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GREEN CORRIDORS ANNOUNCEMENT TOPS SHIPPING'S COP26

By **Richard Halfhide**

While the headlines at the COP26 circus in Glasgow were being grabbed by world leader cameos and a last-minute agreement to 'phase down' (sic) coal usage, the most significant development from a maritime perspective was arguably the announcement of the Clydebank Declaration. Spearheaded by the UK Department of Transport, it's a commitment by 22 countries to establish 'green maritime corridors': specific routes involving two or more ports where vessels and land-based infrastructure alike would be decarbonised from end to end. The Declaration's goal is to establish six such corridors by the middle of the decade, apropos scaling up the initiative in the years that follow.

On the face of it the wording of the Declaration is relatively benign. The signatories express their concern for the findings of IMO's Fourth Greenhouse Gas Study, published last year, and the IPCC's Six Assessment Report, which noted that global warming in excess of 1.5–2°C would occur without drastic cuts. Noting that a transition to clean maritime fuels and zero-emission vessels is imperative, it pledges them to forging partnerships throughout the value chain, developing a regulatory framework for the aforesaid Corridors and corresponding National Action Plans.

The Declaration later states that: 'all vessels transiting a green corridor would not be required to be zero emissions or to participate in the partnerships'. In others, the entire scheme is voluntary... or is it? Some news platforms reported that shares in shipping companies fell upon the announcement, and while the use of clean fuels may be voluntary it's also being interpreted in some quarters as a further step towards the implementation of carbon taxes.

The announcement is closely aligned with a study recently published by the Getting to Zero coalition, 'The Next Wave: Green Corridors', which advocates such routes as a means of piloting and demonstrating new technologies. In particular, the study focuses upon three routes: the Asia-Europe container trade, the Australia-Japan iron ore corridor, and the Northeast Asia-US pure car carrier corridor (the latter also serving as a case study for the report).

Clearly, zero emission vessels demand zero emission fuels and the report identifies a viable fuel pathway as one of the critical building blocks, with green hydrogen bunkering infrastructure being required. In the case of the Asia-Europe route, it anticipates that the pipeline of previously announced green hydrogen projects (62GW of hydrogen electrolyser capacity) expected to be online by 2030, will be sufficient to achieve this. There's also an acknowledgment that fuel subsidies will be necessary to incentivise shipowners, given the significantly higher cost.

Green Corridors, the report suggests, could offer specificity and leverage favourable financial conditions for accelerated action, working like special economic zones

THE TITAN CRANE AT CLYDEBANK. SOURCE: PAISLEYORGUK/FLICKR

for their own regulatory measures, financial incentives and safety regulations. The Getting to Zero coalition itself consists of some heavy hitters in the industry, including Maersk, NYK Line, Port of Rotterdam and Lloyd's Register. But is it really the voice of maritime or that of a feted elite who have the resources to make it work to their advantage? And, for that matter, isn't China conspicuous in its absence from the list of signatories?

Of course, taken overall the Declaration has to be a positive development and there's a lot of sense in targeting the busiest (and among the heaviest polluting) trade routes and waiting for the 'trickle down' effect as those technologies and innovations are assimilated. If, as its advocates hope, five percent of vessels operating along the Green Corridors are 'zero emission' by 2030 (although let's see how the definition of that term morphs in the coming years) then it will represent huge progress towards the mid-century goals.

But, let's be honest, COP26 was a platform for grandstanding and the shipping, keen to address the public perception that it's among the bad boys when it comes to climate change, was only too happy for an opportunity for a little of the limelight. The real work to achieve decarbonisation in shipping will be a lot dirtier and less glamorous, requiring the participation of industry players who were nowhere near Glasgow. ■

Clydebank Declaration signatories	
Australia	Ireland, Italy
Belgium	Japan
Canada, Chile, Costa Rica	Marshall Islands, Morocco
Denmark	Netherlands, New Zealand, Norway
Fiji, Finland, France	Spain, Sweden
Germany	United Kingdom, United States of America

NEWS

TANKERS

STENA BULK LAUNCHES ITS FIRST METHANOL VESSEL

STENA PRO PATRIA IS DUE TO BE COMPLETED EARLY NEXT YEAR

Swiss-Swedish tanker operator Proman Stena Bulk has announced that *Stena Pro Patria*, the first of three 49,900dwt methanol dual-fuel MR tankers, has been successfully launched at Guangzhou Shipyard International (GSI), China. The vessel is expected to be completed during the first quarter of 2022.

In total, GSI will build six vessels of the same design by the end of 2023. Proman Stena Bulk, which is a joint venture between Swiss methanol producer Proman and Sweden's Stena Bulk, has also ordered the *Stena Pro Mare* and *Stena Prosperous*. Additionally, Proman will have sole ownership of *Provident*, *Progressive* and *Promise*.

All the vessels will be equipped with MAN B&W 6G50ME-C9.6 MW Tier III engines, as well as state-of-the-art energy efficiency technologies, including continually controlled combustion, optimised tuning, aerodynamic hull lines, and an energy shaft generator. Annually, each vessel will use approximately 12,500tonnes of methanol as fuel, meaning reduced CO_2 emissions and 60% less NOx. However, this will be sourced from what the operator describes as "cost-competitive" 'grey methanol' derived from natural gas.

Proman and Stena Bulk say that they share a vision of leveraging their companies' expertise to make methanol more widely available to shipowners around the world.

WIND PROPULSION

MOL AND VALE ANNOUNCE ROTOR SAIL JOINT STUDY

Japan's Mitsui O.S.K Lines (MOL) and Brazil-headquartered Vale International SA have announced a joint study on the installation of a rotor sail on a bulk carrier.

The project, which will be undertaken in partnership with UK-based manufacturer Anemoi Marine Technologies, will see an in-service 200,000tonnes iron ore carrier equipped with Anemoi's rotor sails to monitor the effect on greenhouse gas reduction and determine the optimum number of sails that should be used. Anemoi already has the distinction of having installed the first rotor sail on a newbuilding Ultramax bulk carrier, *MV Afros*, in 2018.

The project falls under the umbrella of MOL's Group Environmental Vision 2.1, which strives to reduce GHG emissions in cooperation with leading companies in various industries, with the target of net zero GHG emissions by 2050.

Elsewhere, another British company, Windship Technology, revealed in November that its Zero Emissions hard sail concept for shipping had been independently assessed by class society, DNV. Using the COSSMOS analysis modelling suite for the drivetrain and based on the information provided,

VALE MOL ANEMOI

DNV assessed that Windship Technology's solution captures 100% of the CO_2 generated, as well as 49% fuel savings.

Simon Roger, Windship Technology's technical director, boldly states: "Today everything changes. The world now has a True Zero Emission solution for the shipping industry with technologies that are available today and a commercial case rooted in economic sustainability. It's a significant inflection point for the shipping industry. From a technical standpoint, Windship Technology is now proven."

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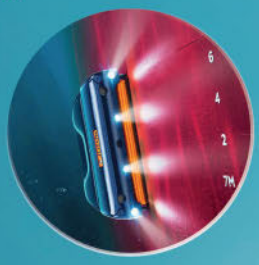

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NEWS

TANKERS

LR AIP FOR KOREAN HYDROGEN CARRIER

Lloyd's Register (LR) has granted Approval in Principle (AiP) to South Korean shipyard Samsung Heavy Industries (SHI) for a 160,000m^3 liquified hydrogen carrier design developed during a Joint Development Project (JDP) earlier this year.

SHI developed the concept and basic design for the vessel, including its membrane-type hydrogen cargo containment system. This concept design was then reviewed by LR to determine its suitability and risks in accordance with LR Rules and Regulations for the Classification of Ships. The AiP was officially awarded on 21 October during a presentation at SHI Pangyo R&D Centre in Korea, in the presence of Dong-Yeon Lee, SHI vice president, and Young-Doo Kim, North East Asia TSO manager at LR.

Dong-Yeon Lee comments: "This is a significant milestone for SHI and demonstrates our commitment to the maritime industry by developing an efficient solution to transport large amounts of hydrogen in a safe and economical way. We hope to play a leading role in revitalising the hydrogen industry ecosystem."

SHI LR AIP

Meanwhile, ABS has granted an AiP to a compressed hydrogen carrier design with a 430-tonne cargo capacity by Global Energy Ventures (GEV). The AIP for the Handymax design, which GEV says will be the first commercial-scale vessel available for the marine transport of hydrogen, follows another AiP in July this year for another GEV design for a compressed hydrogen vessel with a 2,000-tonne capacity.

FERRIES

AUSTAL DELIVERS *BAÑADEROS EXPRESS*

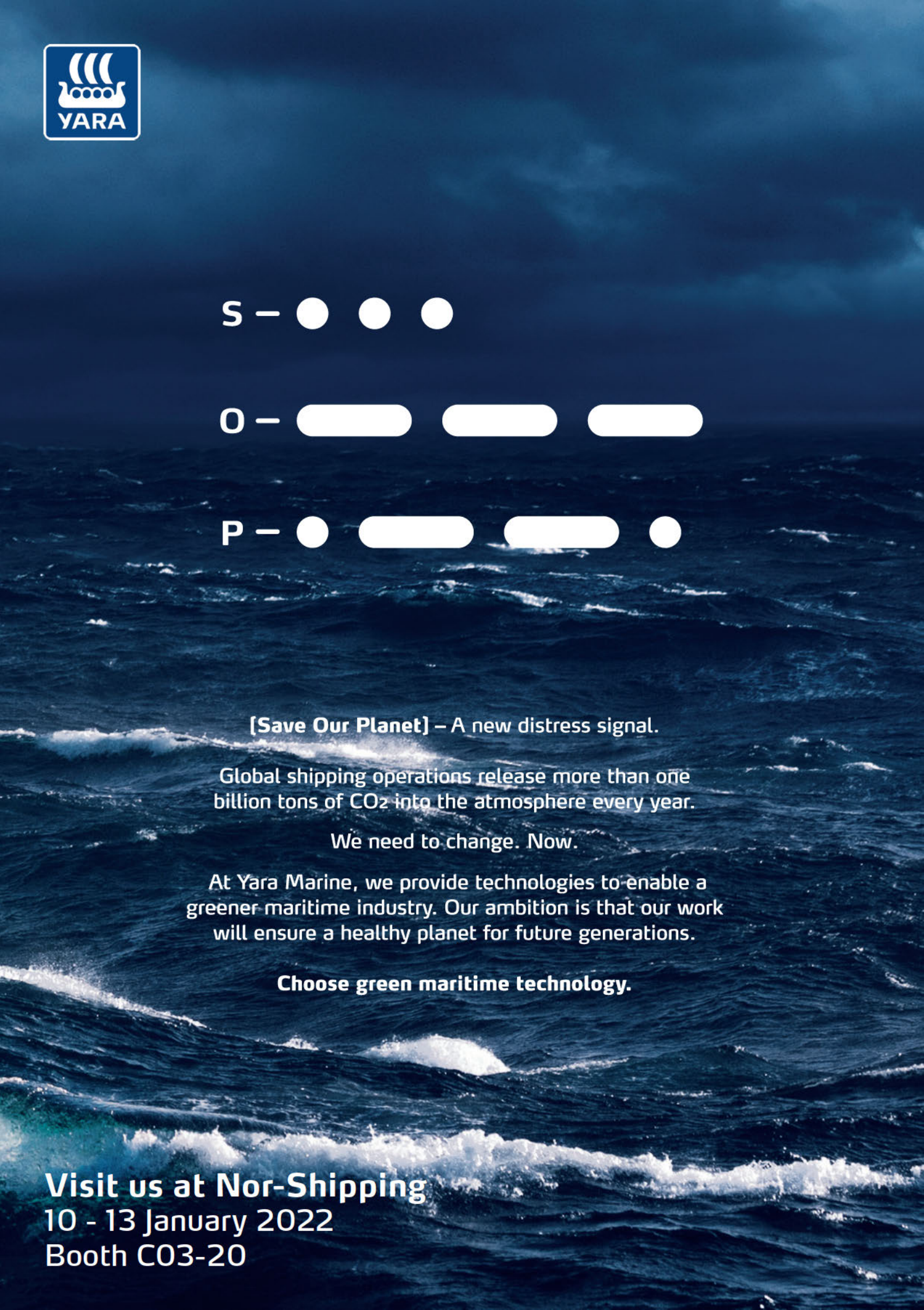
BAÑADEROS EXPRESS

Austal Philippines delivered *Bañaderos Express* (Austal Hull 395), an Austal Auto Express 118 high-speed trimaran ferry to Fred. Olsen Express of the Canary Islands, it was announced on 5 October.

The 118m high-speed trimaran ferry was the second of two ordered from Austal in a $190 million (US$140 million) deal announced in December 2018. The other, *Bajamar Express* (Austal Hull 394) was completed at Austal's Australian yard in July last year and was later among RINA's *Significant Ships of 2020*.

According to Austal CEO Paddy Gregg, the delivery is further testament to the popularity of the trimaran platform with shipowners, as well as the Philippine facility's ability to deliver larger, high quality vessels. He notes: "Fred. Olsen Express was the world's first ferry operator to see the unique value of the Austal trimaran hull to deliver a superior customer experience, operating the 127m *Benchijigua Express* since 2005."

Bañaderos Express is capable of transporting up to 1,100 passengers and 276 cars. In addition to its 118m length, the vessel has a 28.2m beam, 4.2m draught and deadweight tonnage of 750tonnes. It is powered by four 9,100kW M71L Rolls-Royce MTU diesel engines with a cruising speed of just over 37knots.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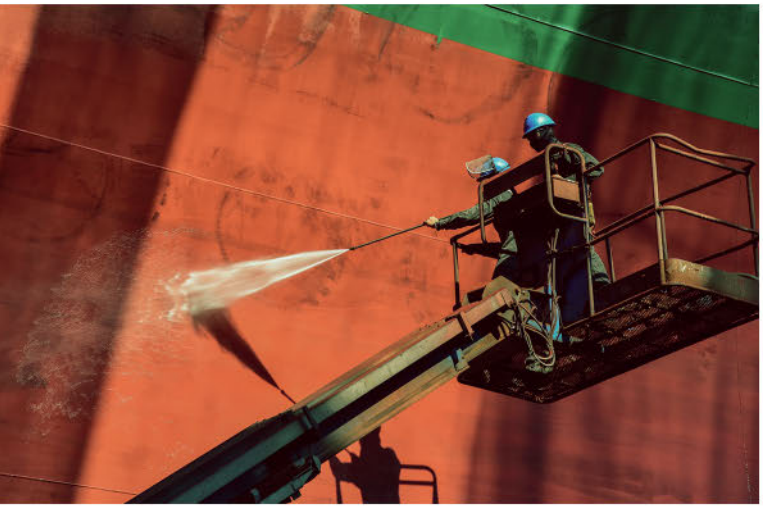
NEWS

HULL PERFORMANCE

BIOFOULING REPORT LAUNCHED AT COP26



GIA FOR MARINE BIOSAFETY

The Global Industry Alliance (GIA) for Marine Biosafety, a group of companies that have joined forces to develop biofouling management solutions, in conjunction with IMO, used the COP26 conference in Glasgow in November to tease its 'Report on the Impact of Ships' Biofouling on Greenhouse Gas Emissions', which is due to be published in full in February 2022.

Undertaken in response to the GIA's 2020 decision to address a lack of understanding within the shipping industry about the relationship between biofouling and GHG emissions, the report aims to analyse the impact of biofouling on the energy efficiency of ships and the sustainable solutions currently available to shipowners to help them mitigate this problem.

According to the report's preliminary findings, biofouling from microorganisms and barnacles can increase a ship's GHG emissions by as much as 55%, in instances where there is severe calcareous growth (e.g. barnacles or tubeworms) due to reduced fuel efficiency. Even a 0.5mm layer of slime can increase GHG emissions by up to 25%, depending on the ship's characteristics and other prevailing conditions.

'Combined with recent surveys on the true level of biofouling prevalent within the shipping fleet, the preliminary results of this report clearly highlight the importance of biofouling mitigation measures, as an essential component in the toolbox for GHG emissions reduction by the shipping industry,' it states.

The full report will outline 'best practice' guidance for shipowners on how to minimise the problem using the best available technologies.

LNG

COP26 METHANE PLEDGE RAISES GAS DOUBTS, BUT WELCOMED BY SEA-LNG

An initiative led by United States' President Joe Biden, and backed by more than 100 countries, has pledged to cut methane emissions by at least 30% by the end of the decade, in one of the major announcements to emerge from COP26 in Glasgow.

The Global Methane Pledge, which is being driven by the US and European Union, aims to use the best available inventory methodologies to quantify methane emissions, with a particular focus on high emission sources. Delivering on the Pledge would reduce warming by at least 0.2 degrees Celsius by 2050, it is claimed. However, China, Russia and India, three of the world's largest methane producers, were notably absent from the list of signatories.

However, the news was welcomed by SEA-LNG, the coalition of companies engaged across the maritime value chain, which believes that stronger regulations of methane emissions will create more certainty in shipping about its benefits.

Peter Keller, SEA-LNG chairman, says: "The pledge to reduce GHG emissions, including methane, by 2030 presents a challenge for the shipping industry but it is a target we are confident can be met... As we look to the future, methane reduction coupled with the growth of bioLNG products, followed by the introduction of renewable synthetic LNG, will be capable of providing the air quality and carbon free future we all see as essential."

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NEWS ANALYSIS

CARBON, CONGESTION AND CRUISING ON THE COMEBACK TRAIL

By: **Malcolm Latarche**, correspondent

October and early November headlines have been dominated, as expected, by COP26 and decarbonisation with the shipping industry coming in for the usual attacks, despite being the only global industry that is actually obliged to reduce emissions. Nevertheless, the week opened with a Danish initiative supported by another 13 states signing a declaration calling on the IMO to take action to support a reduction to zero carbon by 2050.

Although signed by two of the largest FoC countries, Marshall Islands and Panama, persuading other nations to back the call at MEPC 77 will be a tall order. But if it remains an ambitious target rather than a set in stone obligation, then perhaps a fair number of the member states will feel able to pick up the banner.

Away from the COP talks, the last month has seen two impacts of the Covid pandemic affecting shipping in very different ways. The container sector has been hit by congestion at all major ports around the globe. The situation has been building over the year as ports become choked with containers unable to be moved due to a combination of transport shortages and failed businesses.

In early November there were no less than 75 container vessels anchored off Los Angeles waiting for berths. Some major shippers have even chartered other vessel types to move cargoes to non-container ports.

If container shipping is grinding to a crawl, the cruise sector is rebounding strongly from its enforced idle period. A year with almost no activity has obviously hit the finances of all operators and some will be carrying losses into 2022, and perhaps beyond, despite strong bookings. Highlighting the bounce back, Norwegian Cruise Holdings reporting Q3 earnings noted the company's overall cumulative booked position for full year 2022 is in line with 2019's record levels and at higher pricing levels.

Some of the ships now carrying passengers were delivered during the pandemic and were obliged to delay maiden voyages. These include Carnival's *Mardi Gras* and Celebrity Cruises' *Celebrity Apex*, which in November will finally be officially christened by their owners several months after delivery.

October has been an eventful month for newbuilding activity in the cruise sector. On 6 October, Fincantieri began steel cutting on *Explora II*, the second of four vessels in MSC Cruises' new luxury brand.

RCL'S *WONDER OF THE SEAS*

It was a particularly busy month at China Merchants Heavy Industries' Haimen yard where three of the Ulstein CX103 expedition cruise vessels being built for SunStone Cruises reached significant stages.

On 12 October, *Ocean Victory* was delivered and went on charter to Victory Cruise Lines for the Southern hemisphere summer season after which it will transfer to Albatros Expeditions for the winter season. Less than two weeks later, *Ocean Odyssey*, was successfully launched at the CMHI Haimen yard on 23 October 2021. The ship marks the charterer Vantage Cruise Line's second entry into five-star ocean cruising, being the sister ship to the 2021 delivery *Ocean Explorer*.

Other deliveries making the news were the 183,200gt *AIDAcosma* built by Meyer Werft for Carnival subsidiary AIDA Cruises. The ship is the third LNG-fuelled ship built by the Germany yard and, highlighting how far LNG propulsion has penetrated into the cruise sector, all the remaining 13 vessels in the yard's orderbook stretching out to 2025 will be LNG-fuelled.

The cruise ship most worthy of a fanfare has though made a very quiet entrance to the world. Now the world's largest cruise ship, Royal Caribbean International's new 236,857gt *Wonder of the Seas* was handed over at the end of October by Chantiers de l'Atlantique and will sail to Marseilles for some final fitting out before entering service early in 2022.

Wonder of the Seas was planned to be operated in the Chinese cruise market, but Royal Caribbean has decided instead that the vessel will be based in Florida from March and later in the year switch to European cruising. ■

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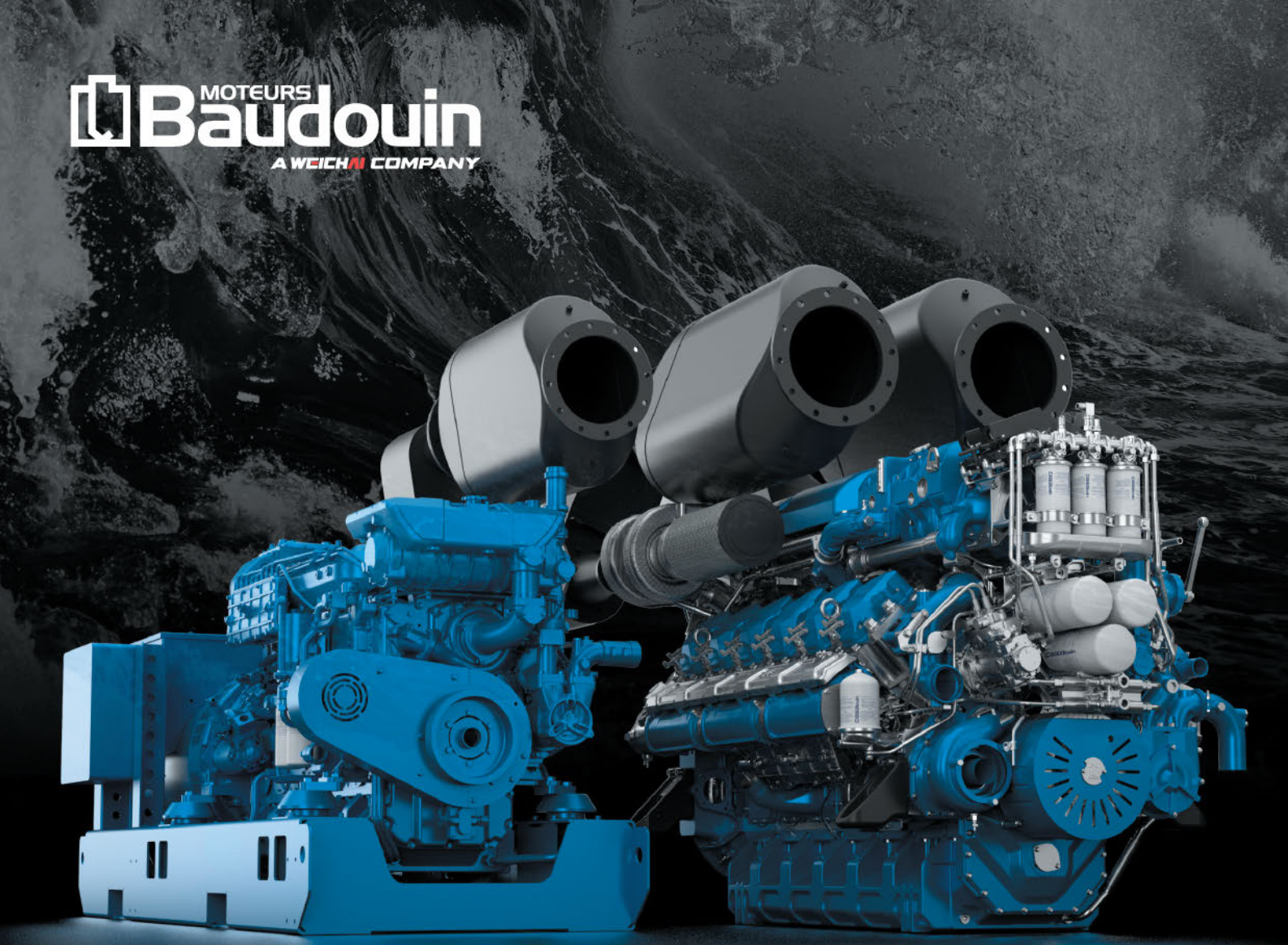

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NEWS EQUIPMENT

EMISSIONS CONTROL

EMINOX AND KBB TO TACKLE ENGINE EMISSIONS

KOMPRESSORENBAU BANNEWITZ

Emissions control specialist Eminox and turbocharger manufacturer Kompressorenbau Bannewitz (KBB) announced a major collaboration aimed at meeting tightening emissions requirements for marine diesel engines at Europort trade show in Rotterdam in November.

The two companies say that they will provide engine manufacturers with what they call a fully integrated emissions control solution, "from turbo to tailpipe", to deliver clean marine diesel engines. The project will bring together KBB's turbocharging expertise and air handling with Eminox's EMx exhaust aftertreatment system (EATS) technology and be suitable for medium-speed engines of 1MW and above. An end-to-end integrated solution, it will be optimised to the shipowner's specific engines, whether newbuilding or retrofit and designed for 20 years of service.

David Phillips, engineering director for Eminox, comments: "Diesel engines are the backbone of the marine industry, making it vital to optimise their performance to lower emissions as we move to a zero carbon future. Working with KBB, we're committed to helping achieve this. We've developed a complete, integrated solution for the maritime industry that builds on the proven strengths of diesel while reducing harmful emissions, preserving investment in existing engines."

ENGINES

WÄRTSILÄ PROPULSION PACKAGE FOR ASPHALT CARRIER

Finnish technology group Wärtsilä is to supply the propulsion solution for a new 11,700m³ asphalt carrier under construction at the Wuhu Shipyard in China for Canadian operator McAsphalt Marine Transportation, it was announced in October.

The order includes two Wärtsilä 20DF dual-fuel engines, Wärtsilä controllable pitch propellers (CPP), gearboxes, Energopac rudder solution and a Wärtsilä transverse thruster. Environmental sustainability was a key consideration in the choice of the Wärtsilä 20DF, while the Energopac is described as a proven fuel-saving solution for both controllable and fixed-pitch propellers applications, offering outstanding vessel manoeuvrability and improved comfort. Delivery is scheduled to take place in December 2022.

It's the third order for dual fuel propulsion signed between Wärtsilä and Wuhu Shipyard this year alone, and the 22nd order overall, in what has proven a successful relationship. Those ties have been further strengthened with the signing of a strategic cooperation agreement which will see the two parties collaborate on the research and development of green energy solutions in the shipbuilding field.

BOIL-OFF GAS

ALFA LAVAL LAUNCHES GAS COMBUSTION UNIT 2.0

Sweden's Alfa Laval has launched an upgraded version of its Gas Combustion Unit (GCU) solution for boil-off gas onboard LNG carriers.

The GCU 2.0 is said to offer design enhancements and enhanced connectivity while retaining the original design's simplicity. Refinements include further optimisation of the flow of combustion and dilution air. The company says this has resulted in steadier combustion at a reasonable temperature, which extends the burner lifetime while reducing distortion of the burner plate.

Jeppe Jacobsen, global sales manager, explains: "The GCU has proven its capabilities at sea many times over, but we're constantly developing it at the Alfa Laval Test & Training Centre. The simplicity and design principles don't change, but even small adjustments can create large performance gains."

But the company believes the real advantages of the GCU 2.0 are with the overall service offering. The product will be delivered connectivity-ready, giving users access to Alfa Laval Digital Services for Gas Combustion Units.

"Online remote monitoring lets GCU customers secure their readiness to operate, and the access to live and historical data makes troubleshooting easier. With data guiding our support team, service visits can be kept to an absolute minimum," he says.

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ENGINES

WINGD AND HHI-EMD ANNOUNCE SUSTAINABLE ENGINE TEAM-UP

ALFA LAVAL GAS COMBUSTION UNIT 2.0

Engine designers WinGD and Hyundai Heavy Industries' Engine Machinery Division (HHI-EMD) have signed an agreement to collaborate on the development of "environmentally sustainable" two-stroke engine technology.

The agreement, signed during the Kormarine 2021 exhibition in Busan in October, will see the pair combine their efforts to devise solutions to further reduce greenhouse gas (GHG) emissions, as well as improving the engine's overall efficiency. In particular, it is hoped the cooperation can lead to further enhancements to WinGD's successful dual-fuel, low-pressure X-DF engines.

As well as targeting GHGs, the project aims to tackle toxic air pollutants such as NOx, cut fuel consumption and reduce the engine's footprint, with an integrated design that will be optimised for both newbuildings and retrofits. Prototype testing is scheduled to take place during 2022.

Dominik Schneiter, WinGD's VP for R&D comments: "This development reinforces our long-standing relationship with HHI-EMD and illustrates the expertise and commitment both companies share to help customers build and operate the most efficient and environmentally sustainable vessels."

COMMUNICATIONS

INTELLIAN LAUNCHES NEW ELERA L-BAND TERMINALS

Maritime communications supplier Intellian has received type approval for its new FB250 and Fleet One terminals, becoming one of the first on the market equipment providers to offer terminals for Inmarsat's ELERA L-band network.

Launched in April, and described as an "innovation catalyst network", ELERA is a narrowband service that's said by Inmarsat to be ideally suited to the rapidly evolving world of the Internet of Things (IoT), offering improved resilience and faster speeds, combined with smaller, lower cost terminals. It is expected to play a key role in areas such as the deployment of autonomous vessels for search and rescue operations. Inmarsat plans to launch two new I-6 satellites, described as the largest and most sophisticated commercial satellites ever produced, by the end of this year.

Intellian says the FB250 is the most innovative and feature-rich terminal on the market, being a compact solution while enabling simultaneous voice and data connectivity up to 284kbps. It can support a range of data-critical maritime applications, including IoT, smart shipping, ocean monitoring and green energy initiatives. Features include built-in firewall, analog and digital voice lines, soft PABX and a WAN port.

Its sister, the Fleet One terminal, is a lightweight, dependable and affordable solution for simultaneous voice and data connectivity of up to 150kbps, for smaller vessels not in need of the capabilities of higher-end satellite communications. Both models are designed to be robust, compact, lightweight and simple to install.

SHAFT BEARINGS

THORDON'S COMPAC NOW COMES WITH 5% REBATE

Shipowners will now be able to claim a 5% rebate on Thordon Bearings' COMPAC open seawater lubricated propeller shaft bearing system under the Green Award Foundation's Incentive Provider programme.

The rebate, which applies to shipping companies and vessels which have been Green Award certified, will be issued to the shipowner after the complete COMPAC system has been paid for by the shipyard. The offer is intended to incentivise ship owners to eliminate oil discharges from their propeller shaft lines.

Green Award certification works on a points system, with differing requirements for seagoing and inland waterways vessels, and owners/operators receiving extra points if they operate equipment that's designed to prevent or reduce pollution. Since the COMPAC system operates without the use of traditional lubricants it qualifies for more points than an oil-based system.

"Green Award certified ships are recognised as being some of the most environmentally efficient in the world fleet, with operators benefitting from various operational, promotional and financial incentives," says Craig Carter, Thordon Bearings' director of marketing and customer service.

Currently more than 150 port authorities, classification societies, trade bodies, flag states and equipment manufacturers have signed up as Incentive Providers offering a range of benefits to certificate holders, including reduced equipment and service costs and heavily discounted port fees.

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OPINION

NAVIGATING A MORE DIVERSE FUEL LANDSCAPE FOR SHIPPING

By **Ulrik Dan Frørup**, chief commercial director, Bureau Veritas Marine & Offshore

When it comes to the fuels used to propel ships, the one-size-fits-all days are over. Shipping is inevitably moving towards a new era where multiple fuel options will coexist, at least in the short and medium term. Navigating this new landscape will require information sharing and flexible thinking.

The world is urgently in need of action to reduce greenhouse gas emissions, as the impacts of climate change is hitting communities with unprecedented floods, droughts, heatwaves and fires. Shipping, which accounts for nearly 3% of all carbon emitted worldwide, has been singled out a sector where drastic and immediate change is needed.

The encouraging news is that action is already taking place within the sector. A growing number of shipowners, charterers, shipyards and investors are well aware of the importance of reducing their emissions, and are taking steps to tackle the climate crisis. Across the globe, we are seeing maritime stakeholders working together to develop innovative solutions to decarbonise the sector, from clean technologies that improve energy efficiency to alternative fuels such as hydrogen or ammonia.

There is no doubt that a key part of the equation to decarbonise shipping in the long term will rely on the development of new fuels, but this cannot be done overnight. Developing the engines and technologies required to use ammonia or hydrogen as fuel is a complex process. Scaling up these innovations so they can safely propel the 50,000+ merchant ships that currently trade on the world's oceans will require time.

Setting up the supply chains that will allow vessels to refuel along international shipping routes is another challenge that will involve multiple actors and moving parts. The reality is that carbon-free fuels may not be fully deployed until 10, 15 or even 20 years from now. Furthermore, the production of alternative fuels is likely to be very costly compared to the fossil fuels used today. In other words, to this day, there is no silver bullet, or no single alternative fuel system that is ready to deploy on a wide enough scale to singlehandedly decarbonise shipping.

Towards a multi-fuels world

Instead, we are likely to see a variety of alternative fuels coexist in the next few decades. Existing vessels may be retrofitted to dual fuel (bio-fuel/-gas), and new small-medium sized ships may be battery powered based on bio-fuel and hydrogen as fuel, whereas many green

ULRIK DAN FRØRUP

seas / large vessels will wait for ammonia propulsion to gradually enter into service. All these will require bunkering infrastructure to take shape. While the ultimate goal must be to go completely carbon-free, intermediate solutions such as biofuels and biogas will play an important transitionary role and they could potentially be further developed to represent an almost fully carbon neutral solution. In other words, we are entering an inevitable transition phase where multiple fuels and supply networks will coexist, and we need to accept that there is no single pathway in the short and medium term – with different solutions being deployed depending on the regions and ship types.

It is probable that one fuel will establish itself as the new norm across shipping, but with many options still in their infancy, it is too early to tell which one will come to dominate markets in the long term. Meanwhile, a "wait-and-see" approach is untenable, given the urgency of the climate crisis and the tighter regulations on emissions that were recently put forward by both the IMO and the EU.

In this context, the industry's most important asset will be information and international collaboration, which will support both innovation and decision-making – and this is where classification societies like Bureau Veritas can play a key role. Our expertise and knowledge on developing comprehensive technical guidelines and Rules for seagoing vessels, combined with our close

collaboration with engine manufacturers, has allowed us to issue Rules for all main alternative fuels. This includes our new ammonia-prepared notation, which certifies that a ship has been designed and constructed to later be converted to use ammonia as fuel.

These rules make safe innovation possible, by guiding shipowners, shipyards and technology providers on the safe use and carriage of new fuels, with specific rules to mitigate risks linked to flammability and toxicity, for example. Moreover, our neutral position enables us to provide insights and information that support the key decisions facing ship owners and operators, without advocating for any fuel in particular, not least because the optimal solution for each owner may be different, depending on their business, their vessels and their trading routes.

A dual focus

Shipping is fighting two simultaneous battles. In addition to substantial efforts towards the long-term green transformation of the energy supplies used to power ships, it needs to show significant progress now, through immediate pragmatic actions that will reduce emissions in a way that is tangible and verifiable.

This is why, as we move towards a new fuel landscape, priority must also be given to short-term action that will curb the need for energy in the maritime sector. This can be achieved by improving the energy efficiency of ships through better routeing and digitalisation, as well as through clean technologies such as wind propulsion, air lubrication or hull coatings. Regardless of the fuels that will be used in the future, being more energy efficient will be an advantage. Maritime stakeholders will need to show flexible thinking, accepting that multiple solutions might be needed to decarbonise their fleets and that innovation in the short and in the long term can work hand-in-hand.

Regulators must also play their part, by putting in place incentives to encourage companies to become first movers and innovate, including through green financing. This will require political support and the willingness to invest in solutions for the wider supply chains. After all, shipping transports around 90% of the world's goods. Shipping may not have the highest public profile, but all of our societies and economies around the globe have a direct stake in supporting our sector's efforts to curb our carbon emissions.

The challenge is major, but pessimism must not be allowed, given the scale and breadth of the actions and commitment that we have seen from the industry in the past three years or so. The maritime sector has come a long way already and is now embracing a major transformation that will see us make a significant and necessary contribution to global decarbonisation. At BV we are there to support this sustainability journey. ■

PRODUCT & CHEMICAL TANKERS

JIANGNAN SHIPBUILDING DEVELOPS AMMONIA FUELLED LIQUEFIED CO_2 CARRIER

By **Ship Economy & Trade**

DESIGN RENDERINGS OF THE AMMONIA FUELLED LIQUEFIED CO_2 CARRIER DEVELOPED BY JIANGNAN SHIPBUILDING

Recently, the R&D team of Jiangnan Shipbuilding (Group) Co. Ltd., a subsidiary of China Shipbuilding Corporation, has developed the latest generation of semi-cooled and semi-compressed C-chamber liquefied gas carriers in response to the market demand for carbon dioxide transportation and the development of ammonia fuel engines. On this basis, a "zero-carbon" ammonia-fuelled liquefied carbon dioxide (LCO_2) carrier design plan was launched, and it has been approved in principle (AiP) by the classification society.

Th shiptype was independently developed and designed by Jiangnan Shipbuilding to meet the design requirements of ammonia fuel 'ready'. It is equipped with 3,500m^3 of ammonia fuel storage tanks, which can achieve 'zero-carbon' operation throughout the voyage, thereby achieving the goal of no carbon emissions while transporting carbon. Moreover, the design of the ship's cargo system meets the requirements of the combined installation of CO_2, anhydrous ammonia and liquefied petroleum gas (LPG) at the same time, which improves the flexibility of ship operations. The successful R&D and design of this type of ship further demonstrates Jiangnan Shipbuilding's independent research and development capabilities in the field of a full range of liquefied gas ships, while maintaining the shipyard's leading position in the new ship type market facing the 'dual carbon' goal (transporting liquid CO_2 without itself emitting any additional carbon).

Temperature controls

The CO_2 is sealed in a storage tank on the ship in liquid form before being transported. However, due to frequent extreme weather at sea and excessively high or low ambient temperature outside the tank, it is easy to affect the form of the contained CO_2. Once the temperature reaches -56°C, the triple point of carbon dioxide is attained, that is, the coexistence of solid, liquid, and gas states. According to the gas-liquid ratio of 1:200, the gaseous state or solidification of carbon dioxide will not only challenge the storage tank's ability to withstand excessive pressure, but can also easily cause some vapour or impurities to mix with the CO_2 as it changes between states, compromising the safety of transportation. In this regard, Jiang Wen, a senior engineer at the Economic Research Center of China Shipbuilding Corporation, comments: "Accurately controlling the temperature and pressure in the cabin is the biggest technical difficulty for a CO_2 carrier."

The cargo tank developed by Jiangnan Shipbuilding is a semi-cooled and semi-pressurized C-type tank. For CO_2 boil-off gas, it provides two alternatives:

CO_2 reliquefaction and liquid cargo tank pressure accumulation. In particular, the ship's cargo tank can safely convert solidified and gaseous CO_2 back to the liquid state, or even if the CO_2 appears gaseous and solidified, while withstanding the resulting pressure changes and continuing to achieve safe transportation. The shipowner can choose the most economical option among the two options according to different voyage requirements and initial investment budget.

With the peaking of carbon emissions, the approach of carbon neutrality, and the development of carbon capture and storage technologies, zero-carbon carbon dioxide transport ships will usher in broad application prospects. On 28 August 2021, China National Offshore Oil Corporation announced that the official launch of the country's first offshore CO_2 storage demonstration project. The facility will permanently store more than 1.46 million tons of CO_2 in the submarine reservoirs of the Pearl River Mouth Basin in the South China Sea.

At present, there are many potential pathways being explored for carbon capture and solidification, including biological, physical, and chemical absorption methods, ore carbonisation, seawater carbon sequestration, and mine storage. Regardless of the technology, the transfer and transportation of CO_2 will be an important part of that infrastructure, with water-based transportation being a critical component.

As a leader in the design and construction of a full range of liquefied gas ships in China, Jiangnan Shipbuilding has successfully developed cryogenic containment systems that have covered International Maritime Organization (IMO) A, B and C types and GTT Mark III membrane types. While developing mainstream ship types corresponding to various cryogenic containment systems, Jiangnan Shipbuilding is also paying attention to the emergence of cutting-edge technologies and the development of derivative ship types. In 2012, Jiangnan Shipbuilding cooperated with a large foreign shipping company, classification society and liquefied gas system integrator to carry out liquefied CO_2 transportation using a 22,000m³ of semi-cooled semi-pressurised C-chamber liquefied gas carrier. ■

A version of this article was originally published in the Chinese publication 'Ship Economy & Trade'

CARBON STORAGE OPENS NEW MARKETS FOR CHEMICAL TANKERS

By **Richard Halfhide**

EXMAR AND LATTICE TECHNOLOGY'S 40,500M³ LCO_2 CONCEPT

Until very recently the shipping of CO_2 was a relatively niche segment catering for industries such as agriculture (fertilisers), beverages and construction, but as carbon capture, utilisation, and storage (CCUS) projects gather momentum across the world so serious thought is now going into its large-scale transportation. Estimates and methodologies vary enormously, but analysts Allied Market Research recently projected that the global CCUS market would grow from US$1.9 billion in 2020 to US$7.0 billion by 2030, a compound annual growth rate of 13.8%, and a figure only likely to grow exponentially as nations step up their efforts to combat climate change.

Similarly, shipyards are seeing a surge of interest in specialised CO_2 carriers, with numerous projects announced recently. In China, Jiangnan Shipbuilding has recently unveiled its ammonia-fuelled concept (see pages 20-21). Meanwhile in September it was announced that Korean shipbuilder DSME was partnering with class society ABS to develop a 70,000m³ very large liquefied CO_2 (LCO_2) carrier; while compatriot Hyundai Mipo Dockyard and its parent company Korea Shipbuilding & Offshore Engineering (KSOE) are also working with ABS on a separate LCO_2 project.

That was followed in November with the news that Korean containment solutions provider Lattice Technology and Belgian engineering firm Exmar have signed a joint development agreement for the design of a 195m Panamax beam 40,500m³ LCO_2 carrier that will also be suitable for ammonia and LPG transportation. The design will incorporate Lattice's patented Lattice Pressure Vessel (LPV) system as a solution for shipping CO_2 at low or medium pressures.

Some of the strongest interest at the moment is coming from Japan, where Mitsubishi Shipbuilding is actively pursuing commercialisation of LCO_2 carriers as part of Mitsubishi Heavy Industries (MHI) Group's strategic initiative for energy transition. A few weeks ago, it announced an agreement with NYK Line to develop a large-scale LCO_2 carrier. At the same time, MHI joined the European CO_2 Logistics by Ship phase 3 project, an initiative which brings it into partnership with French firm Air Liquide, BP, TotalEnergies, and Norwegian companies Brevik Engineering, Equinor, Gassco and research institute Sintef.

As if that wasn't enough, Mitsubishi Shipbuilding also recently completed a concept study with Mitsui O.S.K. Lines (MOL) into the most effective and practical hull forms for CO_2 transportation. Cargo tank capacities of up to 50,000m³ were explored and a range of different pressure settings considered. MOL said in a press release in November that it was prioritising its efforts to realise a large LCO_2 carrier, with a high degree of difficulty and exploring a variety of ship designs, in order to flexibly respond to customer needs.

MOL signalled its ambitions for the segment back in March with its investment in Norway-based Larvik Shipping, a ship management company which specialises in CO_2 transportation. The Japanese operator has stated its ambition of making emission-free shipping its core business and the two companies will collaborate on the development of larger CO_2 carriers with a view to further expansion.

Just two months later came the news that Larvik and MOL had signed an agreement with oil and gas terminals operator Klaipėdos Nafta (KN) to commence a feasibility study to develop LCO_2 loading facilities at KN's existing infrastructure in Klaipeda, Lithuania. The ultimate ambition is to create an LCO_2 logistics and value chain for the entire Baltic region, with Klaipeda as its hub.

"With MOL's resources and experience, coupled with our CO_2 expertise, we will be able to provide reliable CO_2 transportation service at sea for the CCUS industry," Stein Tollevik, Larvik's technical manager, tells *TNA* while stressing that the company's existing clients will remain its priority. Currently the company operates on trade routes between Norway, the Netherlands, Denmark, Germany, UK and Ireland, Finland, Latvia and Sweden.

Larvik Shipping was formed in 1988 at the request of Norsk Hydro as a dedicated shipping company for Norsk

MITSUBISHI SHIPBUILDING'S CONCEPT FOR THE MOL/LARVIK CO_2 CARRIERS

Hydro's new CO_2 business. This coincided with the launch of *Hydrogas I*, the world's first dedicated CO_2 tanker, which operated between a production facility at Porsgrunn, Telemark, and a receiving terminal in Fredericia. The fleet was strengthened by further vessels, *Hydro Gas II* and *Hydro Gas III*, during the 1990's before these were eventually supplanted by the arrival in 2013 of two larger vessels, *Embla* and *Froya* as services were extended to the UK and France. At present, Larvik manages four LCO_2 carriers on behalf of Nippon Gases and Linde Gas.

As a cargo, LCO_2 has some markedly different characteristics to other chemical products. At ambient temperatures CO_2 liquifies at a pressure of 45-65bar, requiring the use of a tank type C containment system. Moreover, at 1,101kg/m³ it has a significantly higher density than LNG (430 kg/m³), methanol (275.5 kg/m³) or even crude (800-900 kg/m³). Tollevik says that places a particular emphasis on ensuring the hull structure is capable of meeting the demands of the operational and environmental loads. A limit state design (LSD) approach is employed during the design phase to ensure the structure has sufficient strength in yielding, buckling and fatigue failure modes, along with thicker tank materials and additional strengthening of the tank supports.

In the past this has raised some doubts about the viability of upscaling capacity for bigger ships. But Tollevik says that while there are some technical and operation challenges to be resolved, the company doesn't foresee problems as long as the the containment system is designed for medium pressure (15-18bar, which would would require the use of refrigeration), with the use of cylindrical or bi-lobe tanks, either side by side or after each other. He adds: "We are also studying the CO_2 transportation at low pressure (7-9bar), which does not exist yet."

THE PLANNED VESSELS MARK A SIGNIFICANT SCALING UP FROM LARVIK SHIPPING'S CURRENT FLEET, SUCH AS THE 1,770M³ *FROYA*

Tollevik says that it's expected the first LCO_2 carriers for CCUS will begin entering operation in 2024, with similar projects expected to come online over the following years. "We assume we would be operating a majority of [our] ships for CCS around 2025," he concludes. ■

FERRIES

BRINGING CLEAN FERRY POWER TO DOVER

By **Richard Halfhide**

TWO NEW DIESEL-ELECTRIC HYBRID FERRIES WILL OPERATE FROM DOVER, BUT FULL ELECTRIFICATION OF SERVICES REMAINS SOME WAY OFF. SOURCE: P&O FERRIES

It hardly needs saying that the Port of Dover plays a central role in the British economy. With up to 120 ferry movements a day, carrying 11 million passengers, two million cars and 2.4 million trucks annually, the port handles around 122 billion of trade in goods, amounting to 17% of the UK trade in goods. But there's also an acceptance that the port is lagging behind some of its European counterparts, not least when it comes to making the transition towards cleaner transportation and the UK's wider goals of net zero carbon emissions by 2050.

In September 2021, a £450,000 seven-month research project was announced that aims to assess the scale of that challenge. The Dover Clean Ferry Power project (DCFP) is part of a £20 million programme being funded by the UK's Department of Transport that will support the Port of Dover Air Quality Action Plan. DCFP brings together a consortium consisting of Port of Dover, P&O Ferries, WMG [Warwick Manufacturing Group] at the University of Warwick, Schneider Electric and the University of Kent, which is leading the project.

Dr Ramin Raeesi, director of the Centre for Logistics and Heuristic Optimisation at Kent Business School and Principal Investigator for the project, tells *TNA* that it will explore viable scenarios to electrify channel crossing ferries, in particular the P&O ferries operating on the Dover-Calais route. He explains: "At the end of the project the main requirements for this project is going to be a very clear implementation plan which the port can use to decarbonise its operations regarding the channel crossing ferries."

There are currently four P&O ferries of different classes operating between Dover and Calais, with a variety of characteristics. For example, *Pride of Burgundy* (built 1993) is a diesel-powered vessel capable of carrying 120 freight units, 600 cars and 1,400 passengers with a service speed of approx. 18.5knots (in good weather) that burns roughly 70tonnes of fuel over the course of 24 hours. In 2019, P&O announced it had ordered two diesel-electric hybrid ferries from Guangzhou Shipyard International in China, which are scheduled to launch in 2023.

"The trouble is that right now there is no shore power supply for cold ironing, let alone recharging ferries with those huge batteries," says Raeesi. "Running a hybrid ferry on its own will reduce emissions because you're storing and using energy in a more efficient way, but simply relying on the diesel engine to recharge the battery won't achieve decarbonisation, so we have to think of onshore power scenarios."

"In the short term we will study the current five ferries operating at the port and see how much energy the port requires for cold ironing. The second stage will be how to satisfy demand with the addition of the new hybrid ferries, and longer term the electrification of all the ferries that are operating at the port."

That electrification won't be achievable in the near future, but one of the project's aims is to clarify the various steps necessary to realise that goal. Raeesi says part of the problem is a chicken and egg situation: ferry operators can't be enticed to go electric unless they know there is shore power, but the cost of installing shore power isn't justified without being confident of demand. Currently the National Grid has a contract to supply the Port of Dover with a comparatively modest 4.5mkV of energy, although there are longer term plans to increase this to 20mkV.

Although Dover is trailing compared to some of advances made with electrification of ferries in countries such as Norway, Raeesi points to the very particular challenges it faces. Most of those ferries travel far shorter distances, meaning they can operate with much smaller batteries. Nor are they generally based in locations that are such a key strategic hub, enclosed by cliffs that put space at a premium and limit the possibilities for expansion. Another consideration is how to achieve synergy with Calais. Raeesi says meetings with the French port are planned for the near future to consider the practicalities, with the possibility of securing some EU funding for the project, despite Brexit.

Ultimately, he is confident that the project will lead to practical suggestions that can be taken to the market and applied at other ports in the UK and beyond. "There is a very strong consortium around this project and we're hoping to deliver real hope for electrifying the maritime sector in the mid to long term," he concludes. ■

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ECO SHIP TECHNOLOGY

GAS CARRIERS AT THE FOREFRONT OF SHELL'S DECARBONISATION DRIVE

By **Richard Halfhide**

METHANE PATRICIA CAMILA

Managing the switch to clean energy represents a monumental challenge in shipping and beyond, but it's self-evident that for the world's oil majors it's more challenging than most. It's a task that Shell has taken to heart with its Energy Transition Strategy, which was overwhelmingly approved by shareholders in May 2021.

But the company's maritime division has already been heavily engaged with making shipping cleaner, safer and more efficient for a number of years. There are around 2,000 ships on the water on any given day doing Shell business, from part cargoes to fully managed ships be it LNG carriers, oil tankers or product/chemical carriers.

"Our research is mainly focused on two areas; one is reducing CO_2 emissions and the other is in maritime safety. All the energy efficiency work is built around a decarbonisation strategy that we published at the end of last year," explains James Helliwell, innovation, research & development project engineer for Shell Shipping and Maritime.

"There's a whole report ['Decarbonising Shipping: Setting Shell's Course'] that explains our future aims and it's all focused on hydrogen being the zero-carbon fuel for shipping. It ties into work Shell has done into the most efficient way to make zero-carbon fuels, all the way from renewable electricity and making that into a product to put on a ship."

That work includes the CO_2-free Hydrogen Energy Supply-chain Technology Research Association (HySTRA) project, in which Shell is collaborating with the Japanese government and others on the construction of a proof-of-concept small hydrogen carrier, which is currently undergoing trials. Shell is also heavily engaged in research into hydrogen fuel cells.

However, in the shorter term the focus is on making its existing fleet more efficient. In September 2020's edition of *The Naval Architect* we considered JAWS (Just Add Water), Shell's AI-enhanced draft trim and optimisation software, but it's just one facet of a broader programme, particularly around LNG carriers.

Earlier this year, Shell and air lubrication system (ALS) specialists Silverstream Technologies were the joint recipients of RINA's QinetiQ Maritime Innovation Award, for their 2020 installation of a Silverstream ALS onboard the 2010-built Shell-chartered LNG carrier *Methane Patricia Camila*. During sea trials the retrofitted vessel demonstrated an impressive 6.6% net savings generated by the Silverstream system.

Shell has previous with ALS, having installed the Samsung Air Lubrication System on *Methane Patricia Camila*'s sister ships, *Methane Mickie Harper* in 2015. The company is reluctant to draw comparisons between the two systems, stressing that both were extensively tested and proven to reduce the shaft power required

BLUE HYDROGEN

Given the ongoing concerns about the role of blue hydrogen (derived from fossil fuels) in any future energy solution, *TNA* took the opportunity to question Shell's position. The company responded with the following statement:

"Shell sees great potential for the use of hydrogen in a range of sectors, from transport to industry. Our ultimate goal is to produce green hydrogen through electrolysis, using renewable power such as wind and solar. But in order to keep up with increasing hydrogen and renewable power demand, blue hydrogen can provide an interim solution to help build the hydrogen ecosystem while still lowering emissions.

"Shell is involved in several green (REFHYNE, NortH2) and blue (Acorn, H-Vision) hydrogen projects. And we continue to explore opportunities: in Q3 2021 Shell for instance signed an agreement with Qatar Energy for further studies of identified blue and green hydrogen opportunities in the UK."

RETROFITTING ALS: AN EFFICIENT SOLUTION?

The question of whether the interaction of the air lubrication flow and the propeller undermines propeller performance, particularly with retrofitted ALS systems, has been the subject of extensive research and speculation in recent years. However, Shell tells *TNA* that cavitation tunnel testing has proven that the air lubrication flow does not cause propeller cavitation and that this was proven by its own earlier trials with *Methane Mickie Harper*.

"*Methane Mickie Harper* entered dry dock after five years of ALS operation, where a full hull and propeller inspection was carried out. No damage to the propeller was seen. In addition, hull inspections of several vessels with air lubrication systems have shown that the air flow prevents the buildup of fouling on the hull, further reducing frictional resistance," the company says.

The suggestion is also rebutted by Silverstream's founder and CEO, Noah Silberschmidt, who tells *TNA* that in his company's experience of dealing with industry-leaning owners it has not witnessed any indication of loss of thrust on any vessel on which the Silverstream ALS has been used.

"Evidence we have gathered over more than a decade of developing and scaling our independently verified technology suggests that loss of propeller thrust stemming from the deployment of ALS is unfounded. Indeed, all measurements of our technology's performance show a drop in shaft power at the same time as an increase in ship speed," he comments.

Silberschmidt also points out that the quantity of air used by the Silverstream is negligible compared to the total expected airflow through the propeller. "Even in a scenario where we assume that the entire volume of air in the microbubble carpet that our System generates passes through the propeller, this would account for less than 0.5% of the overall propeller volume flow."

to achieve a given speed through the reduction in hull friction achieved by the ALS. However, Silverstream last year announced it had secured a contract to supply its system for eight LNG carriers under construction at Hyundai Heavy Industries and Hyundai Samho Heavy Industries which are destined for long-term charter to Shell and the plan is for ALS to become the standard on all 24 of the 174,000m^3 LNG carriers it currently has indirectly on order (see also text box).

Another technology Shell is actively exploring is wind-assisted propulsion, having originally participated in trials of Flettner rotors onboard the product tanker *Maersk Pelican* in 2018-19. Work is currently underway to analyse the potential performance of rotors for LNG carriers, with a decision pending the completion of these studies.

"We've done a lot of work with Flettners and although we've not deployed it yet, but it's another that's definitely applicable to LNG carriers. However, there's still the question of how much air draft resistance you want on the vessel and whether there are any restrictions going under bridges and that kind of thing," says Helliwell.

A further innovation Shell is involved with, albeit indirectly, is LNG Optim, a smart shipping solution developed by French LNG containment specialist GTT. It's described as a tool to help LNG shippers prepare for vessel voyages, reduce overall fuel consumption and manage the perennial problem of boil-off gas, with GTT's modelling also taking into account complex phenomena such as LNG 'ageing' (evaporation caused by heat ingress into the storage tank). The system is currently being trialled onboard Shell's LNG carrier *Solaris*, with results and conclusions on savings pending completion of trial voyages and data analysis.

"They're looking at how to manage the boil-off rate from the tank, when to send the gas to the gas combustion unit, when should you put it through the main engine or when to use your reliquefaction system. Again using machine learning and AI to ensure the gas is being used optimally," says Helliwell.

Another AI-based tool, this time developed in-house, is hull coating monitoring platform called Propel which is currently in the process of being licensed out to third parties rather than being restricted to Shell's own vessels.

"The way the software works is by analysing data of the ship's past performance and telling the vessel operator how their coating's performing, so they choose the right coating for the next refit. When a fleet operator's got 10-20 ships with different coatings, the software will determine the best coating that's been applied. It then tells the operator the best time to clean or polish that coating and whether to clean the hull or propeller, or both.

"We've deployed that across 50 ships on the Shell fleet now, both LNG carriers and tankers and it's delivering between 2-5% in terms of fuel savings. But the biggest one is the decision at refit; coatings cost US$300,00-500,000 for an LNG carrier, depending which coating you select, so the software helps advise you on the payback."

Due to a patent pending application, Shell was reluctant to reveal much about the different variables being measured, suffice to say that Propel quantifies separately changes in hull and propeller performance. So far the system has been tested on more than 20 vessels and deployment is underway as part of the dashboard applications on Shell's long term charter fleet. ■

IHM ADVANCES THE CAUSE FOR RESPONSIBLE SHIP RECYCLING

By **Richard Halfhide**

SEA2CRADLE HAS OVERSEEN NUMEROUS HIGH-PROFILE RECYCLING PROJECTS, INCLUDING CRUISE SHIP *CARNIVAL FANTASY* (PICTURED 2012). SOURCE: CREATIVE COMMONS

Nearly a year has passed since it became mandatory for all EU-flagged vessels, or non-EU flagged vessels calling at EU ports, to hold an Inventory of Hazardous Materials (IHM) onboard as part of the EU Ship Recycling Regulation (SRR). Those same rules also make it mandatory for EU-flagged vessels to be recycled only at EU-approved facilities.

"For almost all projects where we get involved now there is already an IHM in place," says Bert van Grieken, commercial director for ship recycling consultants Sea2Cradle. "The quality can vary somewhat and we don't take it at face value. We want to make sure that when it is sent to recyclers we have a good understanding of what's onboard. Firstly, so that a proper plan can be drawn up, but also because we don't want to expose our people to anything that we could have foreseen."

The Netherlands-based company has more than two decades of experience with ship recycling projects, having originally been founded under the auspices of container line P&O Nedlloyd after it was challenged by Greenpeace about the dangerous, polluting methods by which its vessels were disposed of. Ten years ago, having been dissolved by then-owners Maersk, the founders established the current entity.

Sea2Cradle doesn't recycle ships itself, but provides assistance to owners in how to dispose of their assets in a responsible manner. Van Grieken explains: "We help them in finding the right recycling yard for their vessel, setting up the proper contracts and basically arranging everything that needs to be arranged, then monitoring that recycling is actually being done properly.

"We're quite picky in the projects we do because the owners have to believe in certain values. For example, don't work with recycling on the beaches of the Indian subcontinent, because we don't believe that that is up to our standards."

Recycling consultation

The recycling of any vessel is a complex process, but for Sea2Cradle the consultation process begins with a discussion with the owner about what's important to them and the minimum requirements that they aspire towards. Although vessels may be registered under flags of convenience, meaning they are not subject to the same rules concerning EU-listed facilities, a growing number are choosing to meet the higher standards. IHM is split into three parts; Part I, which is required for newbuildings and ships in operation; and Parts II and III, which relate to operationally generated wastes and stores. The latter two only come into play as part of the preparation for recycling and a prerequisite for the issuance of a Ready for Recycling Certificate (RfRC), which in turns requires the selection of an appropriate approved facility.

Sea2Cradle doesn't buy or sell vessels itself, but can assist the owner in drawing up a shortlist of candidate yards and then engage them in the tendering process on the yard's behalf, ensuring that the contract adheres to the agreed standards. "The facility will already have a ship recycling facility plan that we would have looked at in the yard selection process, but a specific plan of attack needs to be written on how they're going to approach that particular vessel based on its characteristics and the hazardous materials onboard," says van Grieken.

Because a vessel bound for recycling is considered hazardous waste, it is also subject to the laws concerning the transboundary movement of such materials under the Basel Convention and European Waste Shipment, which require an export permit. Sea2Cradle undertakes this work on the shipowner's behalf as well as overseeing any outstanding operations and technical preparations, such as pre-cleaning of tanks, prior to the ship's final voyage. Once it arrives, the company then serves as the owner's eyes on the ground; monitoring the recycling process, issuing regular reports on its progress, and highlighting any areas of concern.

The physical demolition and recycling of a vessel can take anywhere from six weeks to a year, depending on its size and complexity. Van Grieken says that some owners like to begin the preparatory work years in advance so that they are prepared for all eventualities as a vessel approaches its next special survey. This can entail setting up the recycling strategy two or three years prior to the final voyage, but doing so can significantly expedite the disposal process.

Hazardous materials

One of the benefits of IHM is that it's established a standard methodology for what hazardous materials to look for and what the threshold should be. In terms of those materials asbestos, heavy metals in paint, and PCBs in antifouling coatings continue to prove problematic. Tankers and offshore vessels are also often subject to mercury contamination, the clean up which isn't straightforward.

"The good thing about IHM and some of the hazardous materials listed in Annex I is they're being phased out, so over the years you see less asbestos, PCBs and PFOS. But it's still a challenge and just because asbestos isn't allowed on newbuilds doesn't mean you don't find it because it can still be found in spare parts such as gaskets. What is considered asbestos in our part of the world might be considered asbestos free in other parts. So you should always be carefully checking those," says van Grieken.

However, he thinks the prohibition of many of the most toxic materials in newbuilding construction is making a huge difference. The next step towards greener shipbuilding could come from a more modular approach during the construction phase that makes recycling easier. Although 90-95% of a vessel is comprised of steel, which can be recycled, other materials such as insulation and panelling, particularly on cruise ships, is pure waste. "On land there's increased focus on modular building and circularity from the start. But look at the amount of work that goes into the demolition of the interior of a cruise ship and the low recycling rate," he observes.

Improving transparency

While there are signs that the EU's mandate on the use of approved facilities is redressing some of the problems associated with ship recycling, it remains a murky world of cash buyers and flags of convenience, with abuses and safety violations regularly highlighted by lobby group the NGO Shipbreaking Alliance.

"I think the real problem is the loopholes," opines van Grieken. "Flags of convenience, especially the end-of-life flags, are easy to put on your vessel with few requirements... But the other option is to apply regulation not just on flag state but on where the owner's based. The other option is to use the rules already in place and try and enforce them, like waste shipment regulations, which are based on where the vessel has been trading. We see more interest from authorities to enforce those regulations, but a lot more could be done." ■

THE CHALLENGES OF RAPID INDUSTRY COMPLIANCE

By **Anders Bergh**, technical sales manager, Yara Marine Technologies

The shipping industry faces a challenging decade as it works to mitigate the climate crisis and reduce the impact of our operations on the planet. With only eight years to meet the International Maritime Organization (IMO)'s 2030 deadline of a reduction of CO_2 emissions from shipping by at least 40%, many stakeholders are concerned about the feasibility of this goal.

The IMO has set what some describe as an ambitious agenda for this upcoming period. This is evident from the impending January 2023 deadline for incoming regulations such as the Efficiency Existing Ship Index (EEXI), and Carbon Intensity Indicator (CII). It is also likely that further regulatory frameworks will see similarly short deadlines for adoption and compliance. With the regulator's scheduled revision to its initial emissions strategy just around the corner in 2023 – and experts predicting a more aggressive approach – industry stakeholders are scrambling to find viable means to achieve compliance.

Compliance with EEXI ensures that existing vessels that had not been subject to the Energy Efficiency Design Index (EEDI) requirements are also assessed and rated. Operators must then invest in technology to ensure that their vessels are compliant. Although a complex endeavour, EEXI's relatively familiar calculations make compliance far easier to understand and gauge in contrast to the CII framework.

CII applies to ships of 5,000 gross tonnage and above, and focuses on operational efficiency, giving ships a rating (ranging from A to E). It requires ship operators to demonstrate consistent improvement in their fleet through improvement of their vessel rating. While an excellent means of incentivising greener operations into the future, it effectively forces operators to commit to the methods of achieving this improvement within a timeline of about a year.

Given the changing timelines for decarbonisation that are subject to national regulation, it is almost certain that maritime stakeholders will need to assess, implement, and scale up solutions multiple times over the coming years. Thus, any onboard measures or technologies being implemented must be flexible and upgradable to be cost effective and sustainable.

This is why ship operators must take a long-term approach and ensure that the solutions that they implement for their EEXI compliance are compatible with their plan to demonstrate consistent improvement for CII compliance.

Good data-gathering and the CII

It is clear that CII compliance will necessitate a different and longer-term approach compared to the EEXI regulation. It will not be sufficient to make a one-time modification to a vessel, as one would do under EEXI. Instead, ship operators will need to analyse their operating methods to estimate the required operational level of carbon intensity and be willing to adapt their processes year on year to meet a decided upon annual reduction factor.

Currently, vessels requiring CII compliance are already subject to regulations needing a data collection system for fuel oil consumption. Therefore, two factors are paramount. The first is knowing if the current monitoring system will be able to help the ship operator to comply with this new regulation. The second is the need to have a solution that enables them to apply their chosen compliance plan precisely and efficiently within the new operational range.

While the addition of low-carbon fuels and green technology is likely to improve operations and reduce emissions, the requirement for consistent improvement in operations suggests that data gathering will be a vital

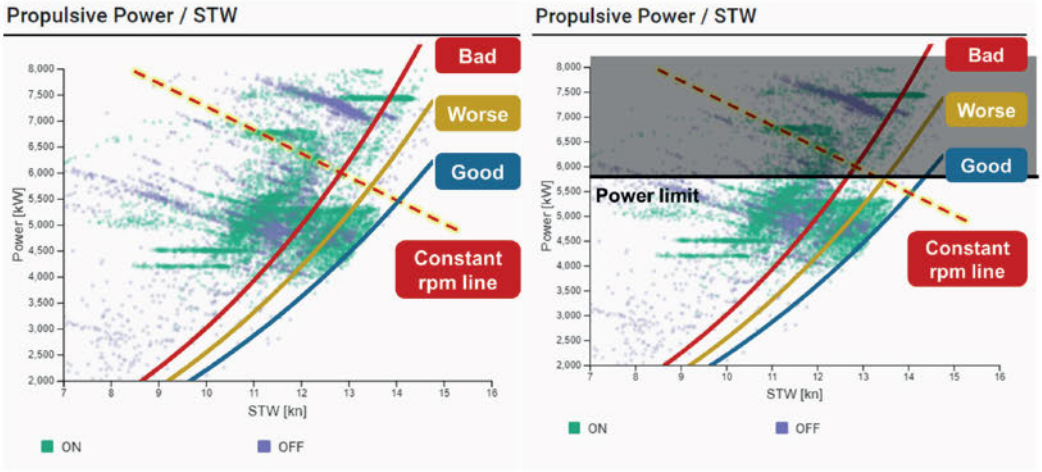


FIGURE 1 AND 2: CHANGE OF OPERATIONAL RANGE FOR VESSELS OPERATING WITH CONSTANT RPM WHEN POWER LIMIT IS REQUIRED TO COMPLY WITH EEXI REGULATION

aspect of CII compliance. Shipowners and operators will need to be able to use this data to locate shortfalls in efficiency or means of improvement, and – upon implementation – ensure that these improvements have delivered the necessary results.

Once higher efficiency levels are attained, further improvements will necessitate strict control on key parameters to maximise vessel efficiency within the new operational range. Therefore, ensuring that a variety of operational factors and measurements are accounted for when seeking a viable new range is key to the implementation of CII.

EEXI is an uphill task

Although EEXI appears more straightforward on the surface, the vast majority of the maritime sector is not currently compliant with this rapidly incoming regulation. Classification society DNV estimates that approximately 80% of the global trading fleet will need to undertake technical upgrades to meet the minimum energy efficiency standards set under EEXI.

As shipowners and operators evaluate existing vessels and seek solutions that balance efficiency with compliance, these rapid upgrades must factor in logistical realities such as cost efficiency, time efficiency, availability of technology, and bunkering in case of emerging fuels. For most, fulfilling the EEXI requirements within the given time frame demands easy-to-implement technologies that offer the benefit of immediate emission reductions within short-term investment plans. But there are existing solutions that can contribute towards long-term emission reduction for vessels.

Among current recommended EEXI technical compliance measures are engine power limitation (EPL), shaft power limitation (ShaPoLi), propulsion optimisation, and energy-saving devices. Within the regulatory framework, derating engine power output via EPL or ShaPoLi offers a direct impact, making these solutions forerunners in the drive to reduce greenhouse gas emissions. The impact on vessel operation arising from capping power output is likely to depend on the vessel operational profile - more precisely the distribution of power usage. While some operators may find it viable to reduce power and speed, for others minimising speed loss will be crucial to operations.

Most commercial operations are planned with certain parameters in mind such as speed, total fuel consumption, and cost allocated per voyage based on predictions of a consistently calm voyage. However, the reality is that a vessel will experience a range of sea and weather conditions that will cause speed and consumption fluctuations. Thus, when the weather worsens, any attempt to operate purely on constant RPM will result in decreased speed and increased fuel consumption.

Vessel operations must be dynamically adapted to the sea conditions to facilitate truly sustainable ship operations. The addition of EPL or ShaPoLi to these already complex operational conditions imposes a limitation on a vessel's operational range. But they also offer a golden opportunity to take increased control of the parameters that are most closely linked to the vessel's operational efficiency.

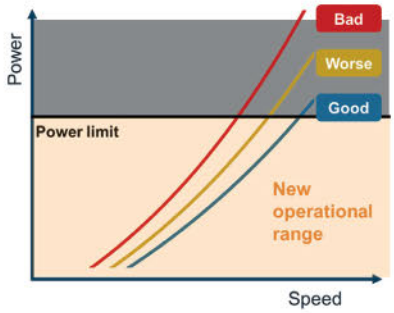


FIGURE 3: NEW OPERATIONAL RANGE FOR VESSELS THAT NEEDS POWER LIMIT TO COMPLY WITH EEXI REGULATION WILL BE USED IN CII FRAMEWORK GOING FORWARD

Connecting the dots between EEXI and CII

Although setting a limit to power output may not impact a vessel's current operations, it is likely to be a factor in future operations given the necessity of continuous improvement mandated by the CII. Therefore, it is vital that even as ship operators and owners take immediate action for EEXI compliance, they should create a parallel improvement plan for the remaining lifespan of the vessel. This evidences a clear market need for flexible solutions compatible with [future] vessel upgrades.

Shipping has traditionally favoured simple, straightforward solutions and thus, equipment providers would do well to offer such solutions for future compliance. Yara Marine's FuelOpt solution answers several needs at once. The system enables ShaPoli application, and thus EEXI compliance, by simply setting an upper limit to shaft power output without any modification to existing machinery. It also includes a crew override option for safety purposes as a standard feature. Below the fixed limit, FuelOpt enables full control of the shaft power or consumption, making sure that a voyage can be planned and executed with direct control of the impact on the CII rating. FuelOpt also gathers vast volumes of vessel data in real-time. The latter is harvested from signals onboard, particularly from the propulsion line and engine.

This data is then integrated into Fleet Analytics – our smart cloud-based performance management and reporting system, or any existing, third-party performance tool used by the ship operator. Thus, ship operators have a performance management tool that evaluates collected fuel consumption data that is combined with an automation tool enabling precise control on operational parameters. The ability to track and demonstrate improvements also meets the criteria for CII compliance, while leaving operators the flexibility to incorporate complementary technologies that emerge in the future.

The IMO's mandate for constant improvement sets our sector down a path that requires flexibility and tech-savviness, as well as buy-in from multiple stakeholders. Collaboration is vital to this challenge, both by companies and also by technologies, such that we can reap better results. While some may view these actions as a mere matter of compliance, we must not forget the true reason for our joint efforts to decarbonise our operations: to fight climate change and save our planet. ■

CLASSIFICATION

CHINA CLASSIFICATION SOCIETY REPORTS 'URGENT NEED' FOR REMOTE SURVEY GUIDANCE

By **Ben Pinnington**, contributor

HANDHELD CAMERAS ARE CURRENTLY THE NORM, BUT CCS IS PLANNING FOR MORE EXTENSIVE USE OF AR HEADSETS

Shipping may be the most efficient form of transportation in terms of raw cargo, but the services provided to it have historically been anything but. Some years ago, classification societies thought nothing of flying surveyors around the world for every yard visit, crisscrossing the globe on planes in order to ply their trade. But in recent times, they have begun to reconsider this approach.

Remote surveys come with a number of advantages. Not only do they eliminate the need for surveyors to fly to successive yards for jet-lagged appraisals of vessels' condition. In many cases, it is also possible to conduct a remote survey underway, demanding less off-hire time for ships whose owners are confident enough.

The third major benefit of this activity lies in safety. Ship surveys are an incredibly demanding task, and abseiling into a vessel's hold to check for faults has, more than once, resulted in tragedy. Enclosed spaces, in the same way, have claimed many lives – and, as is now well-understood throughout the industry – are liable to claim more than one at a time.

But there was a fourth driver looming that the industry did not see coming: the Covid-19 pandemic. Its implications for world trade are still being felt just as much as in 2020, however, in terms of preventing the spread of the virus, flying surveyors internationally to participate in three-day inspections – far shorter than the 14-day gestation period of the virus, and indeed, the self-isolation intervals which would be needed at each end of the journey – is not ideal. This is not to mention that many international flights simply were not happening during this period, and the costs involved in such were astronomical. It was a great time for remote surveys, a nascent technology, to step into the breach.

Covid measures

During the Covid-19 outbreak, normal shipping services, as well as ship surveys, were suspended because surveyors are denied entry to a port or are unable to board a ship. Therefore, some Flag States have adopted interim alternative measures, i.e. issuing short-term certificates or extending certificates beyond the statutory maximum period, which are only applicable in special circumstances. The operation and safety of ships has been greatly affected.

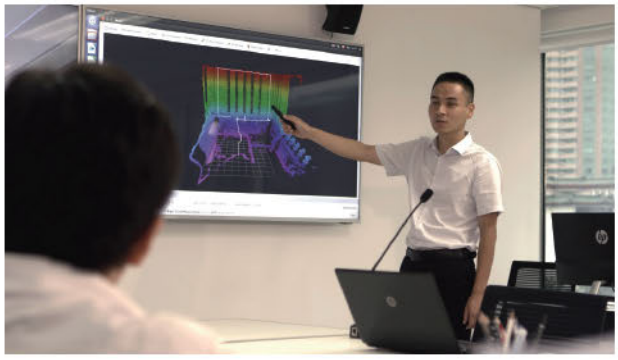
Most Flag State administrations only accept remote survey for extension of statutory survey. A few Flag State administrations accept remote survey in lieu of ship survey. Still, administrations have not provided explicit views on whether to accept remote survey. As the extent of acceptance of remote survey from Flag States differs, the conditions, scope and procedures of remote survey are all varied.

As indicated in document MSC 102/22/11 (Republic of Korea), remote surveying of ships may be identified as new practices in the 'new normal' during Covid. With the development of technology, remote surveys will continue to be applied after the pandemic. The absence of unified guidance on remote surveys may not only bring burdens to shipowners and crew, but also bring about negative impacts on the credibility of survey quality and impartiality among relevant stakeholders. From the perspective of Port State Control, the validity of remote survey may be questioned.

China, South Korea and the EU put forward new outputs on remote survey and audit at MSC 104, identifying that the current legal framework of ship surveys exist with on-site surveyors in mind, and as such, favour in-person surveys by requiring substantive on-site verification processes. This has left them unable to address the barriers to ship surveys in the pandemic era, and unfit for purpose in the face of future technological development.

Lack of uniformity

South Korea, meanwhile, pointed out that a lack of uniform guidance on remote surveys makes negative impacts more likely, as the rigorous standards for in-person surveys are abandoned in favour of more



XIANG LINHAO, HEAD OF CCS NEW SURVEY TECHNOLOGY AND EQUIPMENT LABORATORY

experimental approaches to new remote ones. Ultimately, this could undermine the safety of the ship and of seafarers. The allowable methodology or scope of the remote survey is neither defined in the IMO instruments, nor has it been openly discussed at the IMO level.

Korea clearly proposed that IMO should be developing guidance on remote surveys, with a view to global and uniform implementation, taking into consideration matters related to cases of force majeure and technical innovation. Despite this lack of a common framework and procedures, EU representatives stated, several Flag State administrations have accepted the remote inspection and audit in lieu of the onboard survey/audit. However, to date, there are no provisions or common procedures agreed at the international level for the execution of class and statutory surveys and audits by remote means, i.e. without physical attendance by surveyors and auditors onboard ships. There is an urgent need to develop specific guidance to ensure that remote surveys are carried out in a harmonised way ensuring the same level of safety as a physical onboard survey.

To address this, China tabled a proposal for a scoping exercise to develop technical requirements for remote surveys. Subsequently, a decision was made at MSC 104 to include, in the biennial agenda of the III Sub-Committee for 2022-2023 and the provisional agenda for III 8, an output on "Development of guidance on assessments and applications of remote survey, ISM Code audit and ISPS Code verification", with a target completion year of 2024.

The International Association of Classification Societies (IACS) is discussing putting forward unified requirements for remote survey.

Remotely possible

"China has adopted new technologies and equipment such as public networks, ad-hoc networks, wearable devices and drones to carry out real-time remote annual surveys for ships," explains Xiang Linhao, head of CCS New Survey Technology and Equipment Laboratory , "proving that with certain technical support and procedure requirements, remote surveys can achieve the same effect as onboard ones concerning specific surveys."

In China, there are three main technologies which have enabled this survey strategy. One of them is connectivity. It is famously difficult to get a wi-fi signal through bulkheads, and this is the reason long cabling networks tend to form the central nervous system of modern vessels. But it is also very challenging to make the vast exchanges of data required using standard shipboard networks.

CCS has got around this using a distributed 'ad-hoc' network organised around a central 5G CPE [Customer Premise Equipment]. From there, mesh relay stations, situated on tripods, are set up throughout the vessel, allowing signals to travel throughout the vessel unimpeded. The network must be resilient, as it is being used to relay vast amounts of survey data, including thousands of images, video footage, and documents. When the data reaches the CPE, it is transmitted via 5G – a technology largely pioneered in and by China – at incredibly high transfer speeds, yielded by the band's high-wavelength.

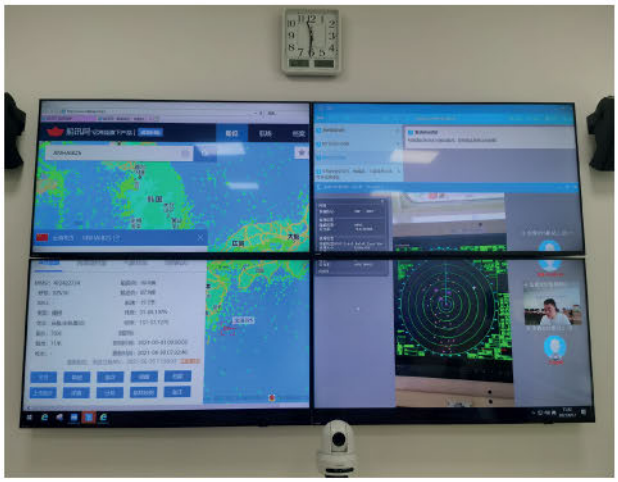
These systems have yielded excellent results in actual survey, says Xiang. "Based on the practical experience in China, remote surveys, as the effective alternative to on-board surveys in some inspection items, with international conventions and rules implemented in a 'non-contact' way, can minimise the influence of Covid-19 on ship surveys, which is of practical significance to reduce the transmission of the virus and respond to the pandemic."

Augmented Reality

Once this complex and high-throughput shipboard network has been connected up, the other survey tools come into play. They appear in two main guises: augmented reality (AR), and drone surveys.

In the former case, a seafarer equipped with an AR headset can travel around the vessel, transferring real-time visual data to the survey centre. Receiving instructions and taking images via the headset, as opposed to a handheld camera, is hands-free and more efficient; but it is also a crucial way to maintain safety.

AR headsets are gaining traction in the maritime industry thanks to their ease of use, and it is thought that, with help from a steady shore connection, they will soon be used



AN AD-HOC 'NETWORK', WITH RELAY STATIONS THROUGHOUT THE VESSEL, RELAY PICTURES AND DATA BACK TO THE ONSHORE SURVEYOR

to guide crew members through onboard maintenance procedures – relieving the chief engineer's workload.

For surveys, as in maintenance operations, they provide an expedient way of putting key information in a crew member's field of vision; shoreside survey staff can indicate and highlight the areas they wish to examine, vastly streamlining the process.

UAVs

The quadcopter drone has proven a reliable and effective platform for various technologies spanning myriad industries. Unmanned Aerial Vehicles (UAVs) prove incredibly valuable as surveying tools, as they allow easy access to spaces where it would be unsafe to have humans perform a close visual inspection.

But with CCS's UAVs, there is a difference; they are specially developed to operate in no-satellite signal, low- or no-light conditions. They are also optimised for use in environments with strong magnetic field interference, crucial in a setting where drones will be surrounded on all sides by metal bulkheads. They use LIDAR for positioning and collision avoidance in spaces where there is no satellite signal.

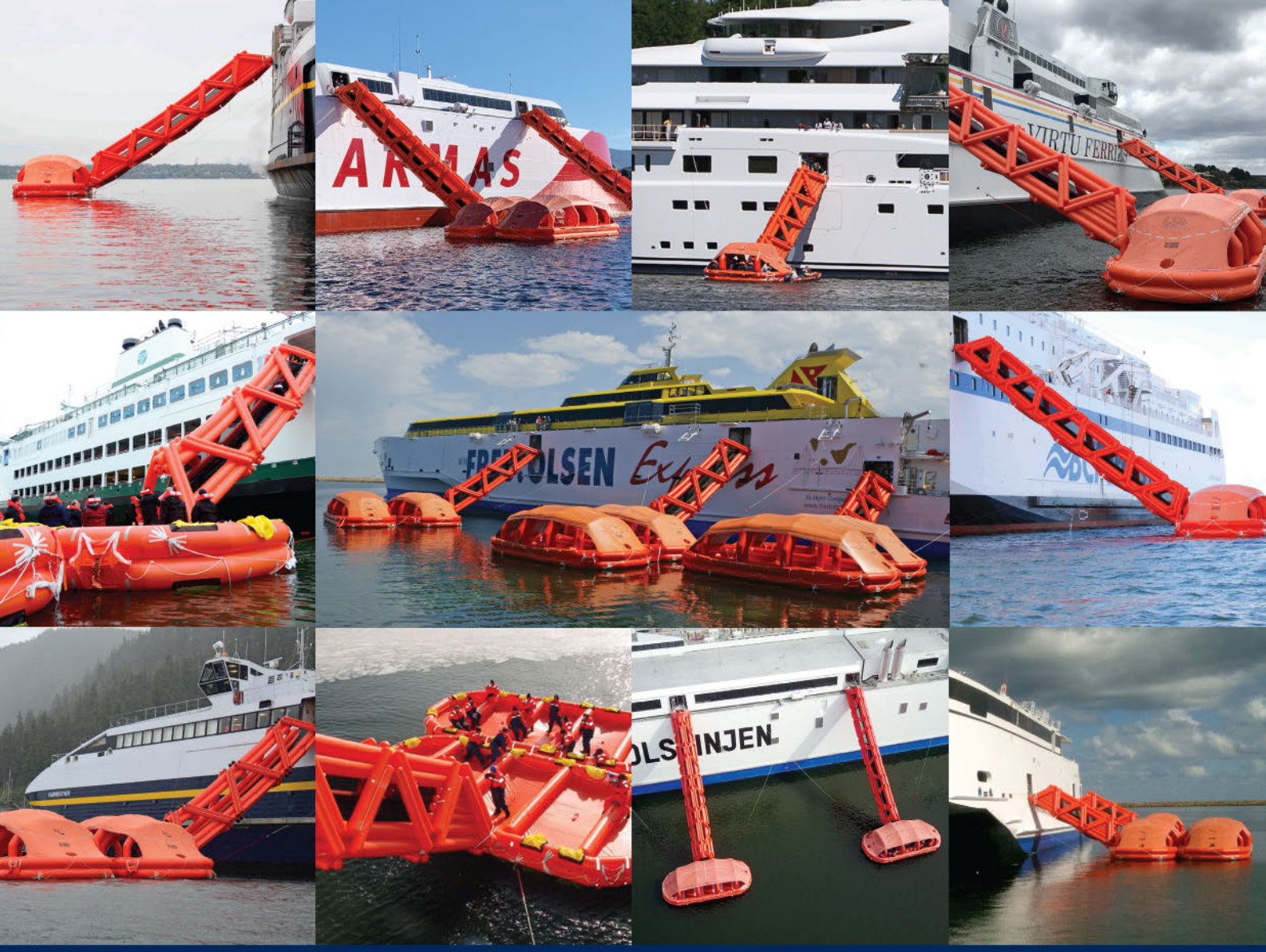
Operated in this way, there is a broad range of use cases for drone surveys on board, as they can be used to access confined spaces, cargo oil tanks, or other areas where surveyors and crew members can expect to encounter larger than normal quantities of noxious vapours.

New horizons

In the near future, other technologies will come to the forefront in the realm of remote surveys. The application of deep learning, for example, is one which will necessarily require a large amount of initial input; however, drone inspections will soon be at the stage where faults in hull structures can be identified by an intelligent algorithm, allowing for a more detailed inspection than the human eye alone could perform.

CCS believes that remote survey technology can augment the capabilities of shipboard inspections whether or not the opportunity arises to dispatch an operative to the vessel; but the law needs to catch up with the technology. "The legal framework for the implementation of remote survey and RIT has not been provided," says Xiang. "Therefore, there is an urgent need to develop specific guidance to ensure that this practice of remote survey is carried out in a harmonised way and in a manner that ensures the same level of safety as that provided by a physical onboard survey.

"Recently, China has proposed to undertake a scoping exercise of the framework and develop mandatory or non-mandatory technical requirements on remote survey, with a view to providing guidance for Flag States and recognised organisations to carry out remote surveys."



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EDUCATION

COPENHAGEN BUSINESS SCHOOL'S BLUE MBA: MOULDING MARITIME'S THOUGHT LEADERS

By **Richard Halfhide**

Since it was first launched 20 years ago, the Copenhagen Business School's (CBS) Executive MBA in Shipping and Logistics (Blue MBA) has been empowering and equipping maritime professionals to take the next step in their careers. But in an industry that's currently undergoing unprecedented change with advances in marine technology, challenges of decarbonisation and the tectonic shifts being experienced across the supply chain, the value of shipping executives with the right skillset to grasp what is required to enable a company to navigate this new world has seldom been more important.

"While shipping has been for long an 'old economy' industry clinging to legacy systems and methods, it has huge potential to move forward through digitisation such as automation of cargo handling and trade processes to achieve what is touted as frictionless trade, and green technology in ship design," says Irene Rosberg, programme director for the triple-accredited Blue MBA.

"Our industry, like all major undertakings, has reached a critical juncture, as technology spurs the pace of change in communications, engineering, commercial transactions and trade patterns. The paradox is that even as unprecedented technological developments appear to hold out the answers to everything, we need more than ever to prioritise the human element in the mix."

At every stage of the maritime chain there is a revolution to be mastered; one need only think of how ports are undergoing enormous transformations in order to handle the new generations of mega-ships. Each segment of the industry – whether container, dry bulk or tanker – remains fraught not only with their specific issues but also common concerns such as new regulatory clampdown on fuel quality.

Having a specific understanding of how this disruption will affect a business is essential, believes Rosberg, but effective management also demands an acute awareness of how and where these changes will fit into a business's micro-strategies "Against this background, the most intelligent companies are rightly considering competent people as the main factor adding value to their modus operandi and their brand," she explains.

"The requirement of the hour is to focus attention on advancing the knowledge of the individual, supplying him or her with a 'toolbox' of analytical expertise and competence to achieve the best in practical and strategic decision-making."

THE BLUE MBA'S CLASS OF 2021

Rosberg thinks this is one of the major reasons why the Blue MBA, which places high importance on the relevancy and currency of its deliveries, is in such high demand. "Digitalisation is today playing a significant role in our curriculum. Additionally, we have stressed on the element of sustainability by including topics such as decarbonisation, environmental issues and connected regulations, cybersecurity among others," she says.

Tailored for professionals

Participants of the Blue MBA typically hold a mid-career to senior level management position and have already been working within the industry for a number of years (the average age of students is 38, with 17 years of work experience). Its alumni includes graduates from more than 20 different countries and every conceivable segment of the shipping and shipping-related industries.

Rosberg comments: "When we compose the cohort we ensure that all the segments of the industry are represented in the group. The programme provides a holistic view of the industry and this needs to be reflected in the profiles of the participants, who bring the diversity of the segment to the classroom. This has been one of the success factors in our programme. The advantage is that our participants not only learn from their professors and lecturer, but also from their classmates and this provides a second-to-none dynamic in the classroom.

"What's more, we do not measure our success in monetary terms – we look at the results our graduates create for their organisations. It is our task to give our participants a holistic view of the shipping industry, and an understanding of each segment that makes up a piece of a fascinating but complex puzzle."

The programme consists of eight one-week modules, all of which deal with leadership issues and personal development, spread across a 16-month period. Each module includes comprehensive reading material presenting the theories, which is studied in between group sessions, with an assignment for each module which focuses upon a challenge relevant to the student's own business. In addition, they are required to complete an Integrated Strategy Project (ISP) or thesis. Students are encouraged to choose an ISP topic that is of strategic value to their company, ensuring the business gains valuable practical insight from their studies.

"Industry leaders have confirmed time and time again how the Blue MBA brings substantial real benefit to the individual businesses the graduates serve and to the wider industry. They have perceived that the programme goes much deeper than mere 'academic exercise'. The industry has accepted that nurturing talent and investing in upskilling brings great advantages to an organisation, as well as lasting benefits to everyone involved," says Rosberg.

A graduate's story

Captain Prashant S. Widge, a Mumbai-born veteran of two decades in the shipping industry, is typical of the kind of students who join the programme. After coming ashore in 2012 to spend more time with his young family, Widge joined Maersk in a role aimed at systemising risk and crisis management in the areas of shipboard HSE, security, navigation and cargo management.

"With the know-how of maritime, shipping and logistics, and its significant role in the global trade, I wanted to leverage my experience and continue pursuing my professional journey in this phenomenal industry," says Widge.

Four years later he was chosen to lead A.P. Moller-Maersk's Responsible Ship Recycling (RSR) department, and credits the Blue MBA with helping him develop the thought leadership skills to start making a difference as the industry evolves towards greener recycling practices.

IRENE ROSBERG, BLUE MBA'S PROGRAMME DIRECTOR

"Having reviewed shipping education offerings globally, I decided that a century-old triple-accredited CBS-offered Blue MBA was a perfect fit. Offering high-quality executive education, this carefully crafted programme for senior management professionals provided a holistic view of the shipping industry and an opportunity to be part of an unrivalled international network."

"The Blue MBA, albeit a challenging assignment to embark on, is one that I would highly recommend to a top-quality maritime professional willing to invest significant efforts in staying ahead of the curve. With the acquired tools and experience, I feel the future is exciting and believe I am well-positioned to meaningfully contribute to our society, community, and the shipping industry at large as it moves into a decisive decade of large-scale sustainable organisational transformation."

Promoting diversity

Shipping is a notoriously male-dominated industry, and currently only one in five Blue MBA students is female, but Rosberg believes that the transformation being spurred by new technologies and tough new emission rules is likely to impact upon the composition of the future workforce. "We are not just talking about the greater emphasis on digital-savvy teams at sea and ashore that is widely acknowledged. What is on the agenda is a fundamental change in the make-up of those teams," she says.

"Digital fluency should be the key to removing the subconscious bias which has for many years held back the appointment of women to senior roles in the industry. One of the positive outcomes of digitalisation has been the facility to support flexible working hours. The ease and accessibility of communication tools has allowed us to stay connected and involved, be kept up-to-date and based on current information and make important decisions regardless of the location and the time zone from where we operate."

In other words, gender is less likely to have a bearing upon the selection of the next selection of executive professionals, as a traditional shipping background takes on reduced importance. Rosberg thinks that CBS needs to be ready to align with this new reality, but accepts there is still a long way to go.

"The gender imbalance currently hampering the maritime industry is undeniable. For instance, it is estimated that only 2% of seafarers are female. Even though many steps have been taken to close that kind of recruitment gap, the integration of women in this industry has been very slow."

"Artificial gender barriers must continue to tumble, and men and women be allowed to qualify and compete on as far a level-playing field as practical. By drawing in new layers of talent, the changing skillsets ought to make the industry a beacon of diversity." ■

MARITIME HISTORY

THE BIRTH OF NAVAL ENGINEERING STUDIES IN EUROPE

By **Jaime Pérez-Martínez**, Royal Institution of Naval Architects (RINA),
and **Rodrigo Pérez Fernández**, Escuela Técnica Superior de Ingenieros Navales (ETSIN) (UPM)

Shipbuilding in the late 17th and early 18th centuries was influenced by the drive towards standardisation. This was possible through the written word and a more informed use of natural resources. It was the state, via the navy, which took on the responsibility of training shipbuilders. As they began to be educated at the same academies, utilisng the same printed resources and knowledge, so ships began to look similar.

The specialisation of the shipbuilders due to the artillery, which increased the ship's load, a geometrical decision (greater submerged volume with the aim of increasing the freeboard and depth of the guns) and greater resistance to enemy fire, made these jewels of 18th century engineering the object of further technical study.

FIGURE 1. THE CROWN AND ANCHOR AT THE STRAND. SOURCE: WELLCOME COLLECTION

Naval power took on increased importance in the 17th century, with numerous armed conflicts across the continent, many taking place against the backdrop of the Eighty Years' War (1568-1648) and the Thirty Years' War (1618-1648). While the Spanish conflicts had dynastic and territorial roots, the conflicts between England and the Low Countries had a strong commercial component, arising from the slave trade and other maritime activities. Spain, England, France and the Netherlands were the main European powers constantly fighting for naval control.

Publications and learned societies

Advances in the art of shipbuilding were rooted in the scientific development of the 17th century and an empirical uprooting from Aristotelian theories. In his Dialogues on two new sciences (1638), Galileo Galilei (1564-1642) presented a primitive version of beam theory, that would later be expanded upon by Pierre Bouguer (1698-1758), and Jorge Juan (1713-1773); while Petrus van Musschembroeck (1692-1761) conducted tests in tensile strength, bending and buckling. In the naval field, the famous naturalist Georges Louis Le Clerc (1707-1788), Comte de Buffon, carried full-scale tests to determine the most suitable trees for shipbuilding.

In mathematics, infinitesimal calculus was developed by Newton (1642-1727) and Leibniz (1646-1716), which proved to be an invaluable tool for scientific development. Works on quadrature, or area determination, appear in publications such as Newton's *De quadratura curvarum* (1704) and James Stirling's (1692-1770) *Methodus differentialis sive tractatus de summatione et interpolatione serierum infinitarum* (1730). The first work concerning the naval domain by Leonard Euler (1707-1783) was the optimal positioning of masts on a ship. But in shipbuilding, his three main works were: *Traité du Navire* in 1746, *Scienctia Navalis* in 1749, and *Théorie complete de la construction et de la manoeuvre des vaisseaux* in 1773. In the field of stability, the concept of metacentre was developed at this time by Bouguer. His work was later developed by Johann Bernoulli (1667-1748).

The emergence of scientific societies in 17th century Europe was based on two different models, either driven by the scientific community itself or by the state. Despite its designation the Royal Society, founded in 1660, was independent of the Crown both financially and organisationally, relying on private donors. The Philosophical Transactions of the Royal Society, originally published in 1665, was the first of its kind in the world.

As the trend for increasingly specialised scientific societies continued across the UK and Europe over the next century, 1791 saw the creation of the Society for the Improvement of Naval Architecture. Formed to compete with the growing excellence in hydrodynamics of French science, and the aim of improving both the British Navy and its merchant navy, its notable activities included the experiments of Mark Beaufoy (1764-1827). This Society is considered the predecessor of the Royal Institution of Naval Architects (1860), and its first meeting was at the Crown and Anchor Tavern on the Strand in London (see Figure 1), a common meeting place for scientists of the time.

Established by Jean-Baptiste Colbert in 1666, the Académie des Sciences aimed to attract scientific knowledge for the scientific advancement of France. Under Louis XIV, French and foreign scientists met in the royal quarters and received a stipend financed by the state. From 1699, the Society began to publish

FIGURE 2: JOSÉ ANTONIO DE GAZTAÑETA E ITURRIBALZAGA

Histoire et mémoires de l'Académie Royale des Sciences de Paris, which published Beaufoy's aforementioned essays between 1740 and 1741. Among the Academy's initiatives were the Meslay Prize, with twenty-two such awards (just over a quarter of the total) between 1720 and 1792 bestowed for works related to fluid mechanics and ship theory.

The Royal Swedish Academy of Sciences was founded in 1739 with the aim of promoting science, especially mathematics and natural sciences. It featured the works of Fredrik Henrik af Chapman (1721-1808), Gilbert Sheldon (1665-1739), Thomas Von Rajalin (1673-1741) and Christopher Polhem (1661-1751) among others. Today it runs various research centres and awards prizes such as the Crafoord Prize and the famous Nobel Prizes in Physics and Chemistry.

Spanish academies first appeared in 1700, with the constitution of the Royal Society of Medicine and Other Sciences of Seville, followed in 1713 by the well-known Real Academia Española (Royal Spanish Academy). It was the military establishment that promoted the creation of centres such as the Astronomical Observatory of San Fernando, and others such as the Royal Military Academy of Mathematics and Fortification of Barcelona, the Artillery Academy of Segovia and the Academy of Midshipmen. From the civil sphere, the Sociedades Económicas de Amigos del País (Economic Societies of Friends of the Country) appeared in the second half of the 18th century. However, it was not until 1929 that the Association of Naval and Ocean Engineers of Spain was formed, which continues to publish the Naval Engineering Journal, founded by Áureo Fernández Ávila (1895-1980).

Notable treatises and publications

There have been many treatises describing the correct construction of ships. José Antonio de Gaztañeta e Iturribalzaga (1656-1728) (Figure 2), an illustrious seaman, wrote three works that served as the foundations for what was to come during the 18th century: *Arte de fabricar Reales* (1691), *Proporciones de las medidas arregladas a la construcción de un bajel de guerra de setenta codos de quilla* (1712) and *Proporciones de las medidas más esenciales para la fábrica de nuevos navíos y fratas de guerra* (1720). Gaztañeta had a great influence on 18th century naval architecture, as he modified the measurements and design of the Spanish Navy's ships, which increased in length. Many of the elements contributed by Gaztañeta were also adopted by the English and Dutch.

Cipriano de Autrán y Oliver (1697-1773) was the author of the handbook *Métodos, reglas y proporciones para la construcción de bajeles* (Methods, rules and proportions for the construction of ships) in 1742. Autrán, a shipbuilder of French origin assigned to the Arsenal of La Carraca (Cádiz), had an extensive shipbuilding curriculum, having learned the trade from his father, a shipbuilder in the service of Philip V. In the Royal Shipyard of Guarnizo (Cantabria), together with Juan Pedro Boyer, he built several ships, including the Real Felipe and the Princesa, which brought him prestige. A great advocate and promoter of Gaztañeta's Proportions, he perfected Gaztañeta's system by correcting the excessive pitch, adjusting the proportions of the rigging and improving the fortification.

Pierre Bouguer (1698-1758), the French astronomer and mathematician, is widely considered the father of naval architecture, for his celebrated *Traité du navire de sa construction et de ses mouvements* (1746), a monumental work that radically transformed the science of shipbuilding. He developed innovative concepts in naval architecture, most notably the idea of the metacentre (although he did not refer to it as such). The treatise acquired an immediate reputation and less than 10 years later, it was translated into English.

Scientia navalis (1749) is one of Euler's rarest books. It was an original contribution to fluid mechanics and shipbuilding and established for the first time the principles of hydrostatics, which form the basis for the theory of naval architecture. In the first volume he presented a general theory of the equilibrium of floating bodies with an original theory of stability and small oscillations in the vicinity of an equilibrium position. The second volume applies the general theory to ship design, and deals with stability, behaviour at sea and wind, as well covering masts, sails and rudders.

Élémens de l´architecture navale (1752) (Fig. 3) by Henri-Louis Duhamel du Monceau (1700-1782) became the reference text of the French shipbuilders' school. Du Monceau was inspector of the navy from 1739 and assembled an important collection of model ships and harbour machinery that would form the nucleus of what would later become the Musée de la Marine. In 1741, he founded the École de Paris (later to become the École du Génie Maritime) which enabled the brightest students to receive for three years a scientific education decisive for

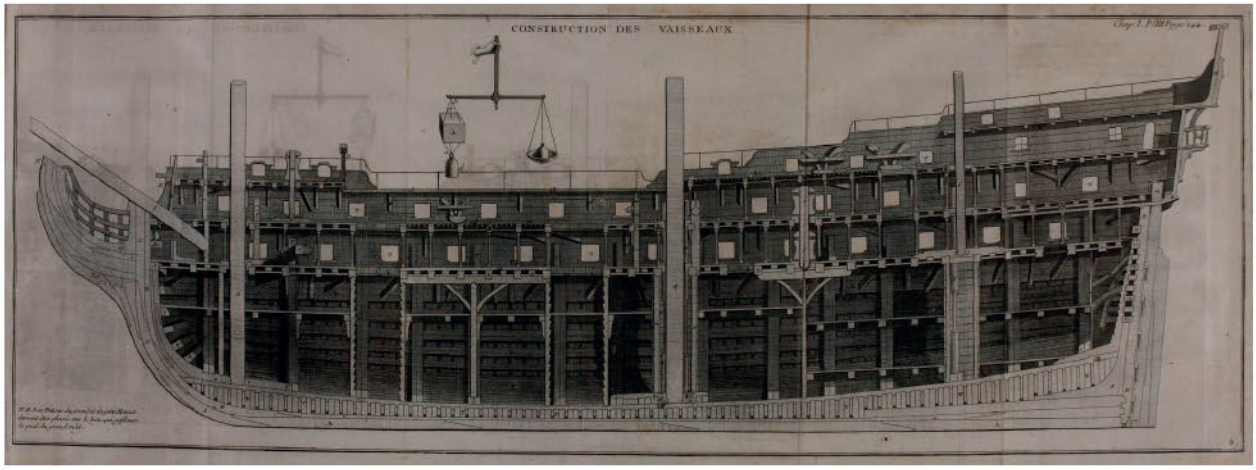

FIGURE 3: DUHAMEL'S *ÉLÉMENS DE L'ARCHITECTURE NAVALE*

the evolution of the French Corps of Naval Engineers, and wrote his shipbuilding treatise to improve their training.

Duhamel du Monceau was not a shipbuilder, but he knew perfectly well how to organise the chapters in a pedagogical way. Both *Élémens de l´architecture navale* (Figure 3) and his other influential text, *Traité de la fabrique des manœuvres pour les vaisseaux, ou l'Art de la corderie perfectionné* (1747), are clearly set out an supported by numerous illustrations. Both were authorised for publication, thus breaking the confidentiality embargo that existed in shipbuilding at the time, to avoid revealing the hitherto jealously protected secrets of French shipbuilders.

Fredrik Henrik af Chapman, a Swede, published his fundamental *Architectura Navalis Mercatoria* in 1768 (Figure 4). Consisting of 62 engravings of vessels of various sizes, classes and flags, the work was later complemented with *Tractat om skepps-byggeriet* (1775). This treatise on shipbuilding, originally written in Swedish, was translated into French, German and English. Chapman has been considered one of the most important exponents of the use of the scientific method in shipbuilding.

Also worthy of mention is Jorge Juan's two-volume *Examen Marítimo teórico práctico or Tratado de mecánica aplicado a la construcción, conocimiento y manejo de los navíos y demás embarcaciones*, (1771), a fundamental work for shipbuilding and navigation in the 18th century. The document, full of mathematical operations and reflections, was to become the cornerstone of shipbuilding theory, the first to be written with mathematical calculations. It analyses the dynamics of the ship, its stability, its relationship with the thrust of the waves, the stresses to which the rigging is subjected, etc., based on experimentation.

Romero Fernández de Landa's (1735-1807) most important work, *Reglamento de maderas necesarias para la fabricación de los bajeles del Rey* (1784), was motivated by the lack of regulations for the cutting and reception of wood, the need to establish criteria for when oak could be substituted with pine and cedar, and that wood must be paid for by the class of the smallest dimension. His work establishes that the differences in the ships lie in the variation in the type or number of pieces, in the scantlings, and finally in the gauge of the pieces.

Influence of the new requirements

The 17th century was characterised by the floating military revolution in which European countries such as Spain, France, England, Holland, Denmark and Sweden, among others, turned to the creation of state navies to solidify their naval power, a concept that has survived to the present day.

The incredible increase of armed naval conflicts in Europe is the consequence of maintaining control of the occupied territories and their trade routes, as a result of the exploration and discoveries of previous centuries. This led to the need to employ military vessels for commercial purposes, such as frigates. These ships and crews had to be able to withstand the inclemency of transatlantic voyages and the aggression of navies and privateers.

The vast territory that European powers had to protect increased the shipping areas and requirements. The transatlantic trade and other trade routes required ships that could withstand the harsh conditions of these voyages. These designs aimed to strengthen the strength of the ships, increase their speed and manoeuvrability. In the scientific field, great advances were made in navigation, including the measurement of the meridian in 1736. Scientific expeditions led to advances in geological, hydrographical, botanical, zoological and anthropological knowledge. They also improved cartography, astronomy and chronometry.

The Pacte de Famille brought about the strengthening of relations between Spain and France, enabling their protection from their common enemy England. These alliances also brought about a homogenisation of naval techniques and design.

Schools, training centres and engineering corps

These works would be of no importance if they did not serve as a basis for the application of construction. Just as institutions such as the Royal Seminary College of San Telmo in Seville (1681-1847) were created to make up for the shortage of seafarers in the Indies

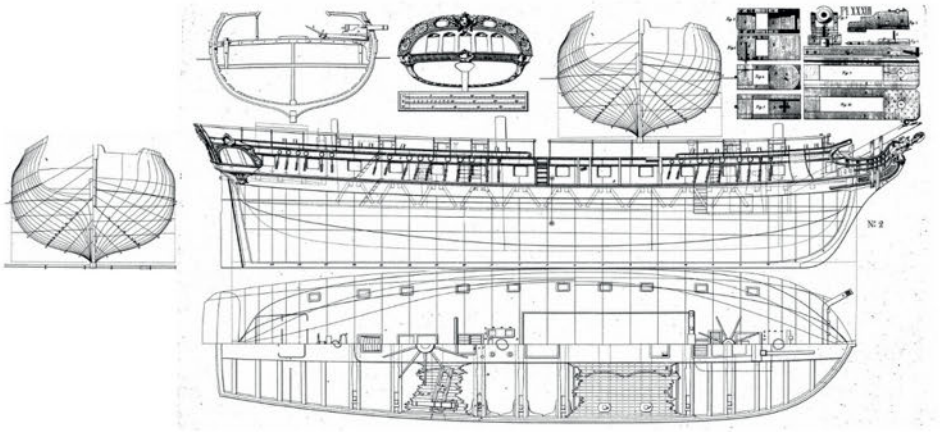

FIGURE 4. ENGRAVING 33 FROM *ARCHITECTURA NAVALIS MERCATORIA* BY FREDRIK HENRIK AF CHAPMAN

race, so too did the technical and scientific application of shipbuilding require qualified personnel. The zealous attitude of Sir William Petty (1623-1687) towards naval education was abandoned in favour of the homogenisation of design and construction.

The origin of naval training is undoubtedly to be found in the shipyards. This system of education lasted in England because military ships were built in private shipyards, although this did not prevent the English ships from perfecting their vessels without applying the new theories of calculation. However, it was not until 1811 that the first School of Naval Architecture was established in Portsmouth, relocating to London in 1864, laying the foundations for the Royal Corps of Naval Constructors (RCNC), established in 1883.

In 1781, Spain's new military commitments, and the need for larger and faster ships, forced a new approach in Spanish shipbuilding. Francisco Gautier (1733-1800), who created the Corps of Marine Engineers (1770), introduced improvements that affected the training of engineers, their organisation and construction systems. He reinforced the strength of the ships, as well as their shapes and rigging to increase their speed and manoeuvrability. Two years later, naval engineering studies began and the Academy of Marine Engineers was established (see also *TNA*, October 2020).

The appearance of the technical office in the shipbuilding environment coincided, in Spain, with the creation of the navy arsenals during the 18th century. These responded not only to the need not only for naval ships to be built and maintained, but also to elaborate the necessary technical information to guarantee that the vessels built in different arsenals were effectively similar in terms of shape and behaviour at sea once built. After Zenón de Somodevilla y Bengoechea (1702-1781), the first Marquis of Ensenada, tabled the urgent need to build and install arsenals, shipyards and workshops for the construction of ships, the Spanish Crown decided to build three arsenals located at the vertices of a strategic triangle, Ferrol, Cartagena and La Carraca.

The formation of the so-called Board of Constructors, which met in Madrid in 1752 under the direction of Jorge Juan, led to the creation of Spanish shipbuilding's first technical office, in the modern sense of the term. Its objective was to specify and execute the project of the vessels planned within the Marquis of Ensenada's plan, and to draw up the technical information necessary to proceed immediately with the construction of the different types of ships in the three Navy Arsenals. Subsequently, the quartermasters of Ferrol, Cartagena and La Carraca respectively, were sent a complete documentation prepared by the Board corresponding to the ships to be built in each arsenal and each type of ship, including: a plan of longitudinal layout, cross sections and water lines; regulation of timbers required; poles needed to make the rigging; bronze pulleys needed; the thickness and length of working ropes and the slope they should be rigged; anchors and anchorages; and the iron and glass needed.

The emergence of shipbuilding studies and early models

The standardisation or homogenisation of shipbuilding education, previously confined to the shipyards, also began in the mid-18th century. In 1741, Henri Louis Duhamel du Monceau, founded a Marine School in Paris to train a select group of shipbuilders. By 1765, it was no longer a private project, but received institutional support, enabling the social and professional status of the shipbuilders to be raised due to this increased scientific training, although it was not until 1786 that the École des Élèves Ingénieurs-Constructeurs de la Marine opened its doors to civilian training.

In Spain, Gautier established the Academy of Engineers of the Navy in 1772. Five years later, Gian Maria Maffioletti (1740-1803) established the Scuola di architettura navale in 1777 inside the historic arsenal of Venice, whose origins date back to the 12th century. In Denmark, however, shipbuilding training was present since the founding of the Naval School, Sø-akademiet, in 1701. Shipbuilding was part of the training of future officers. In the Netherlands, the English influence was decisive for not joining this trend until the Napoleonic Wars.

The studies taught in the academies and schools mentioned were as varied as their entry routes. Students were required to have a certain mathematical ability, mainly calculus, whose knowledge would be enriched throughout their training with mechanics, physics and ship theory, among other disciplines. In these early shipbuilders' schools, the reference texts were from the

works available, which could be publications such as Bouguer's Traité du Navire, but were later replaced by the works of the school directors.

Today, all engineers are required to be trained in basic sciences, applied sciences and specific knowledge of their degree. As the science and technology of shipbuilding progressed, so did the content of shipbuilding. This progress also led to the first specialisation in Naval Architecture and Marine Engineering appearing in Spain in 1964. Something recovered by the current Bologna Process, in effect since 2010, in which a distinction is made between graduates in Naval Architecture and those in Maritime Engineering, is the opportunity to join together in the Master's Degree in Naval and Oceanic Engineering.

Theoretical training was the differentiating element between the teaching methods. The French system was based on it, while experience was favoured in the English system, and these were also evident in the countries under their respective areas of influence. Within engineering education, two main streams prevail, either the fundamentally academic or the apprenticeship. Today both methods share some nuances. Academics are required to undertake a period of internship and the other system requires an activity that can be validated as part of formal academic training.

The evolution of shipbuilding is a clear example of technology transfer. Since the first ships, shipbuilders have incorporated different techniques and knowledge from a variety of sources. This could be through spies, the incorporation of foreign shipbuilders, the capture and purchase of ships, among others. Although the main naval powers gradually imposed their model of shipbuilding, this did not mean that they adopted it completely. This influence could be the result of friendly collaboration, such as the case of the France-Spain and England-Netherlands axes, or of war, as in Holland after the Napoleonic invasion.

The legacy of shipbuilding schools

The vast legacy of shipbuilding studies is still relevant in our time. Mention has been made of the contribution of du Monceau with his small Ecole de Marine in 1741, the origin of the acclaimed ENSTA ParisTech. Others such as the Norges Norges teknisk-naturvitenskapelige universitet (NTNU) also trace their origins to this period with the Trondheim Academy in 1760. Elsewhere it was the navy that included shipbuilding in their studies, as was the case in the Netherlands. In 1869, they included a shipbuilding curriculum in the current TU Delft, which five years earlier had been transformed into a Polytechnic School, originally founded to train civil servants to work in the Dutch East Indies.

In others, its naval origin is more debatable, as in the case of Chalmers University, having been founded in 1829 with the donation of the former director of the Swedish East India Company. In the UK's industrial heritage is still evident, favouring apprenticeship with support from academic institutions. In Spain, the military origins have left their mark on the schools that make up the country's technical education. The legacy of which is maintained by the former Special School of Naval Engineers, now known as the School of Naval Engineers (ETSIN) (Figure 5).

Conclusions

William of Ockham (1298-1350), the English theologian, said that the irrefutable proof that God existed was that ships floated. Without entering into philosophical dilemmas, it is clear that for centuries shipbuilding was a science, or group of technologies, reserved for a few, the so-called master builders, who jealously guarded their knowledge. The art and science of modern shipbuilding is the result of the ingenuity of those scientists to whom we owe not only the development of science, but also a new way of interacting with the world and of understanding education. The reader well versed in European scientific history will notice that some names are not mentioned, but their contribution has not been ignored. It should also be noted that the mathematical and physical principles on which they were based were centuries, in some cases more than a millennium, old.

It could be argued that the birth of naval engineering studies in Europe was brought about by the technological awakening of the 17th and 18th centuries. That said, one would only be looking at part of this fascinating period of European scientific and cultural history. Expeditions and discoveries brought to Europe an extraordinary knowledge of the world, and more importantly a greater need for mastery of that newly discovered space. From the work presented above, the influence of the two naval powers of the time, France and England, is evident, even so, the rest of the maritime nations had their contribution and implemented the different models and knowledge according to their own needs. Despite the clear state support for advances

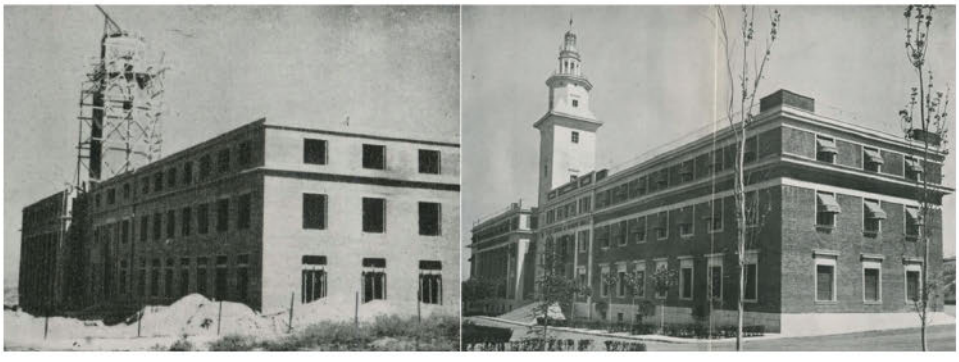

FIGURE 5. LEFT: THE MAIN FAÇADE OF THE BUILDING THAT NOW HOUSES THE ETSIN (1944). SOURCE: HUARTE & CÍA, S.L

RIGHT: PHOTOGRAPH OF THE INAUGURATION DAY OF THE SAME BUILDING (1948). SOURCE: INAUGURATION DOSSIER.

in navigation and shipbuilding, private scientific and mercantile initiative also fostered this development.

Finally, it is appropriate to recall the reflections of W. F. Stoot who in 1956 highlighted the importance of teaching naval history in the curriculum of engineering schools. This article has set out the origins and educational models that remain today. It is thus of value both to the student who ventures into this fascinating science, and to the lecturer who teaches it, who consciously or unconsciously continues the naval legacy by creating the history of tomorrow. ■

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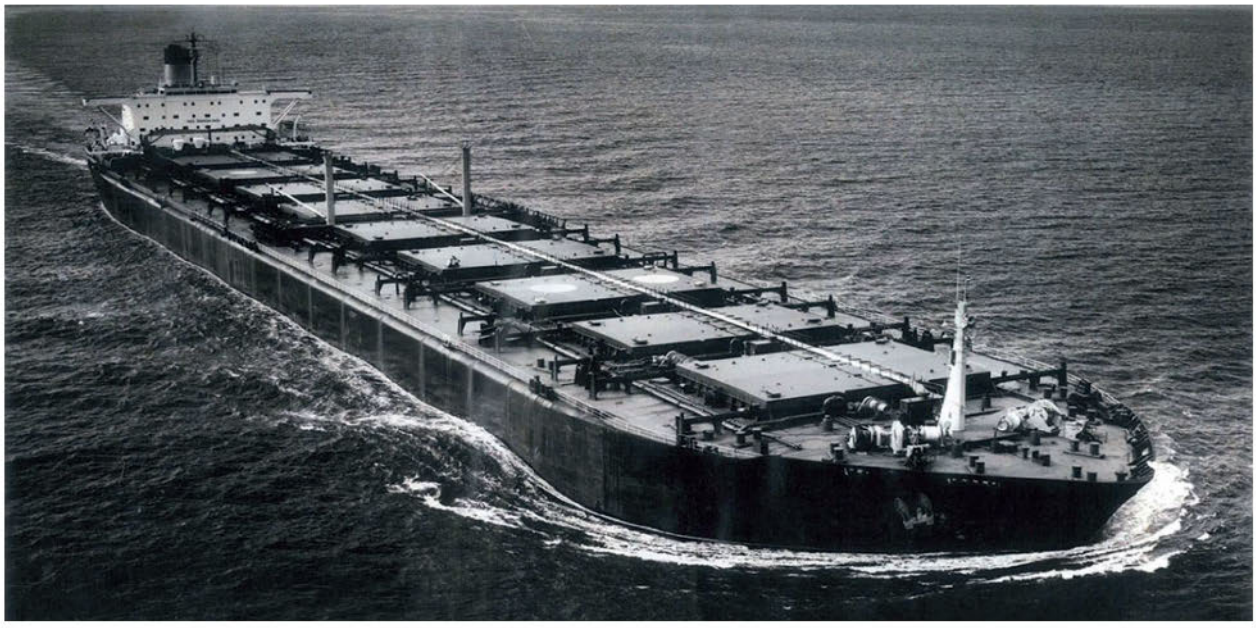
LETTERS TO THE EDITOR

HEEDING THE LESSONS OF THE M.V. *DERBYSHIRE*



THE 169,000DWT *DERBYSHIRE* REMAINS THE BIGGEST BRITISH VESSEL TO HAVE BEEN LOST AT SEA

This response to the January 2021 contribution on bulk carrier design and safety to *The Naval Architect* by Dennis Barber ('Localised stress and failure on bulk carriers and OBOs') needs a brief introduction covering history and credibility, as I am not a naval architect, although I have a lifetime's experience in welding design and construction.

I appeared as an expert witness for the National Union of Seamen at the first government Formal Inquiry into the 1980 loss of the M.V. *Derbyshire* en-route from Canada to Japan and some 500 miles south of Japan at a depth of 2½ miles. Marine surveyor Peter Ridyard had established prior to the Inquiry that the five sister ships had various amounts of cracking in the deck structure close to the forward faces of the superstructure leading eventually to the bridge of the vessel. After five years in the fabrication industry including Berkeley, the first full-scale nuclear power station in the United Kingdom, I spent 15 years lecturing on welding design and fracture mechanics to post graduate welding technology students and carried out research on welded components.

The first Formal Inquiry was speculative as the wreck of the *Derbyshire* had not been located at that time. The report was naturally inconclusive, yet the speculation that the *Derbyshire* had probably been overcome by the sea was on the right track.

Japanese aircraft searching for the *Derbyshire* two days after she was due in port, plotted the positions of two upwellings of oil, but there was no sign of the vessel.

Shaun Kent, a buccaneer interested in the scrap value of the vessel and its cargo, had bought the wreck of the sister ship, *Kowloon Bridge*, when it foundered on the Stag Rocks close to Cork in Southern Ireland in 1986. Having dived down and removed the remaining oil in the wreck he came to some of the first days of the Formal Inquiry and turned up at Church House, Westminster, with a section of the vessel the size of a car, including the fractures adjacent to the superstructure. The Wreck Commissioners refused to accept this visual evidence, unless the unions paid for the extension of the Inquiry and they refused.

Fourteen Secretaries of State for Transport had failed to order any on-site investigation into the loss and it was left to the *Derbyshire* Families Association, representing the dependants of the 42 crew and two wives and under the able leadership of Paul Lambert, to tackle this problem.

Shaun Kent came up with a possible solution which he estimated would cost about £2 million. Fortunately working back from the oil sightings and the possible lateral drift of the oil, as it rose some 2½ miles from the seabed, the maps of the local seabed revealed gentle slopes, so wreckage should be located with suitable sonar.

This hypothesis was taken to a meeting at the International Transport Workers' Federation, attended by representation of NUMAST, the officers' union, NUS, the seamen's union and the *Derbyshire* Families Association. Shaun Kent presented his hypothesis with the tag of some

£2 million. Much doubt was cast on the viability of finding the wreckage and Kent was increasingly angry. I recall that I had to kick him under the table and was subsequently able to persuade the gathering to spend some £25,000 on investigatory scientific work. There was some doubt about the quality of the pictures of the fracture surfaces at depth: these pictures would need to be used in a forensic check to determine the nature of the failures.

This meeting was critical to the finding of the *Derbyshire* and the massive subsequent international investigations into the loss of bulk carriers. All credit must go to the *Derbyshire* Family Association for their persistence. Historically this was the starting point for a more fundamental understanding of the behaviour of bulk carriers.

Part of the expenditure was a meeting of myself, Kent and Dr Alan Wells, the one-time Director of the Welding Institute who had previously published a fundamental paper on crack propagation in structured steels to select fracture specimens from the section of the *Kowloon Bridge* recovered by Kent. Subsequently some deep water activity was discovered in the Caribbean, where Kent took the samples and these were photographed at depth. The quality of the pictures was somewhat similar to the early pictures taken in the House of Commons and published in the newspaper. The results were passable but not crystal clear.

DERBYSHIRE'S SISTER, *KOWLOON BRIDGE*, SANK OFF THE COAST OF IRELAND IN 1986

I negotiated a verbal contract for some £300,000 between the Oceaneering Department of Southampton University and the International Transport Federation for eight days on location using their TOBI sonar system. Having secured this agreement whilst on holiday from the local telephone box, I returned home a few days later to find a letter withdrawing the Southampton offer with no explanation.

Dr Andrew Segalavitch, the Russian who had two deepwater titanium spheres with viewing ports, was invited to London, where unions decided in the morning of the proposed afternoon meeting that they would not deal with the Russians. Subsequently, Segalavitch took *Titanic* film director James Cameron down to look at the wreckage prior to the making of the film.

Third time lucky, the Americans took on the job at a much higher price and in a working window of eight days found the bow of the wreck. Dr Ballard who, after much searching, found the wreck of the *Titanic*, also at 2½ miles depth, advised one of our group that we would be unlikely to find the *Derbyshire*.

After far too long, the maritime industry, in the early 1990's, recognised the merit in trying to improve bulk carrier safety, following the appalling history of catastrophic losses in the second half of the century – scores of bulk carriers and many hundreds of deaths followed the despatch of unseaworthy ships.

There was some knowledge of bulkers falling apart at sea, leading to incoming seawater which dragged the vessels below the surface. A major problem was the side shell plating cracking and/or detaching from corroded frames and folding out into the seaway, one case occurred with the sides of a hold both on port and starboard opening up leaving a rectangular window with deck above and keel below and side plating adjacent to the bulkheads for the hold providing the vertical sides of the opening. In the event of a ship being laden with heavy ore – a single flooded hold was likely to lead to a rapid and progressive collapse and sinking.

There were reports of deck fittings furniture at the bow being ripped off by boarding seas, allowing bow flooding. I was never sure whether there was any understanding of the maximum forces on the deck furniture and if the attachments to the deck were appropriate. In the 1950's the pressure vessel industry found to its cost that the recommended fillet welded details around annular area compensating plates at openings in the vessel wall were unreliable and there was a move to butt welding inserts into the wall of the vessel guaranteeing unbreakable performance in service. The extra cost of a few butt-welded items in the deck at the bow would be trivial affecting overall fabrication costs.

Dennis Barber draws attention to the connection of the corrugated bulkhead to the stools. There are at least three issues: the ability to fit the sections of the bulkhead to meet tolerances for successful welding, the ability of the stool material to accommodate the large welding shrinkage strains and the ability in service to withstand the higher stresses at the corners of the bulkhead especially at the join to the stools. The British Standard for welding would require that the stool plate immediately below the corrugated bulkhead be Z quality which would mean proven ductility through the thickness with a proven reduction of area anywhere between 10 and 25%.

To fit up of a section of a bulkhead some 20m high to a maximum gap of 3mm for a satisfactory weld preparation is wishful thinking. If the top stool plate is torn apart by welding strains due to a population of non-metallic inclusions would there be 100% ultrasonic checks to find this potential weakness. With the presence of a micro-crack up to 0.2mm at the toe of the weld any repeated loading would be accompanied by fatigue crack propagation at the point of highest stress, probably the corner of the bulkhead to the stool.

These problems could be more acute at the top of the bulkhead with a partial width connection to the topside tank relying on the more severe challenges associated with overhead welding. The bottom of the tank should be Z quality material to avoid lamellar tearing.

In 1994, the Classification Societies published some 90 typical welded details in bulk carriers, where cracking and/or corrosion was most likely to take place. This revealed, after scores of lost bulk carriers with the deaths of their crews, the vulnerability of the traditional design of this type of ship. It was a gross condemnation of the basic design of bulkers which should have been recognised earlier, resulting in their withdrawal from service. The shiptype should have been redesigned, taking into account the disastrous behaviour of the welded connections. Both the Comet and Boeing 737 were withdrawn from service after two fatal crashes.

I recall that in 1953, Dr Gurney from The Welding Institute had published fatigue design curves for typical welded bridge connections which were planned to last for 120 years. Gurney's book, *Fatigue of Welded Structures*, first published in 1968, should be compulsory reading for any person designing welded steel structures subject to repeated loading in service. The original edition was 300 pages and this was expanded to 450 pages in the Second Edition in 1979.

Moving on to 2000 the emphasis in most if not all of investigations and conferences post *Derbyshire* has been on the interaction between the bulk carrier and its behaviour in a spectrum of sea states. Nor am I aware that the deficiencies of the welded details has apparently merited technological discussion. I am not aware that fatigue performance is regularly analysed and also that vibration prompting cycles of micro-damage have been assessed. Dennis Barber has raised various relevant issues to add to the above list of subjects, which merit much more detailed attention.

Sadly there is no excuse for the multiple losses of bulk carriers. The wife of one captain of a large bulker mentioned her husband was always monitoring the cracks in the deck, but knowing my association with the investigations into the loss of the *Derbyshire*, she said that he would lose his job if he spoke to me.

Catastrophic losses over some 50 years reflect very badly on most parts of the shipping industry.

On a personal note you feel the agony of the dependants of a bulk carrier loss, when you are given a hug for recognising the loss of a close member of their family. It is not just the loss of numerous bulk carriers, it is the permanent disgrace of unnecessary and lasting pain for thousands of people.

Sincerely,

John Jubb,
STRUCTURAL ENGINEER

THE *DERBYSHIRE* SCULPTURE AND MEMORIAL GARDEN IN LIVERPOOL WERE UNVEILED IN 2018

John Jubb is a retired Chartered Structural Engineer who specialised in welding for more than 50 years. After graduating with First Class Honours in Civil Engineering at Birmingham University he held the Aluminium Development Association's Scholarship of the Institution of Structural Engineers. He spent four years in design and fabrication companies including a spell as chief pressure vessel engineer at John Thompson, pioneers in making nuclear power plant. For 15 years he lectured to postgraduate welding technology students at Cranfield also carrying out research and some major contract work. Over the next 10 years he quality managed over 5,000 contracts covering buildings, bridges and some unconventional structures, mostly in structural steel. For 20 years he worked independently as a specialist structural welding expert.

RESPONSE

Sir,

I read with interest the contribution by John Jubb, who as an authority on welding knows a thing or two about how things can go wrong when joining steel, and with his background in nuclear pressure vessels he deserves to be heard. His involvement with the *Derbyshire* enquiries, like my own, has concentrated attention to the structural issues he has highlighted.

The points he has raised about sloping bulkhead connections and corrugated bulkheads on bulk carriers in response to my own observations made in *TNA* in recent years is particularly pertinent as there were similar discussions in the FSA Bulk Carriers in the early part of this century. These discussions related to successive failures and rapid progressive flooding of adjacent holds following a flooding event in one compartment.

The welding issues, in particular the shrinkage on cooling that builds in stress to a joint that will be highly stressed in service, was something pointed out to me by a chief engineer I sailed with when, together, we were attempting to address fractures in our hull structures some 40 years ago. He too was from the nuclear industry so I paid attention, as I have done since. My subsequent concentration on failure points always took me to similar welded joints in highly stressed areas, side shell included.

It follows that the bulk carrier design, and other types (our gas ships were very similar), should be the subject of a more intense study of built-in stress, which I have reason to believe has not been fully accounted for if at all – the presumption being that once constructed a ship is evenly stressed until loaded in service. I suspect this is wrong. The bulk carrier issues, whilst ignored for many years, cost the lives of thousands of seafarers. That troubled many of us in the industry. I hope it troubles many in the design sector as well.

We may be coming to the end of an era as the carriage of large quantities of carbon products reduces, but there are other ships out there that may well suffer a similar fate to the bulk carrier workhorses. Having more recently specialised in risk I am increasingly aware of the tendency to design to minimise materials. During a period during the early eighties, Capesize bulk carrier lightweights reduced by some 10,000tonnes. Unfortunately a possible outcome is a single point of failure. The single side of a bulk carrier was one such point. The corrugated bulkhead as opposed to the double cofferdam bulkhead of the OBO was another. There would seem to be a tendency towards hubris in design that should really be challenged at an early stage. In-service is too late.

Yours,

Dennis Barber,
MASTER MARINER,
FNI. FRINA. MRIN

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