions and fuel savings a possibility. The benefits are potentially very significant. Blue Visby studies include a very large simulation / hindcast based on 13,000 merchant vessels sailing 250,000 voyages throughout 2019. These studies revealed the potential to reduce global carbon emissions from shipping by about 16%.

Not all calculations are based on hindcast data however. As Zografakis explains, Blue Visby also have a pilot program running in real time: "By using a sophisticated digital twin of the participating ships receiving the instructions from the Blue Visby control tower, the changes are simulated and measured in the digital twin, then compared with the carbon intensity outcomes of the real ship over the same voyage."

Over the course of their research, careful consideration has been taken towards matching speed reductions with the operating characteristics of the vessel: "A key characteristic of the Blue Visby approach is that speed reductions are kept intentionally modest. Over the course of the 250,000 voyages we have modelled, the average speed reduction required was only around 1-2 kts. This is important because ships are designed to operate within specified load envelopes, so Blue Visby keeps reductions within technically acceptable limits."

OTHER CONTRACT-BASED METHODS

Another example of contract-based collaboration was announced in February 2023 by KCC Charting and integrated energy company, Raizen. The companies signed a three year contract of affreightment which prioritises energy efficient operations by improving charterer – cargo owner communications and data exchange. By minimising legs in ballast and waiting times during loading and discharge, the partnership expects to reduce the carbon intensity of the contract by up to 40%.[11]

A central enabler of the strategy is KCC's CLEANBU series of vessels which the company claims are unique in how they are designed and operated.[12] The CLEANBU fleet are simultaneously LR1 product tankers and Kamsarmax bulk carriers, meaning they carry both wet and dry bulk cargoes. This allows KCC to transport dry bulk cargo to a Raizen terminal and come away with a liquid cargo, thus maximising utilisation and eliminating ballast legs.

VOYAGE DATA GATHERING AND ANALYTICS

Arnaud Dianoux, Founder and CEO of Marseilles-based maritime data analytics company Opsealog, believes that data holds the key to decarbonising maritime operations for ship owners and charterers. He told Thetius, "We are confident that as long as accurate data is coming into the Opsealog Marinsight platform, we will generate efficiencies."

Opsealog bases its offering around three core products: a digital logbook called Streamlog, which is used by hundreds of vessels worldwide and enables ship operators to digitalise and automate reporting and data collection; a platform called Marinsights which ingests data from Streamlog and other sensors and applies analytics to gain insights and understand ship performance in a more detailed way; and a consulting arm, where experts help Opsealog users to transform their data insights into action.

Dianoux points to the advent of satellite communications services as a major catalyst for positive change in data-driven decarbonisation. He said, "The maritime industry is becoming more and more connected and this is an enormous opportunity." Dianoux believes that, "Shipowners need only ask themselves two questions: 'Do I accurately measure my CO2 emissions?' and, 'Do I still use paper and spreadsheets?' If the answers to these questions are 'no' and 'yes', then there is a tremendous opportunity for them to quantify their baseline, and speed up their transition, without doubt."

REDUCING CARBON INTENSITY

In February 2023, Finnish maritime software and data analysis company, NAPA, partnered with ClassNK to announce the results of a joint study carried out with Marubeni Corporation

11 Offshore Energy (15 February 2023) Raizen links up with KCC to cut CO2 footprint by up to 40%. Retrieved from https://www.offshore-energy.biz/raizen-links-up-with-kcc-to-cut-co2-footprint-by-up-to-40/

12 Offshore Energy (11 January, 2021) Klaveness received the sixth energy-efficient CLEANBU vessel. Retrieved from https://www.offshore-energy.biz/klaveness-receives-sixth-energy-efficient-cleanbu-vessel/

which highlighted the potential of voyage optimisation for reducing emissions and improving Carbon Intensity Indicator (CII) ratings for operators. The study examined a fleet of Marubeni bulk carriers, measuring the impact of voyage optimisation on greenhouse gas emissions and CII ratings.

"From an optimisation point of view, we can run into problems with notices of readiness. For instance, the vessels maybe expected to arrive at a port at a certain time and if we don't keep to that time slot, we may well lose our place in the queue and the cargo could arrive later than it could have done, so we have to balance out the requirements of other stakeholders. The key is to continue to communicate frequently with the agents and the charterers."

Natalia Walker, Project Analyst, Carisbrooke Shipping

By optimising voyage and route profiles based on user specified criteria such as maximising daily profit, reducing overall voyage costs, or adjusting arrival times, NAPA's software demonstrated improved safety and efficiency for its users. The Marubeni research concluded that the NAPA suite reduced fuel consumption and CO2 emissions by up to 7.3%. The software also improved CII ratings by an average of 5-6%, extending compliance for an additional two to three years in most cases.

PORT CALL OPTIMISATION

There is no doubt that ports, as interface and service providers to global shipping, play a pivotal role in maritime sector decarbonisation. Ship owners and operators have a remit to reduce the environmental impact of the sea phase of the supply chain, but ship emissions are heavily influenced by the efficiency of their port calls, particularly for vessels conducting frequent cargo operations, and this does not fall exclusively within an operator's sphere of influence.

The just-in-time (JIT) arrival concept is familiar to the industry, but remains difficult to achieve in practice. Chiefly, this is because there are many independent interests involved in executing port calls, and coordinating them effectively is a complex and multivariate task.

However, JIT and the concept of port call optimisation has gathered political and technological momentum in recent months. Many key ports are now using digitalisation as a gateway to improving efficiency and decarbonising their operations for the benefit of the entire port ecosystem and those benefits are great. Ships benefit from reducing idle time by gaining headroom in their schedules which could be used to reduce speed to the next port of call. Terminal operators and harbour authorities gain by reducing the carbon intensity of each cargo operation and by increasing their cargo throughput over a given period of time.

In June 2022, results were released from a study commissioned by the IMO-Norway GreenVoyage2050's Global Industry Alliance

to Support Low Carbon Shipping, showing that CO2 reductions of up to 14% per voyage were possible through the implementation of JIT. Most of the savings resulted from speed reduction opportunities created by processing and releasing ships back to sea ahead of schedule. Interestingly, worthwhile savings were still achieved if speed optimisation was only implemented in the final 24 – or even 12 – hours of the voyage, with results indicating savings of 5.90% and 4.23% respectively.13 What this suggests is that fragmented and globally dispersed ports don't necessarily need to synchronise with each other throughout the course of a protracted voyage, but can operate catchment areas where the speeds of inbound and outbound traffic could be controlled by the proximal port, similar to how traffic control regions work in aviation.

GREEN CORRIDOR SCHEMES

Enabling ports to cooperate on managing the traffic between them is a natural extension of this concept. Partnerships have recently been established to create "green corridors" between international sea ports, offering a complete end-to-end JIT solution. The green corridor concept was formalised by the "Clydebank Declaration" signed by 24 member states at the UN international climate change conference (COP26) in 2022. Signatories including The United States, Singapore, Japan, the Netherlands, and the United Kingdom, agreed to seek partnerships between two or more ports aimed at accelerating maritime sector decarbonisation and developing the required future fuels infrastructure. The consortium committed to a minimum of six green corridors by 2025.

Green corridors work by implementing custom regulatory frameworks, sharing information and infrastructure with partnering ports, and devising incentives for shipping to play their part in adhering to participation requirements in exchange for financial and operational upsides.

THE SINGAPORE-ROTTERDAM GREEN CORRIDOR

Singapore is a major centre for maritime trade and a port of significant global importance to the shipping industry. In 2022, terminals in Singapore handled over 37 million containers and just under 578 million tonnes of cargo. It also remained the largest bunkering port in the world, with sales volumes totalling just under 48 million metric tonnes, despite well-known global economic headwinds.

In August 2022, Singapore's Maritime and Port Authority (MPA) inked a memorandum of understanding to cooperate with the Port of Rotterdam, the biggest port in Europe, to create a green and digital sea corridor between them.

The Singapore-Rotterdam corridor represents a powerful strategic collaboration which will accelerate low and zero-carbon solutions along the longest sea route to be covered by any green corridor scheme to date. A vital link between Europe and Asia, the project will be seen as a model for further development of digitally-enabled decarbonisation and energy transition frameworks across the globe.

Speaking to Thetius in April 2023, Saskia Mureau, Director of Customer Digital at Port of Rotterdam said, "The ports industry is entering the twin transition period of digitalisation and greening, which is rapidly beginning to merge. Ports are not using digitalisation just for efficiency and thus improving margins, but we're also using it very much to tackle climate-related challenges."

The project is working with action partners the Global Centre for Maritime Decarbonisation, the Mærsk Mc-Kinney Møller Center for Zero-Carbon Shipping, and industry partners such as Shell, BP, CMA CGM,Maersk, and MSC. Much of the development is expected to mature by 2027.

The project is building on three main agenda items; just-in-time port traffic, paperless trade, and streamlining customs clearance,

13 IMO and Marine Traffic (2023) Just In Time Arrival. Emissions reduction potential in global container shipping. Retrieved from https://greenvoyage2050.imo.org/wp-content/uploads/2022/06/JIT-Container-Study.pdf

to find ways to harmonise and speed up customer administration.

From a ship operator's perspective, participation in the green corridor scheme will follow a familiar format, delivered in a more mutually beneficial and user friendly way. Once a berth is booked, the vessel will enter a tracking service which exchanges live information between terminals, synchronising departure and arrival times between ports.

The system will use application programming interfaces (APIs) based on terminology derived from IMO Facilitation Committee (FAL) guidelines. Once an arrival is logged, a user portal will be available to the vessel operator or agent to book port facilities and services based on accurate and dynamic timings, without having to duplicate data entry. At the time of the announcement, then Chief Executive of MPA, Quah Ley Hoon, described how the project would, "accelerate our digital efforts to optimise maritime efficiency and improve supply chain resilience."

This and similar schemes around the world underline how important it is for all ship operators to review onboard connectivity to ensure that they are able to facilitate the stable, high performance connections needed to take advantage of the emerging JIT paradigm in port call operations.

TRANSITION DOMAIN 2 – THE SHIP

How ships are operated is evidently of great importance to how efficient they are, but so too is their intrinsic, or "design", efficiency. The design, construction, and propulsion methods embedded in the fabric of a ship are pivotal to what levels of efficiency can be achieved.

THE TOOLS OF SHIP DECARBONISATION

CARBON CAPTURE AND STORAGE

The popularity of carbon capture and storage (CCS) technology has risen rapidly in recent times, with installations beginning in the first quarter of 2023. It is a fact that many ships will continue to rely on conventional fuels in the coming decades, so it is important to take a pragmatic approach to tackling the emission in lieu of a suitable alternative fuel.

SHIPBOARD CARBON CAPTURE

In February 2023, ship management company Eastern Pacific (EPS) announced the successful installation of its first carbon capture and filtering technology on the 50,000 ton dwt chemical tanker Pacific Cobalt.

The system was installed into the ship's stack and will capture up to 40% of the CO2 emissions, filtering out sulphur and particulate matter from the exhaust gases. As part of the announcement, EPS CEO,

Cyril Ducau, told Maritime Executive14 that shipping needed to "start moving the needle significantly" if it is to achieve a net-zero reality. He commented that the CCS technology from Value Maritime offered them a "concrete solution that can be implemented on existing vessels," concluding that, "the result is an immediate carbon emissions reduction while removing the need to wait for the development and rationalisation of alternative green fuel infrastructure."

CARBON CAPTURE AS A SERVICE

Not all CCS systems need to be installed onboard the ship. SETH™, which stands for "Ship Emission Treatment in Harbor", is a concept championed by Florida-based technology firm Greener Process Systems. This patented system captures exhaust gases from the stacks of vessels in port. A tender moors alongside the ship and using a large crane, places extraction hoses over the ship's stack, diverting exhaust gases through an emission capture and treatment system.

The company claims that this approach allows ship operators to use cheaper fuel grades during port calls, saving them money, while the port benefits from an improvement in port air quality. This could be a particularly useful approach for vessels that are not equipped to use cold ironing facilities.

ASSESSING CARBON CAPTURE END-TO-END

In order for trials of carbon capture technologies to maximise their usefulness on an industrial scale, it is important to test the challenges and benefits across an entire cycle of implementation. Lynn Loo points out that end-to-end trials involving multiple stages of deployment across many stakeholders is highly complex and suggests that the efforts of individual shipping companies conducting isolated trials needs to be augmented with more expansive trials with a broader scope. "I believe GCMD can add real value where there is tremendous complexity in the kinds of pilots and trials one needs to do. As a neutral convener, GCMD can bring people across the sector together to collaborate on sector-wide goals," she told an audience in April 2023.

The GCMD recently launched a shipboard carbon capture pilot with Stena Bulk which expands the scope to look at what can be done with the carbon once it is captured. Using one of Stena's medium range (MR) tankers as a test bed, the trial is investigating solutions for the offloading, storage, and treatment of captured Carbon Dioxide (CO2) and seeking ways to close the cycle by making use of captured products.

Loo described the driver for the trials: "In order for a carbon capture solution to work and in order for other companies to

14 Maritime Executive (16 February, 2023) First Carbon Capture System Installed on EPS Managed Tanker. Retrieved from https://maritime-executive.com/article/first-carbon-capture-system-installed-on-eps-managed-tanker

adopt it, we needed to not only be able to capture CO2, we needed to liquefy it, store it onboard ships, and offload it. We built a consortium together to look at this pilot from the beginning to the end."

The team has uncovered some promising results: "We've identified an off taker who's going to take the CO2, make formic acid and use it to make methanol." However, the process of offloading presented some specific challenges. Loo explained, "There are currently no guidelines for offloading CO2. We issued a call for proposal and appointed Lloyd's Register to conduct a study with us. We hope that the results from this study will develop a clearer picture of how guidelines should look for the offloading process."

HULL DESIGN

Hull design greatly impacts the efficiency of a vessel throughout the range of operating speeds and draft profiles. As well as keeping the vessel afloat, the hull causes wind and water resistance, both of which can seriously impact the amount of propulsive power needed to maintain a given speed.

However, hull designs need to balance more than delivering efficiency. They also need to provide the required cargo capacity and possess good seakeeping qualities in a wide range of sea states and weather conditions.

Despite the challenges, some naval architects and ship builders are pursuing efficiency by integrating novel concepts into their designs. Most hull form optimisation strategies involve improving water flow around the forward and aft parts of the underwater hull, and finding ways to reduce resistance around appendages such as rudders, thrusters, propeller blades, and through-hull fittings.

HULL FORM REMODELLING

In late 2018, NYK Line unveiled an 'exploratory' design dubbed the 'NYK Super Eco Ship 2050'. The pure car and truck carrier (PCTC) utilises a remodelled hull form which decreases water friction and reduces the weight of the superstructure by using lightweight composite materials. The concept includes gyro stabilisers to counter the increased motion associated with lighter ships and employs an air lubrication system to further reduce frictional resistance.

Matching this hull design concept with hydrogen fuel cells and waste heat recovery technology, the vessel replaces the traditional 'archimedes screw' propeller with a pair of undulating foils which are modelled on the propulsive methods of dolphins.

Collectively, NYK believes this concept would result in a 70 % reduction in overall energy consumption which is a considerable saving over a conventional 200m LOA vessel of the same type.[15]

ENERGY SAVING COATINGS AND DEVICES

Commenting on the importance of energy saving devices (ESDs) over the entire span of the energy transition in April 2023, Lynn Loo said, "I don't think we talk about energy saving devices enough. They are something we can do today. Energy saving devices improve fuel consumption, and make vessels more energy efficient."

Energy Saving Devices (ESDs) and specialist coatings can have a significant impact on decarbonisation. The nature of the hull surface is intimately connected with the designed form of underwater hull sections. Generally, smooth surfaces reduce

15 NYK Line (N.D.) NYK Super Eco Ship 2050 – Our carbon free concept ship of the future. Retrieved from https://www.nyk.com/english/esg/envi/ecoship/

frictional resistance and encourage more laminar water flow, leading to increased efficiency.

The build up of bio fouling such as seaweed and molluscs which grow on the underside of ship's hulls has a damaging effect, but highly toxic and harmful paints and coatings are no longer in use, requiring new approaches to preventing biofouling build up.

REDUCING FRICTIONAL RESISTANCE

One such approach might at first seem counterintuitive. The concept is to make the hull surface 'stickier' to water using hydrogels. Added to hull coatings, hydrogels trap a microscopic layer of water on the hull surface. In effect, this makes the surface behave like a liquid, which not only deters fouling, but significantly reduces hull friction.

Another approach is to use air to create a boundary layer between the hull surface and the water. Silverstream Technologies' patented air lubrication system creates a "uniform carpet of microbubbles" which coat the flat bottom surface of ships, reducing fuel consumption and resultant emissions.

In September 2021, Silverstream Technologies announced the single largest order of air lubrication systems in the world when it closed a deal to fit its technology to more than 30 new build containerships being commissioned by MSC. According to Silverstream, MSC should expect to save 1.6m tonnes of CO2 over the lifetime of the fleet, saving an estimated $300 m in fuel costs. The technology was independently verified to save between 5 and 10% in fuel consumption and the first MSC vessel to complete the installation was the 24,000 TEU containership MSC Irena in February of this year.[16]

It is not only important to cut down on the consumption of fossil fuels today, it may become even more important when shipping moves to lower energy density fuels. As Lynn Loo remarked in April 2023, "If you go to ammonia, for example, it's two and a half times less dense than LNG. So it means you're either going to be bunkering more frequently or you need a much much larger fuel tank to be able to move that same distance without bunkering. The more energy saving devices you can deploy, the more efficient you are, the less fuel you need, which is good for the environment, but also good for business because you can bunker less frequently or use smaller tanks, creating more space for cargo."[17]

WIND PROPULSION

Wind assisted propulsion has great potential to progress shipping towards a net zero future. For one thing, wind propulsion is fuel-type agnostic, meaning that it works regardless of the primary means of propulsion. This makes it a compelling long-term candidate for ship decarbonisation because it can offer additional efficiency gains even when applied to a clean-fuelled vessel. Modern digital technologies mean that kites, sails, and rotors don't require specially trained crew or sailing seamanship skills to operate them like those needed on traditional sailing ships, and many systems are self-governing during operation.

Wind propulsion company Airseas adapted a technology used in the aviation industry to apply it to shipping. The company achieved proof of concept

16 Splash247.com (22 September, 2021) Bubbles all round as Silverstream celebrates record air lubrication order from MSC. Retrieved from https://splash247.com/bubbles-all-round-as-silverstream-celebrates-record-air-lubrication-order-from-msc/

17 IBID (1)

for its Seawing kite sail technology in 2017 and has been working with Airbus and K-Line on the commercial development since then. By combining a 1000 sqm kite sail with tailored digital twin and route optimisation technology, the company hopes to reduce emissions and fuel consumption by an average of 20%.[18]

FUTURE FUELS

There is no doubt that alternative fuels which are sustainably sourced will ultimately be needed to replace fossil-based conventional fuels where possible. A recent Thetius study showed that around 79% of reported decarbonisation activity over a 12 month period commencing 1st March 2022, was associated with alternative power sourcing.[19]

The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping has reported that only 35% of ship owners have clearly expressed their commitment to International Maritime Organization (IMO) targets. However, the figure varies by ship type, with container shipping leading the way with 53% of containership owners (representing 69% of the global container fleet capacity by deadweight tonnage) setting emissions reduction targets.[20]

These figures suggest that most of the forward momentum in fuel development is driven by larger fleets, biassed towards the containerised and manufactured goods sectors. Further evidence for this can be found among recent contracts for alternatively-fuelled new builds. Speaking to Seatrade Maritime earlier this year, Maritime Strategies International (MSI) Managing Director, Adam Kent, observed this trend when looking at orders for future-fuel ready ships. He said, "The pattern of orders we have seen over the last couple of years has either been for ships transporting manufactured goods such as containerships or car carriers, or vessels that can use cargo onboard for bunkers such as LNG and LPG. For containerships and car carriers, we see pressure from consumers to take action."[21]

This fragmentation may well continue to develop a global fleet which is segmented based on regional fuel options. Speaking on a Lloyd's Register webinar on energy transition strategies in February 2023, LR Consultancy Director, James Frew, said, "I think where we see more of a significant challenge for alternative fuels is in globally trading vessels such as MR tankers, handysize, handymax bulkers and other smaller vessels with a strong global footprint. We believe that these fleets will trade more selectively as a result, so you may see alternatively fuelled vessels trading on specific routes, rather than trading globally."[22]

In March 2023, the EU announced the world's first law on green ship fuels, FuelEU Maritime, an instrument which will apply clearer targets to shipowners and cut GHG intensity from shipping by 80% by 2050. A core commitment is at least 2% of European Union ship fuel supplied will need to come from renewable sources and processes by 2034. In addition, a carbon intensity reduction mechanism is now set in motion, stipulating a reduction in GHG intensity from onboard energy demands of 2% by 2025, 6% by 2030, 14.5% by 2035, 31% by 2040, 62% from 2045, and 80% from 2050.

The legislation will apply to all passenger and cargo vessels of 5,000 gt or greater arriving or departing from EU ports, regardless of dominion of ownership or flag state.

The announcement follows a decision made in December 2022 to include shipping in the EU Emissions Trading Scheme. This is the EU's cap-and-trade system for carbon crediting. Businesses which operate in the EU are allocated credits

18 Airseas.com (N.D.) Advantages. Retrieved from https://www.airseas.com/advantages

19 Thetius (2023) Maritime Decarbonisation Technology Outlook H1 2023. Full report is available to purchase at https://thetius.com/flagship-research-maritime-decarbonisation-technology-outlook-h1-2023/

20 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (30 June, 2022) New Analysis: Ready, set, decarbonize! Retrieved from https://www.zerocarbonshipping.com/news/a-serious-wake-up-call-for-the-maritime-industry-only-35-of-the-major-shipping-companies-have-made-an-imo-or-net-zero-2050-decarbonization-pledge/

21 Seatrade Maritime (January 10, 2023) Shipbuilding market outlook 2023 – a tale of two tiers. Retrieved from https://www.seatrade-maritime.com/shipyards/shipbuilding-market-outlook-2023-tale-two-tiers

22 Lloyd's Register (February 23, 2023) Webinar: How to develop an Energy Transition Strategy. Retrieved from https://www.youtube.com/watch?v=yExfEDV5B6I

which they can use or sell if not all of the credits are required. The EU ETS has been in operation since 2005, but shipping had been omitted until new legislation was drafted by the EU in July 2021. Under a revision of the EU 'green deal', the shipping industry is being phased into the ETS incrementally between 2023 and 2026.

Exactly which future fuels will dominate merchant shipping is yet to be fully determined, but it is most likely that a multi-fuel scenario will develop. Most candidates for sustainable clean fuels serve certain ship types better than others and there are regional variations in the viability of manufacturing, transport, and storage infrastructure which lend themselves to some fuels better than others. Speaking on the subject during Singapore Maritime Week 2023, Chief Operating Officer of Vallianz Holdings, Elisa Woodward, said, "As a ship owner, of course it would be nice to have one fuel for all of our ships, but it's not going to happen. It will be a portfolio of fuels and that will be the way it is. For this reason, we also struggle to say what is best for us, because it also depends on where the vessel is going, what the vessel is doing, and where the routes and the availability in each country and region all come together."

Joining Woodward on the same panel, Sarah Greenough, Head of Sustainability at BHP added, "I agree. For example, the Pilbara region of Western Australia is very important to BHP and we're starting to see a lot of investment in the Asia renewable energy hub. This informs part of our decarbonisation strategy because green ammonia becomes much more attractive in that region and for our vessels going in and out of Port Hedland as a result of that investment. But I could understand that methanol might make more sense for container liners going to different trade lanes and different ports. It's going to come down to where your trade lanes are, the types of vessels you're using, their size, and where the renewable fuel is being produced."

In April 2022, the Renewable and Low-Carbon Fuels Value Chain Industrial Alliance (RLCF Alliance) was launched by the EU Commission. This body plays a pivotal role in setting the pace and direction for producing and supplying renewable and low-carbon fuels in the aviation and maritime sectors. The RLCF Alliance is described as a "key flanking measure" that will operate alongside FuelEU Maritime to bring collaborators from across the transport fuels supply chain together. While it is too early to predict outcome measures from the alliance, it is convened by a range of interests including hydrogen, ammonia, methanol, and bio methane. Most forecasts on clean fuels generally indicate that these fuels are among the most likely candidates, with significant support from wind energy, solar energy, and lithium battery power.

> *"The Port of Rotterdam remains fuel agnostic. Our focus is on providing the facilities and infrastructure which will serve our customers best as they transition to greener fuels."*
>
> *Saskia Mureau, Director Customer Digital, Port of Rotterdam*

Supporting this view, the United States Government released the U.S. Department of Energy (DOE) 'National Blueprint for Transportation Decarbonization' in January, which brings clarity on the direction of travel for US-based ship fuels.[23] The plan focuses on research and development, as well as state incentives for the adoption of alternative fuels and next generation propulsion systems. Ammonia, hydrogen, and methanol are the priority fuels according to the Biden administration.

CONNECTIVITY AND DATA EXCHANGE INFRASTRUCTURE

As this report has described, connected digital technologies are a vital component in maritime decarbonisation. Providing the connective tissue between ship and shore, satellite communications have catalysed a wave of new technologies which are delivering tangible emission reductions. From voyage optimisation, to addressing efficiencies in trade documentation and cargo management,

23 U.S. Government Office of Energy Efficiency & Renewable Energy (2023) The U.S. National Blueprint for Transportation Decabonization: A Joint Strategy to Transform Transportation. Retrieved from https://www.energy.gov/eere/us-national-blueprint-transportation-decarbonization-joint-strategy-transform-transportation

reliable and high performance connectivity secures the highway for maritime businesses to reach new heights in their energy transition.

In March 2023, ZeroNorth founder and CEO, Søren Christian Meyer, released details of the emissions savings made by the company's customers throughout 2022. The ZeroNorth platform successfully prevented the release of 443,780 tonnes of CO2 into the atmosphere.[24]

According to Meyer, if the industry fails to take action on decarbonisation, it will "be responsible for 11% of global emissions by 2050." The company believes that data driven strategies can be very impactful, contributing up to 20% of the overall reductions needed to reach net zero. As Thetius highlighted in the 2022 Optimal Route Report, digital optimisation-based strategies deliver outsized returns for the magnitude of expenditure and greater connectivity and digital data processing creates margin gains too. That analysis found that profitability increases of between 4 and 17% have been demonstrated in trials, and uplifts of up to 50% are predicted in some cases.[25]

The ZeroNorth platform brings together vast amounts of data and converts it into actionable insights aimed at reducing emissions and improving margins. According to Splash247, Meyer told Maritime CEO, "Just by cutting down the 'inefficiency headroom' in how the industry currently operates, and by connecting and more closely integrating the global trade ecosystem, we can cut fuel bills by a fifth in the near term."

TRANSITION DOMAIN 3: HUMAN ELEMENT

This report establishes that the best in class maritime energy transition strategies will apply solutions to both the operational elements of their business, and ships as assets. But the connection between them is people and therefore it is the human element that makes up the third and final transition domain.

Without people who are empowered with the knowledge to manage change through digitally-enabled data-driven inquiry and action, and bought into the why as well as the how of decarbonisation, technologies designed to improve assets and operations will be seriously hindered, if not negated altogether.

Seafarers have chosen a career that goes beyond a nine-to-five routine. Shipping must become leaner and more efficient, but retaining what makes it unique and special to its workforce has to be important. Thetius and Inmarsat covered this topic in detail in a 2022 report titled Seafarers in the Digital Age.[26] In it, our research uncovered some of the best ideas of the day for prioritising the human element in the face of rising digital transformation. The content remains just as relevant today and some of those themes are explored below.

THE TOOLS OF A HUMAN-LED DECARBONISATION STRATEGY

BEHAVIOURAL ECONOMICS AND CHANGE MANAGEMENT

Discussing the role that humans play in maritime digitalisation and decarbonisation, Karin Staal, Founder and Director of Staal Maritime, told Thetius that part

24 Splash247.com (23 March, 2023) ZeroNorth: The next great data revolution in shipping. Retrieved from https://splash247.com/zeronorth-the-next-great-data-revolution-in-shipping/

25 Thetius, Inmarsat (2022) The Optimal Route – The Why and How of Digital Decarbonisation. Available for download at https://www.inmarsat.com/en/insights/maritime/2022/optimal-route.html

26 Inmarsat Maritime (2022) Seafarers in the Digital Age. Available at https://www.inmarsat.com/en/insights/maritime/2022/seafarer-human-element-digital-transformation.html

of the philosophy behind her company is to promote more dialogue between seagoing and shore-based staff. She said, "What I see most often are new technologies, policies, procedures, and ideas being generated on shore, without consultation with seafarers."

This top-down, administrative approach to change fails to recognise an important symbiosis between technology and a highly skilled, experienced, and creative workforce. Staal noted, "Technology is a vital part of the picture, but the people who are expected to operate it must know why they are using it. I think that all too often, they don't. The purpose of the technology is lost on them and they aren't bought into the reason for it. It's people who are equipped with purpose and understanding which will make the most of new technology and that takes more than a standing order or an SOP; it requires you to make them believers."

Staal describes a resistance to technology-driven change from some parts of the maritime community, but hints that there are likely to be hidden drivers for it. Some resistance may exist among crew who feel that the industry is at risk of losing its unique appeal. Staal suggests that shipping companies try to "Help people change their behaviours by first understanding their behaviours. It is a vital step in making ships cleaner and more efficient."

She describes three principal causes of resistance to change. The first is a reaction to the source or methods of influencing a change in behaviour. If it is too authoritarian and inflexible, it may be less well received. The second is scepticism, either directed at the proposed change, or triggered by self-doubt. The third is inertia, which Staal describes as existing when "the intention is there, but action is lacking. Reasons might be that companies are expecting change from staff who are tired, who have other priorities, or who are focussed on other things without sufficient headspace to tackle change. Planning the timing of change and priming key staff members ahead of time is vital to a successful change program."

For owners and operators looking to bring their staff with them on their journey toward net zero, finding a balance between tradition and innovation could be useful. While it is important to embrace new technologies and sustainability measures quickly, it is also important to allay any hint that the industry is losing some of its appeal as an occupation.

BUILDING SKILLED DECARBONISING TEAMS

The IMO formally acknowledged the link between training and ship safety in 1993, when Resolution A.772 (18) recognised the role of fatigue factors in manning and safety. Since then, through the Seafarer Training and Certification for Watchkeepers (STCW) regulations, they have developed a recognised pathway to competence through training, skills development, and experience.

In particular, the rapid development of digital connective technologies offshore raises the profile of cybersecurity in the maritime domain. According to recent research by Thetius, seven of the world's top ten container carriers have publicly acknowledged being victims of cyber attacks in recent years. As part of that research, data from maritime security provider CyberOwl suggested that 95% of the cyber incidents they detected on ships during 2021 could be traced back to an "unintentional insider".[27]

Training crews to use digital technology safely is a vital first step in maximising the utility of systems on board. This begins with building a resilient system which is safe by design, augmenting this with formal training for those with significant access, control, or responsibility over digital and connected systems on board. More detailed advice on how this can be achieved is available for free in the Inmarsat report Beyond Compliance – Cyber Risk Management After IMO 2021.[28]

27 Thetius (2022) The Great Disconnect – The state of cyber risk management in the maritime industry. Available for download at https://www.hfw.com/CyberOwl-HFW-Report-Maritime-Industry-Pays-Average-US3m-Ransom-In-Cyberattacks-March-2022

28 Inmarsat (2022) Beyond Compliance – Cyber Risk Management after IMO 2021. Available for download at https://www.inmarsat.com/en/insights/maritime/2022/beyond-compliance.html

THE THREE-BY-THREE FRAMEWORK FOR DEVELOPING A MARITIME ENERGY TRANSITION STRATEGY

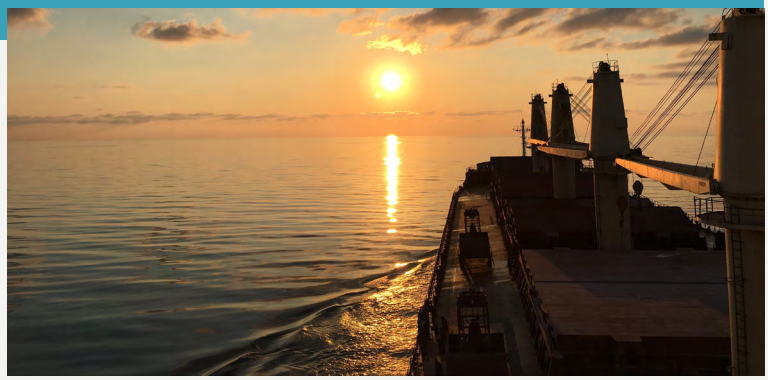
Strategic Phases and Action Steps			
Transition Domains	**Phase 1: Discover**		
	Define Map out business goals and international and regional reduction targets required by customers, port states, flag states, class societies, insurers, and the IMO.	**Gather** Implement methods to collect, organise, and validate data with the potential to develop insight	**Analyse** Understand the baseline for your company, knowing the current status of how the company is operating
Domain 1: The Operation Concerning efficiencies in the operational domain such as vessel performance, navigation and routing, and optimisation.	Which routes and trades does the company compete in now and which does it intend on competing in the short, medium, and long terms? Which flag states, port states, jurisdictions, and emissions control areas affect current and future fleet operations? Which requirements need to be met today and in the short, medium, and long terms?	Seek internal and external data sources which can be used to generate ship, fleet, and voyage operating statistics. External sources may include AIS tracking data, port call data, and data from charterers and trade partners.	Analyse and benchmark fleet utilisation, cargo management operations, voyage performance etc.
Domain 2: The Asset Concerning the technical domains such as hull, machinery, and future fuels.	What is the intended lifespan of each existing ship on the line? Which of these will require remedial action for compliance with any of the relevant stakeholders? Next, consider the new build or acquisitions program and plot the anticipated time scales against decarbonisation requirements. These requirements could be divided into (1) minimal / essential, (2) ideal	Invest in onboard data collection and develop a system to standardise and validate the data generated. Installing sensors such as fuel flow meters, yaw, pitch, and roll accelerometers, and power demand telemetry and automating data collection and recording can improve the frequency, accurancy, and consistency of data collection. Digitalising logbooks and reducing manual reporting demands on officers and crew also helps.	Analysis and benchmarking of vessel emission profiles, hull condition, engine performance, and potential future fuels using technologies such as digital twins and machine learning
Domain 3: The Human Element Concerning behavioural and organisational domains such as crew management, training and development, and change management.	What characteristics can be attributed to staff and seagoing crew? What proportion are directly employed? How many are agency staff? What interfaces are there for crew communication and engagement?	Gather data from the human resources domain through crew and staff survey. What drives voyage decision making, with particular reference to choosing routes and speeds, define how decisions are made on weather routing, sea states, engine power, and onboard power generation. What attitudes do crew have to turning off lights and systems which aren't in use? Is excessive heating applied to empty cabins when air circulation would suffice? etc.	Analysis and benchmarking of crew technical competence and organisational factors (safety, team culture, communication)

Strategic Phases and Action Steps

Transition Domains	Phase 2: Understand			Phase 3: Execute	
	Diagnose Know the gaps that need to be addressed within your company, honing in on the potential improvement areas and setting desired strategic outcomes	**Tool** Select the options available based on the company's baseline, gaps, and desired outcomes to identify the potential options aligned with the intended strategic outcome	**Connect** Link all three implementations to support each other in the most efficient and effective way.	**Plan** Consolidate information on company baselines, gaps, options, and desired strategic outcomes to generate an achievable and measurable roadmap.	**Implement** Install the technical requirements, and carrying out the operational and organisational strategies consolidated in the planning phase.
Domain 1: The Operation Concerning efficiencies in the operational domain such as vessel performance, navigation and routing, and optimisation.	Identify gaps and limitations and diagnose of problems – actual and potential	Select operational emission reduction options according to identified gaps - i.e. vessel performance optimisation systems, decision support systems	Connect the dots. How does this operational implementation affect options in other domains? - Operational implementation must be supported by the correct technical requirements, applicable training, and should take into consideration the feedback of crew members into its implementation (use of operational strategies that consider the vessel's technical specifications and the operator's experience)	Operational Baseline will show the gaps that are present. Based on those findings, the company can use options available that work harmoniously with the asset and human domain options.	Factors to consider prior to implementation - cost, time, industry climate, organisational integrity. If any of the following factors limit the company's implementation, repeat the following process until organisation-wide alignment is achieved
Domain 2: The Asset Concerning the technical domains such as hull, machinery, and future fuels.	Identification of gaps and limitations, Diagnosis of faults - actual vs potential	Selection of technical emission reduction options according to the identified gaps - hull cleaning, engine maintenance and overhauls, retrofits, and fleet renewals	Connect the dots. How does this organisational implementation affect options in other domains? - Organisational implementation must be aligned with the correct technical approach using scalable operational strategies (ex: LNG fuelled ships would use optimisation software with gas management features and would require crew members to undergo LNG-specific energy management and safety training)	Asset Baseline will show the gaps that are present. Based on those findings, the company can use options available that work harmoniously with the operation and human domain options.	Factors to consider prior to implementation - cost, time, industry climate, organisational integrity. If any of the following factors limit the company's implementation, repeat the process from the beginning until organisation-wide alignment is achieved
Domain 3: The Human Element Concerning behavioural and organisational domains such as crew management, training and development, and change management.	Identification of gaps and limitations, Diagnosis of faults - actual vs potential	Selection of crew-related emission reduction options – behavioral analytics, data literacy training, energy management training, future fuels training, alternative engine training, crew feedback mechanisms on energy efficiency and performance management	Connect the dots. How does this technical implementation affect options in other domains? - Technical implementation must be supported by an aligning operational workflow, crew training and education, and a conscious implementation for the well-being and sustainability of crew members (use of technologies that will support seafarers and will not be a burden when they work)	Human Element Baseline will show the gaps that are present. Based on those findings, the company can use options available that work harmoniously with the operation and asset domain options.	Factors to consider prior to implementation - cost, time, industry climate, organisational integrity. If any of the following factors limit the company's implementation, repeat the following process until organisation-wide alignment is achieved.

KEY TAKEAWAYS

Regardless of size and scope, all shipping companies who wish to remain compliant, relevant, and competitive in the years ahead now need to put ideas into action and develop an actionable energy transition plan.



This report has taken an in depth tour of the process of strategising for maritime decarbonisation and handpicked a range of examples where decarbonisation strategies are already yielding results, or where technologies which have real potential to make an impact in the short, medium and long terms. These are the tools of decarbonisation, which when applied to their respective transition domains, have the potential to deliver results that extend the useful lives of ships as assets and increase their value over time.

Compliance will ultimately compel change for all operators. But the pace of change will be dictated by the sum of several accelerating forces. Taking a proactive approach to data and decarbonisation in tandem will help businesses get ahead of a changing risk register and unlock untold additional benefits in the form of improved profit margins, more resilience, and more choice over charterers, cargo owners, and trade partners.

A good transition strategy can be broken down into the “three-by-three” transition model, which breaks the process into three planning phases – discover, understand, and execute, to be applied across three transition domains – the operation, the asset, and the human element. Within the planning phases are a total of eight action steps, which provide a pathway to building a coherent transition plan and putting it into action.

Across the three transition domains, this report describes nine tool groups which provide technological, contractual, or behavioural mechanisms which have been shown to deliver emissions reductions when applied diligently. These groups are voyage optimization, collaboration and data exchange, port call optimisation, green corridor schemes, carbon capture and storage, hull design, energy saving coatings and devices, wind propulsion, future fuels, connectivity and data exchange infrastructure, and lastly behavioural economics, change management, and skills training.

This list is not designed to be exhaustive. It shows the pathway which appears today to be offering the biggest results. The key message is to implement a structured and workable plan, which identifies and prioritises tools which can be implemented when they are needed to build leaner, healthier, and greening shipping companies for this decade and the decades to come. As a long standing technology partner to the global shipping industry, Inmarsat remains committed to helping businesses to imagine new possibilities, create new realities, and achieve their decarbonisation goals.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