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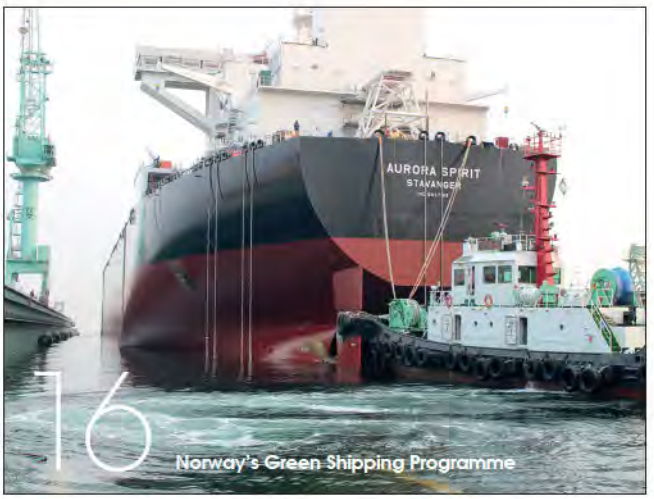

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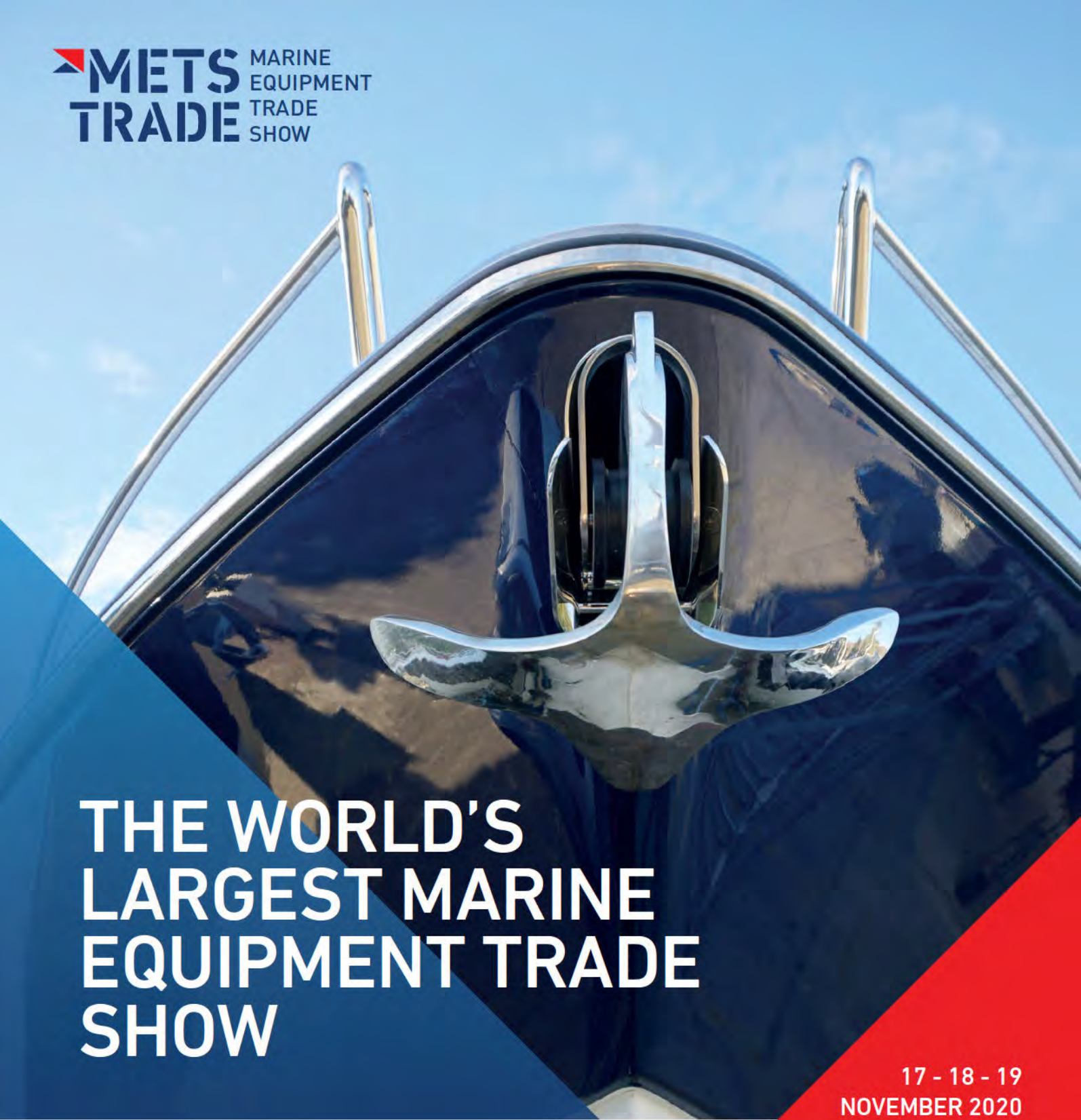

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Containers, cruising and coasting

HMM Algeciras at its launch ceremony in April

As the pandemic lockdown continues (albeit gradually loosening) across Europe and many other parts of the world, maritime discussion and debate remains fairly tempered at the moment. It will still be several more months until we can begin to quantify the full impact both upon trade and the shipyard orderbooks.

One thing is clear: nobody wants to make any predictions until the Covid-19 curve is well and truly 'flattened'. Although a few operators – such as Maersk and Hapag-Lloyd – did report stronger than expected results for the first quarter, the effects of the global slowdown were only really felt in the final weeks of March. Hapag-Lloyd even went so far as to say it's still targeting EBITDA of US$1.8 to 2.4 billion for this year, but that's being done at the expense of postponing plans for a new fleet of 23,000TEU container ships it had been intending.

This news came shortly after HMM (the rebranded Hyundai Merchant Marine) set a new record for the world's largest boxship: with the 23,964TEU *HMM Algeciras* being formally named at Daewoo Shipbuilding & Marine Engineering's (DSME) shipyard at the end of April, in a ceremony attended by South Korean president Moon Jae-in. But while DSME are due to deliver a further six such vessels, and Samsung Heavy Industries an additional five 24,000TEU vessels for HMM over the next few months, there's a growing sense that supersizing is becoming an awkward legacy of a more innocent time.

HMM shouldn't have difficulty putting these vessels to use (*HMM Algeciras* departed for Europe with a record breaking 19,621 cargo in May), even if freight rates are likely to slide over the coming months. Sadly, the same cannot be said for the beleaguered cruise sector where many of the shiny newbuilds we heralded back in our February issue face months in layup and no way of knowing when it will be safe to resume operations, or even whether passengers will feel confident about placing bookings.

Much of cruise shipbuilding remains focused in Europe, where Italy's Fincantieri, Germany's Meyer Werft and the French Chantiers de l'Atlantique, have all either slowed down or suspended operations for periods over the past few months. Meyer Werft announced 450 jobs would be lost at its Turku shipyard in Finland, while 3,500 workers at its Papenburg facility have agreed to reduced hours for at least two months. Managing director Bernard Meyer has warned he expects it to be a decade before the cruise industry recovers.

Fincantieri, which was one of the first Italian companies to halt business in mid-March, revealed in May that Q1 had seen a 20% drop in production but still managed a modest increase in revenue from the same period a year earlier. That was due in no small part to the ongoing success of Norwegian subsidiary Vard's cruise ship unit, which has delivered several expedition cruise ships over the past year for operators such as Ponant, Hapag-Lloyd Cruises and Coral Expeditions.

But a project I personally find far more tantalising is one that two of Vard Engineering Brevik's naval architecture team, Karl Fredrik Vistad and Andreas Buskop, discussed with me about how Norway's coastal bulk carrier fleet might be revitalised (p.18-20). Beginning life as a pilot in the Green Shipping Programme, their ambitious vision of standardised designs and modular power systems has the potential to cause positive disruption and, crucially, could be commercially feasible if the Norwegian government comes good with its promise of support for fleet renewal. Not only is it yet another example of the opportunities for innovation emerging with shortsea and coastal vessels, but also the possibility that European yards might adopt some of the mass production approach of the Asian yards.

Norway is not an EU member, of course, but recently there have been signs the European Commission (EC) is exploring the possibilities for providing European shipbuilders with greater protection against their Asian competitors. In May, SEA Europe, the Shipbuilders & Maritime Equipment Association, published a position paper in which it called upon the EC to engage in dialogue with European shipyards and equipment makers about developing models for sustainable financing. It comes in response to the EC's 'New Industrial Strategy for Europe' published in March.

The EC had previously concluded in a 2017 study that the next decade would be decisive for European shipbuilding and it's a problem that's only grown more acute as demand for complex shipbuilding from the offshore sector still struggles to return to its old levels. If the coronavirus has now brought an abrupt end to the cruise boom then very lean times could be ahead without greater support. But, given the expectation of a significant global recession, how much support should it reasonably expect? *NA*

Bulk carriers

Intercargo calls for better accident reporting

The International Association of Dry Cargo Shipowners, Intercargo, claims that shipowners have become complacent when conducting incident reports for cargo accidents and calls for a more efficient record into the loss of *Nur Allya* in August 2019.

According to Intercargo's 'Bulk Carrier Casualty Report Years 2010 to 2019 and trends' report, of the 39 bulker carrier losses that occurred in the last decade, only 24 were recorded by January 2020.

Intercargo insists 'the industry' finds it unacceptable that not only were just 62% of incidents recorded, but also that those incident reports took an average of 32 months to become available for viewing on the IMO Global Integrated Shipping Information System (GISIS).

The association also identifies that cargo failure and liquefaction, including carriers transporting nickel ore, iron ore and bauxite, caused eight vessel losses from 2010 to 2019, and 106 out of 173 human causalities across the 39 recorded incidents.

Intercargo warns that the implementation of additional safety measures relies upon studying previous incidents and prompt casualty investigation reports submitted to the IMO are crucial to identifying the root cause of problems and appropriate corrective actions.

Lessons learnt from the incident report of *Bulk Jupiter*, a vessel that was carrying bauxite fines from Malaysia, has influenced an amendment to the International Maritime Solid Bulk Cargoes Code (IMSBC 05-19), which will be implemented on 1 January 2021.

In addition, following the investigation into the *Stellar Daisy*'s sinking due to structural failure in March 2017, IMO will consider further bulk carrier safety measures in Safety of Life at Sea (SOLAS) chapter XII as well as the 2011 International Code on the Enhanced Programme of Inspections during Surveys of Bulk Carriers and Oil Tankers (2011 ESP Code).

Bulker casualties have fallen sharply in recent years, but Intercargo has warned of complacency

Autonomous vessels

Autonomous ship concept receives AiP

Classification society ClassNK has given approval in principle (AiP) to Nippon Yusen Kabushiki Kaisha (NYK Line) and MTI, for their joint development project of an autonomous ship framework concept design.

Safety verifications of the autonomous ship framework's system usage conditions, fall back systems and more, were conducted by ClassNK with the cooperation of NYK Line and MTI. The society also confirmed the framework's feasibility after evaluating its safety in accordance with ClassNK guidelines and granted the project AiP.

ClassNK published its 'Guidelines for Automated/Autonomous Cooperation of ships' in January 2020. The guidelines include requirements for conceptual design, design development, installation, and maintenance stages while operating autonomous technologies.

The society adds that to improve conditions for the use of autonomous operation technologies, it will continue to provide standards for advanced initiative and technological verification, and this project is one of many it is involved in as part of this ongoing work.

Japan

SAJ denies Japanese shipyard 'supermerger' plans

The Shipbuilders Association of Japan (SAJ) tells *The Naval Architect* that it has not been consulted following recent reports that the Japanese government had spoken to some domestic shipyards about merging.

Under the so-called All Japan Shipbuilding plan, led by the Ministry of Land, Infrastructure, Transport and Tourism, as many as 15 major yards could merge and the Japanese media outlets stated in late March that discussions were already underway.

However, the SAJ asserts it "has not been informed about such integration and the Japanese Government has not made this announcement. The shipbuilders in Japan are now increasing their competitiveness and seeking cooperation and/or collaboration to ensure business stability."

The SAJ also expressed its support for the Japanese government's complaint to the World Trade Organi-

sation concerning subsidies provided by the South Korean government for its own shipbuilding industry.

"In the continuously sluggish market, the Chinese and Korean shipbuilders have been trying to survive with generous supports aided by their governments. In particular, the support measures Korean government has provided to its domestic yards have obviously been distorting the shipbuilding market," says an SAJ spokesperson.

Highlighting the strength of the Japanese shipbuilding cluster of builders, operators, equipment, classification finance the SAJ adds: "Along with further reinforcement of related industries, we think it is important to increase our competitiveness with the strategy of using high technical standards we inherently have."

Alternative fuels

BP investigates hydrogen energy production

BP Australia is conducting a feasibility study into a renewable hydrogen production facility in Geraldton, Western Australia, which the company says will better the energy sector's understanding of using hydrogen as a renewable energy at export-scale.

Both a potential pilot and commercial scale green ammonia production plant will be techno-economically evaluated during the company's feasibility study, as well as the plants' technologies and process configurations which are needed to manufacture green hydrogen and ammonia.

The pilot plant will use onsite and/or grid-sourced renewable power to produce green hydrogen which, once converted, will cultivate about 20kilo-tonnes per annum (ktpa) of green ammonia. Whereas BP's commercial-scale plant, aimed at domestic and export markets, will require 1.5GW of power sourced from solar and wind resources in Western Australia, and could increase production to an estimated 1,000ktpa.

Frédéric Baudry, BP chief operating officer for Asia Pacific, says: "Western Australia is the study location, due, in part, to its vast solar and wing resources, existing port infrastructure and proximity to large, long-term markets for green hydrogen."

Performance monitoring

Miros launches superior STW measuring system

Technology company Miros has commercially launched its real time wave and current measuring system, Miros Speed Through Water (STW), which the company claims is more accurate than traditional instrumentation.

Andreas Brekke, CEO of Miros, comments: "Measurements of wind, currents and waves have historically relied on inaccurate equipment, model data, or the captain's trained eye. However, accurate sea state is such an important factor in measuring actual vessel speed, that such inaccurate error is no longer acceptable."

Building on the company's prior research (see *TNA* June 2019), Miros' STW solution is a combination of its Wavex dry sensor and Miros Cloud services, which provide continuous analysis of sea state.

The dry sensor uses data available from an X-band radar operating in short pulse mode (50-80ns), GPS and gyro onboard a vessel to calculate wave spectra, wave parameters, surface currents and STW in real-time.

Miros states that its STW solution can not only improve speed and fuel optimisation, but also provides directional wave data that can be used to reduce vessel motion and cargo damage, which is of interest for LNG/ro-ro carriers, as well as ferries/cruise ships for passenger comfort.

The company adds its STW and surface current measurement system, which observes wave direction in 360 degrees, has an accuracy of 0.05m/s, compared to speed logs which can be several m/s, and a wave speed calculation range of 0–5 m/s irrespective of the actual speed the vessel is travelling.

Gunnar Prytz, chief technology officer at Miros, comments that the Wavex sensor measures unaffected water 100m in front of the vessel, compared to speed logs which observe water near to the vessel that is subject to the influence of noise and systematic errors. He adds that other tech, such as model data, is often unsuited. "Model data fails to correlate at all when there is a quick shift within the conditions the ship is sailing through." *NA*

Wavex technology has previously been trialled onboard LNG carrier *Arctic Lady*

Shipping recovering slowly from virus impact

As the world takes cautious steps to end the Covid-19 lockdowns, shipping is still suffering and looking for some clues as to what the future reality for the industry may be, writes Malcolm Latarche

The middle of May saw two quite high profile victims of the current uncertainty as to when some normality might be expected to return. The first was the SMM exhibition due to be held in Hamburg in the first week of September. Given that Germany had imposed a ban on large scale public gatherings that runs until at least 31 August, it was always doubtful whether an event that attracts around 50,000 visitors could be considered safe from an extension to the ban so the cancellation came as no real surprise.

The event – arguably Europe's most important marine exhibition and conference – will now be held in February 2021, just four months before Nor-Shipping, which would normally be the highlight of the year for the marine equipment and service sectors.

The second shipping victim of the pandemic might even be considered as being of more significance than SMM. For three years, one of the most talked about newbuildings has been the *Yara Birkeland* – the autonomous 120TEU vessel being developed by fertiliser giant Yara and marine technology specialist Kongsberg. Since being championed by several shipping organisations, autonomous ship projects have been headline news and the issue of unmanned vessels has been high on the IMO's agenda.

Yara Birkeland, was due to launch later this year after first being mooted as possibly in operation as early as 2018. A week after SMM was postponed, Yara announced that it was putting the project on hold despite the hull of the vessel already being on its way from Romania to the Vard Brevik yard for completion. In a statement, Yara said it has decided to pause further development of the vessel and will assess next steps together with its partners.

Yara Birkeland was scheduled to be the first purpose-built commercial autonomous vessel afloat. Assuming that Yara – which is in the process of restructuring its operations and looking to concentrate on its core business of fertiliser production – does not decide to cancel the project altogether, the ship may yet realise its planned destiny.

The pause of the *Yara Birkeland* project was not the only autonomous ship news in May as ClassNK awarded NYK Line and MTI an Approval in Principle for their joint project on the concept design of an autonomous ship framework APExS. NYK describes this framework for realising Maritime Autonomous Surface Ships (MASS) as including high-speed computer-based information processing technology and risk analyses that support crew members' situational awareness and the decision-making necessary for manoeuvring. NYK says this is the first time an autonomous ship framework has been approved in Japan.

Shortly after receiving the AiP, a number of NYK Group subsidiaries partnered to test the remote navigation of a tug in Tokyo Bay. The manned tug was remotely operated and manoeuvred over a distance of 12km.

There have been other forward looking developments which also prove that Covid-19 will not be around forever. The IMO has announced that following a video conference in mid-May the Global Industry Alliance (GIA) is to intensify its work on the ship-port interface to reduce emissions. The GIA is a public-private partnership initiative of the IMO that aims to bring together maritime industry leaders to support an energy efficient and low carbon maritime transport system.

The 21 participants in the online meeting set new goals for the GIA through to 2023 including a new workstream aimed at creating a "holistic approach to reducing emissions in the ship-port interface". This will support implementation by ports of regulatory, technical, operational and economic actions to help reduce GHG emissions from ships, such as providing onshore power supply as well as safe and efficient bunkering of alternative low-carbon fuels.

Some organisations seem to feel that there are more urgent matters to attend to. VSM – the German body representing shipbuilders and equipment makers – forecasts problems ahead for the continued survival for Germany's and Europe's marine technology sectors. The VSM, together with its colleagues throughout Europe, is campaigning for a temporary fleet renewal programme based both on public contracts such as pilot boats, coastguard and patrol craft, research vessels and the like to compensate for at least some of the expected loss of demand so as to prevent an uncontrolled breakdown of the entire sector.

But the VSM did not entirely abandon the IMO path saying: "It is imperative to continue research and development efforts and maintain the focus on maritime climate and environment protection, even during the crisis. A well-designed fleet renewal programme can be a decisive factor in getting a head start on tomorrow's technology. *NA*

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Engines

MAN supplies engines for LPG Tankers

German shipowner Hartmann has placed an order with MAN energy solutions for its MAN B&W ME-LGIP (Liquid Gas Injection Propane) dual-fuel engines to be installed on three 5,000m³ LPG tankers, with an option for two further vessels.

The LPG tankers, which are being constructed by CIMC Sino pacific Offshore & Engineering (CIMC-SOE) in Shanghai, will each be fitted with a 5S35ME-LGIP engine, alpha controllable pitch propeller, power take-off, propulsion control system, as well as MAN energy solution's Triton control platform.

Scheduled for delivery in the second half of 2021, the engines will be constructed in Lingang, China, by MAN's two-stroke licensee, CMD.

MAN has received a series of orders for its ME-LGIP engines, with Hartmann the latest acquired. Others include an order from BW LPG to convert further HFO-burning vessels in its fleet to dual-fuel engines, which MAN received after the successful type approval test of its first ME-LGIP retrofit engine, built by two-stoke licensee STX HI in South Korea.

Bjarne Foldager, senior vice president, head of two-stroke business at MAN Energy Solutions comments: "After the success of our dual-fuel ME-GI engine running on ethane, orders for our ME-LGIP variant capable of running on LPG are now taking off."

The company comments that overall interest in LPG fuel is increasing as the fuel is sulphur-free, has widespread availability and ease of bunkering. It adds that the ME-LGIP engine, when running on LPG, has seen a reduction of 18% CO_2 and around 90% particulate matter reduction compared with HFO.

The MAN B&W ME-LGIP engine was unveiled at a ceremony in Copenhagen in 2018

Boilers

Alfa Laval solves sulphur-compliant issues

Alfa Laval has provided an integrated steam boiler plant as a solution to Seaspan Ship Management's steam balance and redundancy issues related to sulphur compliant fuels, which will be put into practise on eight Seaspan-owned container ships.

Prior to the company's switch to low sulphur fuels, its container ships were fitted with a single oil-fired boiler and waste heat recovery boiler. Whereas the Alfa Laval integrated steam boiler plant solution comprises oil-fired steam production, waste heat recovery and advanced control and connectivity.

The company says its previous set-up was insufficient to work with sulphur-compliant fuels as it did not allow for redundancy. Arvin Dsouva, fleet manager at Seaspan Ship Management, explains: "To avoid wax formation, the fuel temperature has to stay above the pour point at all times. But the existing boiler solution on the above-mentioned vessels can't guarantee the required steam capacity as these vessels do not have heating coils in all the designated fuel oil tanks and rely on a shifter system."

Each vessel's existing boiler will be replaced with the Alfa Laval Aalborg oil-fired boiler and steam coils in all tanks will support fuel heating, in order to solve steam supply issues onboard.

Additionally, Alfa Laval has incorporated advanced connectivity in its solution, which allows its technicians to support onboard crew and guide them through, for example, maintenance procedures. Onboard each vessel, the new oil-fired boiler and waste heat recovery boiler are connected using the Alfa Laval Touch Control system, allowing the company to remotely monitor the system's condition for troubleshooting, assistance and optimisation purposes.

While the first container vessel will be fitted with the solution in spring 2020, the latter seven vessels will be equipped throughout 2020 and 2021.

LNG

Wärtsilä to build first Japanese LNG-fuelled ferries

Technology company Wärtsilä will supply a 31DF engine, gearbox and LNGPac storage, supply and control system for the first LNG-fuelled ferries built in Japan.

Under construction at the Mitsubishi Shimonoseki shipyard in Japan for Ferry Sunflower, a subsidiary

of Mitsui O.S.K Lines (MOL), the two 200m long newbuilds, named *Sunflower Kurenai* and *Sunflower Murasaki*, will operate along the Osaka – Beppu route when they begin service, which is planned for 2023. Each ferry, travelling at 22.5knots, has a capacity of approximately 763 passengers, as well as 136 trucks and 100 passenger cars.

According to Wärtsilä, its 31DF engine was chosen due to its high efficiency, as well as its ability to provide safe, continuous gas mode operation, as MOL's newbuild project has been adopted for Japan's energy conservation rating system for coastal ships, a test programme to enhance operational efficiency.

Makoto Yamaguchi, general manager, technical division at MOL, comments: "MOL is dedicated to reducing the environmental impact of its business activities, and these two ferries are being built in line with that objective. By operating on LNG, they will have a greatly reduced carbon footprint, and the high-performance Wärtsilä engine fits our requirements perfectly."

Wärtsilä notes that this is one contract in a history of cooperation between itself, Mitsubishi and MOL, as it has previously supplied its engines for Mitsubishi-delivered ferries, LNG carriers and a seismic research vessel.

Cargo pumps

Framo installs 4,000th liquid cargo pump

Shipping company Utkilen's oil/chemical tanker, *Saltstraum*, is the 4,000th vessel worldwide with Framo's liquid cargo pumps installed onboard.

Delivered in May 2020, *Saltstraum* is the third in its series, has a 10,500tonne capacity and 14 different stainless-stall cargo tanks onboard, all fitted with Framo pumps. Utkilen has four new chemical tankers under construction at Dingheng shipyard in China, which will all feature Framo-produced pumps.

Leif Larsen, newbuilding director at Utkilen, comments: "We are proud to take delivery of these newbuildings, which represent the future of chemical tankers. The ships will sail along the Norwegian coast for many years to come. Although the vessels are built in China, most of the equipment comes from Norway and Europe, such as the Framo pumps."

Norway-based Framo says its pumps can cope with any liquid cargo, whether purposed for outbound or inbound voyages, and notes that it has become an established supplier in Bergen, where many chemical tanker companies are based.

Framo CEO Martijn Bergink adds: "Our pumping systems allow crew to get cargo ashore quickly, followed by an efficient cleaning process, so ships can soon be on their way with new cargo onboard."

Evacuation systems

Stena Line delivers 100th Survitec MES reference

Stena Line's new E-Flexer ropax ferries, *Stena Estrid* and *Stena Edda*, mark the 100th sale of Survitec's Marin Ark 2 Marine Evacuation System, which is one of the largest dry-shod marine evacuation systems (MES) in the world.

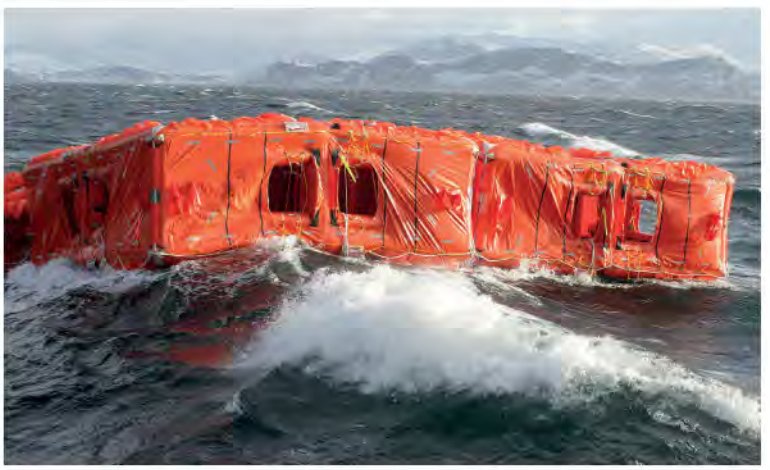
Each high-capacity Survitec MES can evacuate up to 860 people using its fully enclosed evacuation chute with spiral slide for natural descent, and every 215m long Stena Line vessel is fitted with two units. The ferries also feature Survitec's over-capacity liferafts and Crewsaver Premier Compact lifejackets, which provide a minimum of 150Newtons for increased buoyancy and performance.

Paul Clarke, operation director for MES, Survitec, comments that with a multitude of lifejacket designs available ship operators have to ensure that their lifejackets are compatible with the MES.

He adds: "There have been compatibility issues where the size and type of some lifejackets are unsuitable for use with chute-based MES. If a lifejacket is incompatible, it can actually hamper safe descent, resulting, at the very least, in increased stress and panic for passengers."

Survitec has installed over 2,500 MES units across 800 vessels globally. *Stena Embla*, the final vessel in Stena Line's series which will be built at the AVIC Weihai Shipyard in China, will also feature Survitec equipment. *NA*

Survitec's Marin Ark 2 has been supplied to a number of vessels in the operator's fleet



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Jiangnan Shipyard overcomes virus challenge to complete gas carrier

CSSC's Jiangnan Shipyard negotiated various difficulties brought about by the pandemic to deliver the last in a series of 84,000m³ VLGCs

On 17 April, Jiangnan Shipbuilding, a subsidiary of China Shipbuilding Group, signed and delivered its fourth 84,000m³ VLGC, *Red Marauder*. The company says that it received positive feedback from shipowners after the construction of the first three vessels, and the fourth and final ship, *Red Marauder*, was built for Petrotec in Singapore.

Red Marauder had reached its final stages of construction when the Covid-19 outbreak struck internationally, and Jiangnan Shipbuilding faced difficulties as foreign shipowners, ship inspectors, service providers and its own construction workers were unable to arrive at its factory on schedule. This altered the vessel's original timetable, with targets within those plans being affected to varying degrees.

The company's management team led efforts to overcome problems and complete various project tasks. Zhang Jian, deputy general manager at Jiangnan Shipbuilding, put forward a mantra of 'no waiting, no relying, take initiative and stick to the original plan'.

The fourth and final 84,000m³ VLGC, *Red Marauder*

Using the pre-trial window of opportunity

During the Covid-19 outbreak, the shortage of foreign service providers was one of the trickiest problems for the Jiangnan Shipyard team. In order to guarantee that the ship's trial voyage went ahead as planned, the project team, in cooperation with the company's marketing department, decided to contact shipowners, crew members and service providers. Collectively, before the overseas Covid-19 outbreak, they had persuaded over 20 people to make arrangements to travel to the company. After 14 days of home observation, the attendees successfully boarded the ship and participated in the trial voyage.

Additionally, work on the vessel's liquid cargo system, which was originally planned for after the ship's trial run, was moved to the pre-trial period and the commissioning team were able to overcome many of the issues caused by absent foreign service providers and co-workers being unable to return to Shanghai.

Commissioning team director, Yu Wei, combed through the liquid cargo system's condition in advance and led six commissioning technicians who worked overtime to finish 70% of the total work required, which was completed before the ship's trial voyage.

From an application aspect, the team completed construction, engine room casting, renovation of the pipe support system, etc. In this way, the project group sufficiently utilised the pre-trial period, as well as planning and bringing forward work due to begin after the ship's trial voyage, improving conditions for that upcoming trip.

Pandemic trial voyage poses serious challenge

Red Marauder's trial voyage not only tested the quality of products used, but even more so virus control work. In accordance with Covid-19 prevention measures, the project team appointed an employee responsible for each task and upheld control measures including irregular official inspections, temperature measurements, regular disinfection, socially distanced eating arrangements, and more.

All trial voyage employees made extensive efforts to adhere to the trip as planned during the day, as well as key projects planned for the evening, and more than 140 people worked overtime to complete the journey in only four days.

Prior to disembarking the ship, 1,143 comments were recorded and translated, and divided up into the responsible staff and department, 80% of which were acknowledged by the shipowner and laid strong foundations for shortening the delivery period.

Deputy director of the second general assembly department, Zhang Guihu, says: "In 23 days, we completed the delivery programme and set a new high." On 25 March, following the ship's return from its trial voyage and with the mindset of 'today's business is done today', the company's management organised for the secondary commissioning, general assembly, loading and supporting departments, as well as the company's research institute, to invest in the idea of eliminating and completing the remaining work.

At the end of each working day the leading supervisor, along with the heads of each relevant department, checked the completion status of that day's scheduled tasks and clarified the plan for the following day. Within 15 days, the testing of the liquid cargo system was completed and delivery inspection was finished by 10 April, nearly 20 days ahead of the previous record.

During this period, in order to thank production line employees for their efforts, Jiangnan Shipbuilding's various heads of departments boarded the *Red Marauder*, bringing food, drinks and other gifts with them to express their support to those employees who had stuck to their posts and worked overtime.

The signing ceremony for *Red Marauder*

Projects achieve new highs

"Only through continuously optimising the management process and improving the construction quality can we realise the dividends of the VLGC series and create a high quality 'Jiangnan' brand," says Wei Xiaoyong, deputy director and chief engineer of the second production and operation department.

Since 2019, Jiangnan Shipbuilding has begun construction on eight series of ships, which involved three shipowners, two production areas and with 11 production departments working together, the scope of management is large and area wide.

During the construction process, the project team gradually enabled complete control over the entire project. Tests on the liquid containers' strength was reduced from 30 to 20 days and was solidified as a standardised time period, which laid a solid foundation to achieve an 100 day docking cycle.

The vessel's completeness prior to trial voyage has been improved and motorisation of the liquid cargo compressor has been realised for the same pre-trial period. The hoisting of cargo tanks has also reached new highs, with the lifting of six tanks completed in a month. *NA*

Norwegian shipping's green ambition

Five years after it first launched, the Green Shipping Programme continues to develop innovative shortsea pilot projects and advance Norway's ambitions of establishing itself as the world's most eco-friendly shipping nation

As a country with 2,650km of shoreline, coastal and shortsea shipping has always been essential to Norwegian transportation. It's understandable then why Norway has grown into a leader in developing innovative and, increasingly, environmentally sustainable marine technologies that not only cater to coastal and shortsea requirements, but also serve as a means for trialling concepts that could in the future be upscaled for deep-sea shipping.

In the early part of this century, Norway pioneered the use of LNG as fuel for ferries (beginning with the *Glutra* in 2000), PSVs (*Viking Energy* in 2003) and offshore patrol vessels (*Barentshav* in 2009). More recently, it has done the same for battery propulsion. The first battery-powered car ferry, *Ampere*, debuted in 2015 and there are now nearly 450 fully-electric or hybrid vessels in service or currently on order, according to DNV GL's Alternative Fuels Insight platform. Of these, 187 are or will operate in Norwegian waters and include such high-profile projects as the autonomous container vessel *Yara Birkeland* which, until Covid-19 disrupted plans, had been due to commence operations later this year.

Another project having considerable success is the Green Shipping Programme (GSP), a Norwegian private-public partnership. The programme's ambitious goal is to establish coastal Norwegian shipping as the most efficient and environmentally friendly in the world, focusing upon emission reduction solutions that are both profitable and potentially exportable to international markets. Consisting of some 26 pilot projects to date, the programme also places a strong emphasis on sustainable and cost-effective logistics, actively seeking to involve all stakeholders in the supply chain.

Narve Mjøs, GSP director for DNV GL, believes such an inclusive approach is key both to achieving a successful green shift and the programme's continuing growth. "We started up in 2015 with 16 private organisations and two government ministries, today we have 65 organisations altogether. The programme is a common effort with cargo owners, ports, yards, vendors and specialists in different types of alternative energy all participating. We also have the regulatory authorities and representatives of the financial world, such as investors and lenders, involved," he tells *The Naval Architect*.

The Green Shipping Programme currently consists of 26 pilots, in various stages of completion

"For Norway it's also about creating green jobs and increasing our competitive advantage. In particular being the first with green technologies in different segments of shipping. Coastal shipping can be an incubator for environmentally friendly shipping."

Getting greener

Although Norway was among the first countries to implement a carbon pricing scheme for fossil-based fuels, as far back as 1991, its green credentials have sometimes been called into question by environmentalists. On the one hand, its electricity is almost entirely derived from hydro plants, yet conversely it exports five times more carbon (via North Sea oil and gas) than any other nation. While it participates (as a non-member) in the EU's Emission Trading Scheme, critics have accused Norway of 'buying its way' into carbon neutrality through the purchase of emission quotas while only achieving modest reductions within its own territory.

To reconcile that duality may be a project in itself but in 2016, the Norwegian parliament approved a radical goal of becoming carbon neutral by 2030, 20 years earlier than Paris Agreement targets. Similarly, the goal is that sea transportation in Norway should achieve a minimum 50% reduction in CO_2 emissions by 2030 and for Norwegian ports to achieve zero emissions by the same date, well in advance of the GHG timeframe IMO agreed upon in 2018. Such pre-emptive measures, it is hoped, can keep Norway at the vanguard of new technologies and the evolution towards renewable fuels, such as hydrogen.

Achieving this means the continuous development of both bridging and green technologies that can achieve market penetration. Creating an open dialogue to explore those potential solutions is at the heart of the GSP. "If we're going to achieve a green shift then all players in the value chain need to be focused and participate. Every partner has a different way of participating, but a pilot study with everyone sitting

around a table is always more effective than not having it. For instance, if there's a safety question you have the class society there, the maritime authorities or the vendors of safety equipment," says Mjøs.

Successful pilots

Among the 26 pilot projects there have been some notable successes. One of the first pilots launched in the initial phase of the programme was a project led by Altera Infrastructure, (formerly Teekay) to develop a next generation Suezmax shuttle tanker which runs on LNG, volatile organic compounds combined with a hybrid battery system for the main machinery that cuts running hours. Teekay ordered an initial six of the e-tankers from Samsung Heavy Industries with the first, *Aurora Spirit*, being delivered in January.

Mjøs notes: "The calculations done by Altera Infrastructure show that the emissions reductions for four E-shuttle tankers are 100,000tonnes, corresponding to 60,000 Tesla vehicles. By comparison, just over 46,000 Teslas were registered in Norway in November 2019. The government supported the 'E-shuttle' vessels with [the equivalent of] £10-12 million. In reality, Norway has received large cuts in CO_2 for small money compared to £500-600 million, on electric car support."

Another pilot involves ASKO, the logistics company for Norway's largest food supplier, the establishment of an emission-free supply route from its main storage facility in Vestby and a regional distribution centre in Sande, on the other side of the Oslo fjord. "There will be electric trucks taking containers down to the port at Moss, autonomous zero-emission cargo handling in the port, an autonomous battery-powered ferry taking the cargo across the fjord and the same facilities across the other side.

"ASKO's board of directors has just announced they have approved the project, so now it's just a matter of initiating the purchase of the different components in the solution. It's an example of how we're seeing forward-looking cargo owners taking an active part in developing the solution, then the solution isn't just green but also cost effective."

Mjøs is also keen to highlight the Environment Port Index, a Phase III pilot which has established a methodology for quantifying and reporting ships' environmental performance in ports. "There are already 13 Norwegian ports striving towards this index, which is a measure with respect to CO_2 emissions, NOx, SOx and particulate matter. Shipowners that score well pay a lower port fee, while a bad score is more expensive."

Naturally, not every pilot is a complete success; a project to develop an LNG bunkering vessel was among the earliest but had to be discontinued when the pilot owner was unable to find the customers that would establish a business case. There was also a project to develop a ferry powered by biodiesel which wasn't found to be economically feasible at that time in the north of Norway."

The future

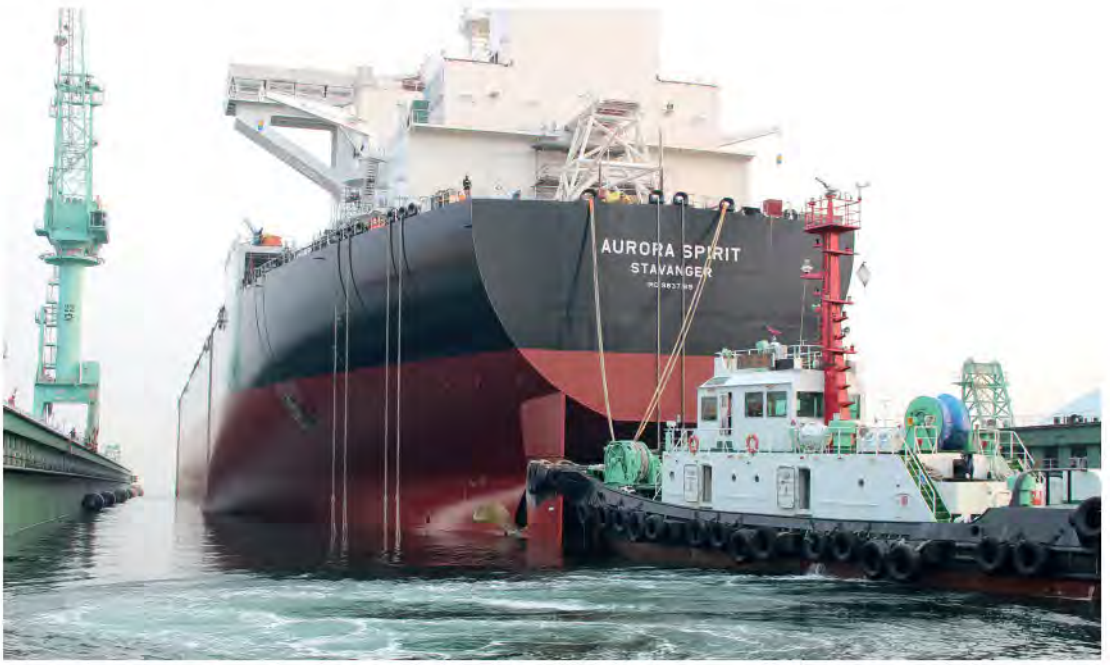
Phase IV of the program is due to finish at the end of this year but there are already plans to extend it for a further one to one and a half years. It has also gained considerable attention internationally, having received a Lloyd's List Global Environmental Award several years ago and being established as a formal project to promote the United Nations' sustainability goals. Although partner meetings are held in Norwegian the extent of foreign interest has led to some pilots also being made available in English.

"We've had a lot of interest from other countries such as the UK, Sweden, Singapore and the Netherlands. I don't think these countries went on to develop anything but in Washington state in the US they started up a similar project a couple of years ago."

A key difference, Mjøs believes, is that the GSP has a private and public funding while the American project has public funding only.

"The thinking we have in Norway is that with joint funding and collaboration we can come up realistic and cost effective solutions.

By working together everybody learns and there's a higher likelihood that smart, informed decisions are made." *NA*



Aurora Spirit, the first of Teekay's e-shuttle tankers which launched in January, has its origins in the GSP

Future proofing Norway's coastal bulker fleet

A pilot under the Green Shipping Programme led by naval architects Vard believes 'plug and sail' technology could offer a sustainable solution

Norway's domestic bulk carrier fleet is in need of renewal. These vessels constitute 48% of shipping in Norway, but it's a diverse sector in terms of both ship size and operators, ranging from small family-owned firms with a handful of vessels to much larger companies, such as Wilson Eurocarriers, which has 80 ships and also trades across the continent. Overall, the bulkers range in size from 1,000 to 8,000dwt and have an average age of 28 years, but there are several still in service after more than 50 years.

There are more than 100 such vessels, but faced with dwindling profits and increased competition from overseas operators, securing the finance to replace these ageing ships represents a significant challenge. Added to that, it goes without saying, is the pressure to drive down GHG emissions and the Norwegian government's goal of decarbonising the national transportation system by 2030, which threatens to make many of the shortsea fleet unsustainable. But what could be done?

It's a challenge that Norwegian naval architects Vard set out to address in a pilot project it led as part of the Green Shipping Programme in 2019. Working in collaboration with a number of partners including Kongsberg, ABB and SINTEF Ocean, Vard wanted to explore the possibility of developing an innovative and sustainable fleet renewal programme for shortsea bulkers.

Karl Fredrik Vistad, naval architect with Vard, tells *The Naval Architect* that the project originated with a report DNV GL produced for the Norwegian Coastal Administration. "We analysed the market and potential challenges and came up with several concepts before arriving at one. Then we looked into the financial aspects and began planning for further development. We also created some tools for estimating the effects of various technologies and their maturity."

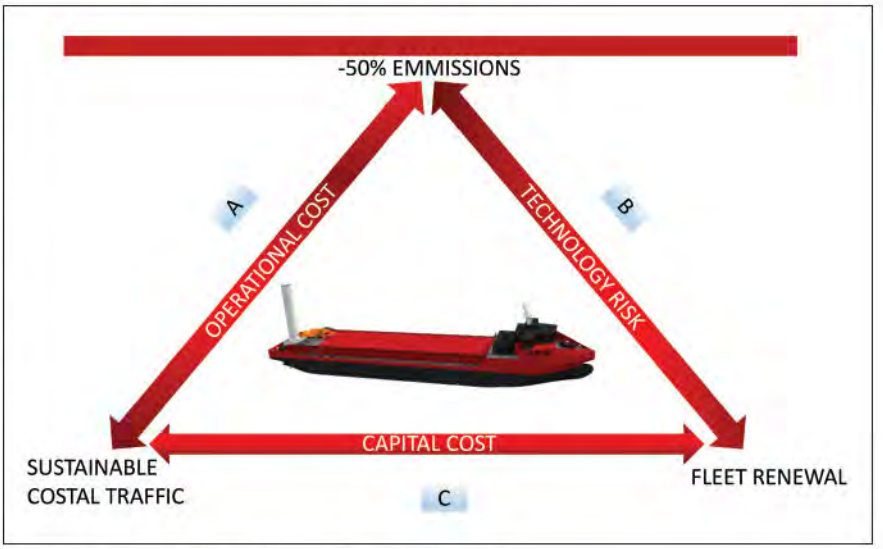


Fig 1: The 'trilemma' facing Norway's coastal bunkers

Although one of the goals was to develop low- and zero-emission ships the project also needed to be pragmatic in terms of what was commercially realistic. Given the relatively short distances these vessels need to travel compared to deep-sea shipping, there are numerous potential fuels that could be awaiting just around the corner, depending on the financial and infrastructure investment.

Risk averse

Shipowners, particularly in this sector, are conservative when it comes to embracing new ideas. Taking a risk with unproven or immature technologies could have disastrous consequences for operators working within such tight margins. It has left the coastal bulk fleet in a trilemma; caught between rising operational costs brought by emissions control, the capital cost of fleet renewal and the technology risk of making the wrong decision. Unsurprisingly, many owners baulk at investing in a newbuilding when they can acquire a second-hand vessel at a tenth of the price.

The problem is further compounded when one considers where such vessels might feasibly be built. Over the past few decades, the Norwegian maritime cluster has become focused on delivering high-end products; Vard's own construction yards in Norway and Romania have mainly focused on building vessels for offshore and latterly (as a subsidiary of Fincantieri) the burgeoning expedition cruise market.

"We have good traditions with high technology and autonomous vessels such as *Yara Birkeland*, and we've been working with batteries and LNG for a long time, but it's expensive and requires extensive planning of the value chain. With coastal bulk carriers that's not quite their ball game and it means recouping the cost in a different way," says Andreas Buskop, general manager for the engineering department at Vard Engineering Brevik.

Achieving a viable commercial framework for the construction and operation of such vessels, Vard determined, requires Norwegian yards to be capable of delivering standardised series vessels, more like a car production line or as shipyards in Asia are more accustomed to. Another important aspect to achieving value growth, while also helping to drive down emissions,

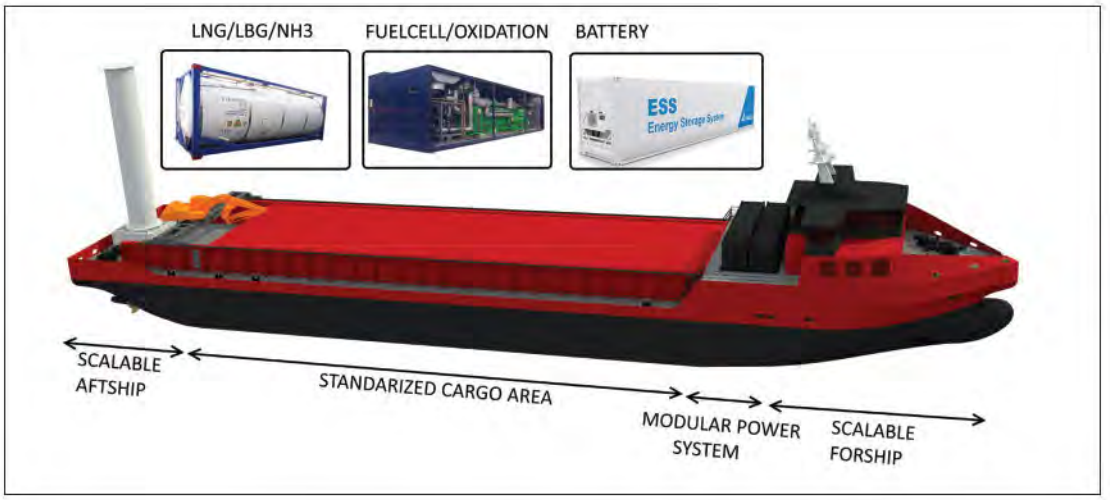


Fig 2: The zerocoaster concept

would be taking more transportation off the roads and onto coastal routes.

Zerocoaster

The solution that Vard and its partners arrived at is the zerocoaster, or what is described as a 'plug and sail' concept for a coastal bulker. While it includes a number of novel aspects such as wind-assisted propulsion, self-unloading technology, and other optimising features that would allow for far greater operational efficiency than even the newer coastal bulkers currently in operation (even these tend to be more than a decade old), the most innovative feature is its modular power system.

Vistad explains: "We figured that the key component we needed to come up with was a way of reducing the risk to the shipowner, so that he is free to use whichever fuel source he might find suitable or, as requirements change, legal. The main idea is to gather together all the main energy components and modularise production and distribution. It doesn't really matter what sort of components they are; whether it's a gas engine, a fuel cell or whatever, because integration with the hull and propulsion system will be standardised."

Under such a scenario, a shipowner might buy the vessel today and operate it with a diesel engine or a hybrid solution for five years or longer, depending on the contractual terms and regulations. But when the time comes, for example when carbon pricing makes it cost prohibitive, they could exchange their power module for one that is greener, or even zero emission.

"Although this sounds like it could initially be quite expensive we believe maritime could learn something from aviation and perhaps introduce some kind of leasing system. There would be no risk to the shipowner at all, he just pays for the type of power he wants delivered and it's then up to the leasing company to take full responsibility for maintenance.... It also changes the responsibility from the shipowner to the charterer as to which fuel they want to provide customers with in the end. If you want green transportation then then you have to pay for it and take the risk, but you would always want to use the most cost-effective fuel solution available on the market."

Fig 3: Cost calculations for different fuel options. Pricing excludes equipment and storage costs

2020 to 2030

Components	Range (nm)	NOK/kWh	NOK / nm	Round trips
Liquid Hydrogen*	2,479	3.00	360.00	4.2
Compressed hydrogen*	1,076	2.76	331.20	1.8
LNG	6,079	0.39	46.95	10.3
Ammonia (fossil)	2,230	1.17	140.85	3.72
Battery (electricity)	99	0.44	52.80	0.17

2030 to 2050

Components	Range (nm)	NOK/kWh	NOK / nm	Round trips
Liquid Hydrogen	2,479	1.20	144.00	4.2
Compressed hydrogen	1,076	1.20	144.00	1.8
LNG/LBG	6,079	1.17	140.85	10.3
Ammonia (green)	2,230	1.88	225.36	3.72
Battery (electricity)	320	0.44	52.80	0.54

Cost estimations

With LNG and battery technology already well advanced, as well as initiatives exploring hydrogen distribution, Norway is already better placed than most countries to offer a selection of different energy options. As part of the exercise, Vard ran

cost estimates for a typical route between Oslo and Stavanger as might be used by two of the other partners in the project, cargo owners Heidelberg Cement and Felleskjøpet Agri (who have also been leading a related Green Shipping pilot looking at the emission reductions of synergising their operations).

It was calculated that for a 5,000dwt bulker travelling at a speed of 10knots for the 589nm distance then, for the next 10 years, LNG would remain the cheapest option, at NOK46.95 per nm (US$4.75). But over the following 20 years, with the likelihood of carbon pricing, LNG could more than treble in cost, while battery power (which for now would only be considered part of a hybrid solution) remains at the same level (see Figure 3). But of course, there are so many variables that it's impossible to predict with certainty what the marine fuel mix could look like in 30 years' time.

While the concept of containerised systems is not entirely new, hitherto there has not been a holistic approach that could see it standardised. However, Vard say they have already received strong support for the modularised fuel concept from the likes of SINTEF Ocean and Grieg Star. Moreover, the idea of fuel flexibility is increasingly gaining traction and Vistad points to the recent white paper by shipping analyst Dr. Martin Stopford about the possible scenarios post Covid-19 (see Editorial Comment, *TNA*, May 2020), with which he sees some alignment.

Looking ahead, the Vard team has secured key partners and in the autumn will commence a new project exploring how best to commercialise the technology, including key engineering considerations such as the interface between the ship and the modular units. Two different designs will be developed; the first will be optimised for a typical 5,000dwt coastal bulker, while the second will explore the feasibility of mass production of these vessels which, with so many different types of cargo and ways of using them, is not straightforward.

"We will try to develop an X-in-the-loop model for all the ship, where we are trying to define the type of cargoes, the type of volumes needed, stability, resistance and all the elements that make a vessel in terms of functionality and have that in one model to standardise the vessel," says Buskop.

"That will make it even more interesting for shipowners because they will save costs in terms of having a series vessel and be key to realising a modern product line and cut costs by 20-30%. By doing that, combined with a modular power system, we believe we can make the coastal market sustainable again. That is the target." *NA*

Optimarin launches 'industry first' leasing agreement for its BWT system

The Stavanger-based company hopes its latest commercial innovation consolidates its position as one of the leading manufacturers of UV ballast water treatment

Norwegian ballast water treatment (BWT) specialist Optimarin has become the first in the segment to offer a leasing option for its equipment. The Stavanger-headquartered company has joined forces with a UK financial fund for a solution which will allow shipowners to spread the cost across three years instead of paying for the entire ballast system upfront.

"We know that a lot of owners have heavy mortgages on ships and there's not a lot of room to maneuver. It's a private equity fund so it looks at financing differently to banks and we will lease the system for 36 equal monthly payments. Although the system would never be taken out, the lessors are the owners in principle until it's paid, which gives them an instrument to arrest the vessel if necessary, although we don't think that would be a big issue," Optimarin EVP Tore Andersen tells *The Naval Architect*.

"We already have a bunch of owners looking into it. The good thing for us is that we're usually selling the system to the fleet director or superintendent, who has a technical mindset, but doesn't handle financing. So it's a different way to sell our system and it won't suit all owners, but we've already heard some say that they would rather use their cash for operational issues than paying for a ballast system."

Optimarin, whose UV-based system has both IMO G8 and USCG approval, have previous experience when it comes to offering innovative commercial solutions. In 2017 it was also the first BWT company to include a five-year warranty as part of sales. Then, in March this year, it announced a strategic cooperation with Chinese BWT manufacturer SunRui, a subsidiary of CSSC which makes electrochlorination-based systems. The idea is to create a 'one stop shop' for shipowners with diverse fleets, since the power demands of a UV system make it more suitable for small to medium sized ships (up to 70-80,000dwt), while SunRui are more used to supplying larger vessels.

Leiv Kallestad joined Optimarin as CEO last year

Optimarin CEO Leiv Kallestad believes the two companies make for a good match. "Like us they don't pretend to be the cheapest provider, they have high quality components and want to strengthen their service. We also know that further down the road there is likely to be consolidation in this segment and we want to make sure we're there in 2024 and beyond."

The boom in orders for BWT systems that began when IMO's Ballast Water Management Convention finally entered into force in 2017 means that of more than 1,000 systems Optimarin has sold, only 680 have been installed to date. Andersen notes that certain regulatory factors, such as the USCG's granting of 12-month extensions and the decoupling of the International Oil Pollution Prevention (IOPP) certificate, which was intended to define the dates when vessels should meet the D-2 Discharge Performance Standard, have muddied the ballast waters somewhat and allowed shipowners to delay.

Consequently 2021-22 will be particularly hectic in the rush to complete retrofits. However, one of the solutions Optimarin has developed is using riding squads to install systems while a vessel is alongside or even while in operation. "Many owners with smaller ships have done this successfully and because the riding crew goes between sister ships they become used to the layout. We expect this will become more common because the yards don't have the capacity," says Andersen.

Of course, one of the problems is ensuring that, once installed, the crew knows how to operate the system correctly. Kallestad laments that, with the postponement of the SMM trade show till next year due to Covid-19, Optimarin has had to postpone the launch of a new remote training tool for crew. However he notes that with much installation work outside of Norway being contracted to Goltens and MacKay Marine these companies are playing an important role in ensuring the engine room is well trained.

Looking to the future, Optimarin is also planning for a significant upgrade to its product later in the year, with several new improvements. These include new filters which are currently being tested to ensure they can attain IMO and USCG approval. "To our knowledge we will be the only company with two approved filter suppliers with a zero to two-hour holding time. We hope to add these to our system in the next six to eight months. With that I think we will be up where we want to be as one of the leading suppliers of ballast technology," says Kallestad. *NA*

Hull girder loading

In a continuation of the bulk carrier ship/berth interface issues raised in January's edition of *The Naval Architect*, Dennis Barber looks at loading of the hull girder from an operator's perspective, both how it has changed and the response in the structural members

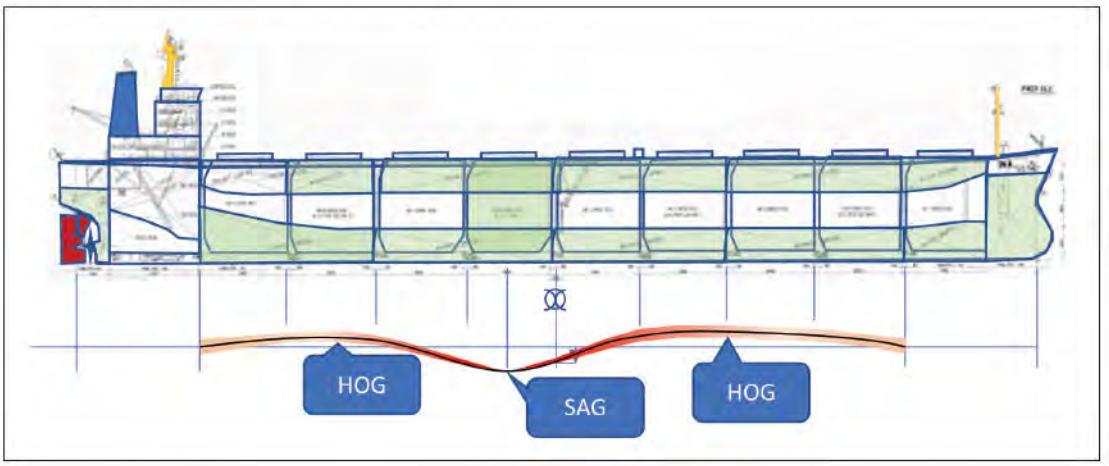


Figure 1 Heavy Ballast condition showing double deflection Vertical scale of curve exaggerated for clarity

Bulker side shell vulnerabilities

I was a senior seagoing officer and a superintendent of bulk carriers for a total of 34 years, during which time their size grew rapidly from Panamax (74,000dwt) to Capesize (100,000-200,000dwt). From the 1980s the latter group were being constructed of high tensile steel, which offered considerably reduced lightweight in proportion to deadweight compared to their mild steel predecessors.

The hull side shell thicknesses reduced from around 22.5mm to 17.5mm. This nominally small reduction in thickness of the main structural member reduced the section modulus and in reality made the hulls considerably more flexible in a seaway. They were also extremely vulnerable to knocks in docks and locks.

It was further noted that high tensile and mild steels corrode at approximately the same rate. A 0.1mm per year reduction in mild steel represented a tolerable wastage over several years. In high tensile steel the resulting reduction in cross section reduced the modulus rather more rapidly.

Regular steel inspections by a specialist whilst on voyage were a precautionary measure adopted by the company, as was the application of hard coatings in ballast and void spaces in a light grey finish, to identify fractures as and when they occurred, which they did. Surveyors and inspectors often noted the contrast in this approach to the more popular oxide red finish that made detection of fractures much more difficult.

Double bottom structure failures

On introducing one particular group of high tensile steel ships we received signals from concerned masters at their flexibility. They had felt compelled to slow down earlier than was their custom in negotiating adverse weather. Regular and, to them, somewhat alarming whipping of the hull was occurring in relatively moderate swells.

This phenomenon, visible to the naked eye, has been experienced by mariners in these large VLCCs and Capesize bulk carries for many years, but the newer ships with reduced lightweight were noticeably worse. Steel inspections subsequently discovered cracks in double bottom longitudinal stiffeners that appeared to justify the masters' concerns.

These cracks were found to be concentrated at the joints with transverse members, creating a notch that focused stress in the longitudinal at that point. Remedial action was taken by the insertion of literally thousands of soft nosed brackets to eliminate the notch stresses identified.

Double deflection

During draught surveys for establishing cargo onboard, the chief officers were finding that between 1,000 and 1,200tonnes were unaccountable when comparing displacement between ballast and loaded conditions. The discrepancy occurred when the ballast condition included a ballasted hold for better seakeeping. More about that later. The discrepancy was causing apparent variances in cargo outturn that could create problematic financial losses. It could also raise doubts on the authenticity of declared weights on board. The suspicion was that the 'variable constant' related to the flexibility of the hulls.

A subsequent investigation verified displacement in the heavy ballast condition using Bonjean data for draughts at perpendiculars and every bulkhead instead of the statutory draught scales at perpendiculars and mid-length. This revealed that in the so-called heavy ballast condition the hulls were taking up a deformation that was in sag at the central

part of the hull in way of the ballasted hold, but in hog forward and aft of that point (see Figure 1). Whereas in the light ballast condition, excluding any hold ballast, the deflection was a single hog throughout the length of the hull. When homogeneously loaded with ore, coal or even grain any deformation would be in sag throughout the length.

The methodology of draught surveying assumes a single parabolic deflection in the hull and in the pre-load or post-discharge survey we were getting three – two hog and one sag. This compared to one – usually sag – in the loaded condition. The opposing deflections in the heavy ballast condition were found to approximately cancel each other, but during draught surveys the draught marks indicated a sag at mid-length (forward end of the ballast hold – see Figure 2) and the second mean calculation on observed draughts took no account of the unmeasured hogs. The ship was being loaded with apparently less cargo than was actually the case.

Structural issues

It was recognised that in this double deflection there may also be structural implications.

The company had committed to the fleet-wide installation of hull stress monitoring. The pattern of strain gauges that formed the system soon detected stresses in a seaway that further corroborated the masters' concerns. The deflections detected were alternating hog and sag (see Figure 1), which corresponded to the visually and physically evident whipping.

Laser measurements

Displacement investigations that took place early in the subject vessels' operational lives were followed by measurements of linearity in the hull using a surveying laser on the upper deck and in the duct keel. This confirmed the initial findings of the displacement investigation and a decision was made to monitor all the ships in the class. Deflections were found to closely agree with the earlier displacement investigation. The curve observed followed the form of the black curve in Figure 1. Furthermore, one voyage from Port Talbot to Las Palmas presented an opportunity to carry out the observations in a seaway.

With the laser positioned beneath the inertial centroid at the centre of No. 6 (ballasted) hold, deflections were observed of magnitude, + and – 100mm at the forward end (after end of No. 1 Hold) and + and - 80mm at the after end (Engine Room Bulkhead) at approximate frequencies 2Hz and 1.8Hz respectively (see envelope; red/orange gradient, Figure 1).

These observations suggested the hull girder was behaving as two quasi-incarcerated beams – one forward, one aft of the inertial centroid – vibrating asymmetrically. Mariners often refer to whipping as the appearance of a wave in the deck steel progressing from forward, which would be a logical illusion created by the two frequencies observed.

With the earlier evidence this strongly suggested the phenomenon was probably the underlying cause of the cracks in the double bottom longitudinals. The area where reversals were most prominently occurring (red shaded envelope) and were thus most susceptible to fatigue. It was a short distance forward of the ballast hold – No. 6 – which coincided with the largest concentration of cracks.

None of these observations progressed to a scientifically controlled study. The data that was collected was intended to be filed in Class records but it is not known if these records were ever established. The sale of the company interrupted the project.

Torsional deflection

The strain gauges on the upper deck were also registering torsional deflections. Deflections registered in port and starboard gauges were frequently recording in the opposite sense. This data related to quartering sea and swell interactions but also occurred during initial ahead movements on the engine when working up to full sea-speed. The differential would gradually reduce as hull speed picked up.

The phenomenon could be explained by counter-clockwise recoil of the after part of the ship, the finer lines of which offer minimal buoyancy derived resistance against the moment induced by the large 10m, right-handed propeller biting clockwise. Further forward, the hull resists the recoil by its much more block form section providing the stiff stability that is characteristic of the type of hull (see Figure 2).

The consequent torsional stress was conducive to a starboard bias on the number of bottom and inner bottom longitudinal stiffeners' cracks concentrated in that part of the hull experiencing greater tensile stress. The tensile stress imposed by torsion could be assumed as additive to that already imposed by whipping. It seemed fair to assume that extended periods of these oscillations, such as during a heavy ballast ocean voyage, would lead to fatigue in structure. The laser readings

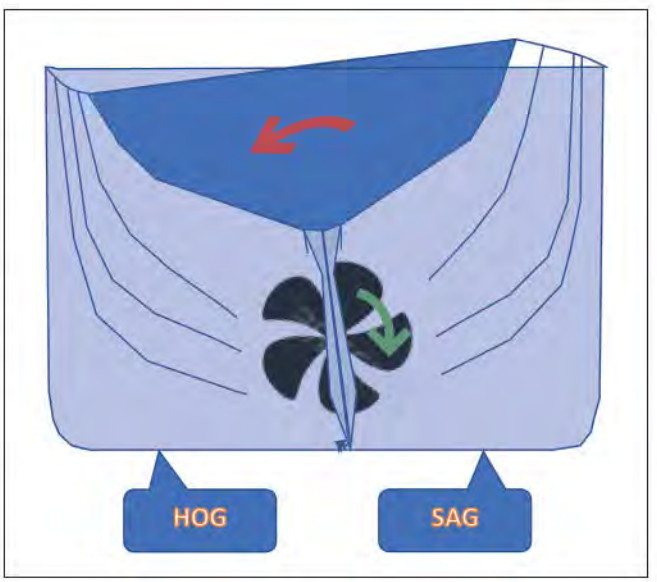


Figure 2 Sectional view from astern Torsional Deflection (Exaggerated for clarity)

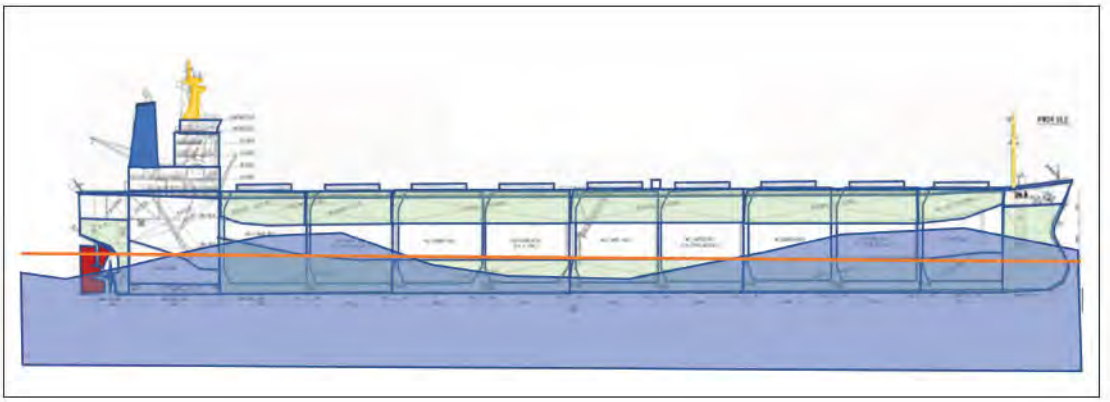


Figure 3 Design Seagoing Condition

were therefore repeated annually to detect any long-term deformation. The readings remained approximately constant, the most likely conclusion being that remedial installation of soft-nosed brackets would appear to have been an effective mitigation.

Design conditions

Double deflection was only occurring in the heavy ballast condition. The design seagoing ballast condition – most masters used to refer to it as the 'light' ballast condition – did not include any hold ballast (see Figure 3). Any deflection follows the single parabolic curve assumed in the draught survey methodology. If the ship is returned to this condition before any such survey the double deflection anomaly is likely to be avoided. Discharging hold ballast at sea, however, requires very still conditions rarely found in the oceans in which the trade is plied. Even at anchor, almost imperceptible rolling can be sufficient to set up damaging sloshing in any hold containing slack ballast.

In earlier designs masters would have been accustomed to carrying two holds ballasted – typically No. 4 and 6 Holds. It not only created a more uniform longitudinal stress pattern but it also extended the inertial resistance to whipping and slamming.

In the drive to reduce the carriage of cost inducing ballast however, designs evolved into a single sea ballast hold, presumed to serve adequately as a heavy seagoing condition. Stability books advocate no ballasting of holds for "normal" sea conditions. They offer no advice on how a master is supposed to load typically 15,000tonnes of ballast on voyage if the sea conditions worsen, noting how easily sloshing can occur.

Profiles always show waterlines as a straight line at the draught appropriate for the condition – the red line in Figure 3. Unfortunately, in the open ocean there are waves, often large ones like those represented by the blue shaded area. When encountered, any propeller emergence will lead to racing of the engine.

Optimised engine design

Optimisation has also been applied to engine design for sound environmental and economy reasons. The engines of modern ships are sometimes only half the size of those they replaced from 40 years ago, though they probably turn out more power in proportion to their size.

Fragility of design? Automated governors to stabilise the speed of engines will reduce the power available to the master, often with little forewarning. The master may be trying to manoeuvre the vessel into an optimum attitude to the imposing weather and swells. Any unexpected power reduction could be critical. How many masters are concerned at not being able to manoeuvre in bad weather? The danger of that should not be under estimated.

Conclusion

The observations and project work referred to above was limited to a group of identical small Capesize bulk carriers (120,000dwt) within a single company that clearly had concerns on safety. Class was also involved and had similar concerns to ensure that the mitigations were themselves not likely to introduce unintended consequences.

The design direction of larger and lighter hulls however looks as though it has been guided by science from the drawing board or CAD output. Has it sufficiently taken into account full scale performance and exposure to damage through fatigue in the structures as a result of dynamic stresses? Studies to address this potential gap on a larger and scientifically controlled scale, directly involving full seagoing conditions in all weathers – in the big testing tank – could be one solution but who will make their vessels available for study?

Owners, hard pressed by a highly competitive industry faced with escalating costs associated with new environmental restrictions are likely to be reluctant and who, amongst equally hard pressed builders, will want to look closely at what could uncover some rather bad news? What should be the approach taken by the professional institutions, including this one?

Acknowledgement

Whilst no direct reference is used in this paper I owe a debt of gratitude to Dr (later Professor) Geraint Price of UCL and subsequently Southampton University, and to his team at the Ship Science Department (Southampton) who was helpful in discussing some of my observations of wave induced hull vibration, which concurred with Professor Price's Hydro-elasticity knowledge. Observations described above would strongly suggest that the flexibility of hulls should be taken seriously and investigated further in full-scale. *NA*

Covid-19 is no excuse to halt decarbonisation

The shockwaves will be felt throughout the shipping sector for many years, believes Noah Silberschmidt, Silverstream Technologies CEO

Recent headlines in mainstream maritime publications such as 'Coronavirus: fallout may derail decarbonisation' and 'Does coronavirus threaten shipping's green push?' reflect a unanimous concern across the sector that Covid-19 may disproportionately impact and delay shipping's decarbonisation efforts.

Delays to pivotal IMO meetings and businesses fighting for survival amidst a crisis unparalleled in living memory are now being highlighted as just some of the many factors threatening to hinder the industry's green transformation.

However, the IMO's carbon target – of a reduction of at least 50% of GHG emissions from shipping by 2050, compared to 2008 levels – does not disappear because of Covid-19. The UN's net zero emission target by 2050 will also not cease to exist because of the virus and its impact.

The necessity for shipping to improve operational efficiencies, adopt sustainable practises and fully decarbonise, has therefore not disappeared. Despite the acknowledged challenges, Covid-19 should be an opportunity to go back to the drawing board, rethink existing processes, and ensure longevity and resilience of business operations by strategically investing in proven clean technology.

This is especially important because the cost of fuel – the largest single operating cost for any shipowner – is only set to increase as new and alternative fuels are brought to market to meet the sector's decarbonisation goals. Proven, fuel agnostic, clean technology has a central place within shipping's decarbonisation strategy as owners look to reconfigure operations and increase efficiencies.

There are the three predominant factors which need to be carefully considered and implemented to ensure the continuation of shipping's decarbonisation during these unprecedented times. Firstly, a change of mindset and the ability to think radically in each of our operations, and as an industry as a whole. Secondly, an investment in proven available clean tech and continued innovation of green technologies. Finally, collaboration.

Noah Silberschmidt

We believe our company values of thinking radically, embracing innovation and always being forward thinking has also enabled us, at Silverstream Technologies, to continue operating effectively during these current unforeseen circumstances. In addition, our focus on collaboration, and thinking outside the box, has enabled our growing team to continue servicing customers and work with our partners around the world.

These ways of thought are crucial if shipowners and maritime businesses are to deftly navigate impending decarbonisation regulations and an uncertain future economic climate.

On the surface, it is simple; if shipowners cease to invest in clean technologies, government bodies and the ship finance sector fail to advance a green agenda, and the industry does not overall radically change its approach to decarbonisation, we will fail to reach the IMO's 2050 carbon reduction target. The recent introduction to the market of the Poseidon Principles, which enable greener ship finance practices, is just one example that show us the dial has been moved too far. Those who regulate and finance our industry have started their transformation, so it is only right that the rest of the sector moves in tandem.

Shipping's challenges need bold solutions and at Silverstream we like to think we are proof that innovative ideas, radical thinking and world-class engineering expertise can not only generate profitability through increased operational efficiency and fuel savings, but also start to enable systemic environmental change. As a market leading clean technology supplier, we have worked tirelessly over the last decade to implement this radical new thinking on efficiency across all strands of our business; proving to the market that technologies can help an industry beset by political and public scrutiny, volatile fuel prices and regulatory uncertainty.

We believe investing in proven available clean technology is a critical element in ensuring the continuation of shipping's green transformation. The industry has already recognised the power of these solutions, with an uptick in enquiries for the Silverstream System, an air lubrication system that can reduce fuel consumption and associated GHG emissions by 5-10%, reflecting the desire in the shipping industry for change.

However, with operational costs so prescient for shipowners and operators, it is increasingly vital that savings claims are fully proven and can be verified. Demonstrating firm payback periods and scientifically backed savings potential is critical to the continued proliferation of innovation and clean technologies within our sector, especially with budgets under the microscope. *NA*

'WindWings' set to amplify reduction in fuel consumption and emissions

Technology and expertise used during the development of racing yachts is being applied to a wind propulsion system that has attracted the interest of a leading shipowner, writes David Foxwell

A chance meeting between Christian Oldendorff, owner of German shipping company Reederei Nord, and BAR Technologies' America's Cup designer and engineer Simon Schofield could see wind propulsion on large commercial vessels take a major step forward.

That meeting saw Mr Oldendorff, a venture capital investor who started Amplifier – which invests in disruptive maritime technology – and Mr Schofield initiate a conversation which led to the development by BAR Technologies of a patented wind-assisted propulsion concept that Reederei Nord plans to help develop and ultimately install on one of its bulkers.

BAR Technologies and Reederei Noord plan to install the first WindWings on a bulk carrier in the near future

BAR Technologies' wind propulsion concept, WindWings, has been kept under wraps since it was developed it, but in an exclusive interview, Mr Schofield revealed as much as the company felt it is able to disclose about it, and provided *The Naval Architect* with an insight into how WindWings was developed and why BAR Technologies believes it could prove to be more effective than many of the growing number of wind-assisted concepts that have been developed for commercial vessels.

Wind propulsion has enjoyed a surge in interest in the last couple of years and a number of devices have been brought to market. Major shipping companies including Mitsui OSK lines, Maersk Tankers, Louis Dreyfus Armateurs, K-lines and Viking Lines are already involved in wind propulsion projects, as are leading yards, and even some non-shipping companies, such as Renault, Airbus, the European Space Agency and Drax.

This surge of interest in wind propulsion is taking place against a background of increasingly stringent legislation on emissions from vessels, and the realisation that wind energy is an abundant, renewable, zero emissions energy source that is free at the point of delivery without the need for additional, external infrastructure. As the International Wind Ship Association (IWSA) puts it, "wind propulsion solutions are significant propulsion providers, not fuel efficiency measures, and the cost of this energy is fixed at zero for the lifetime of the vessel." According to the IWSA, there are other potential benefits from wind propulsion too: The uptake of expensive alternative and low carbon fuels by shipowners could also be accelerated if the requirement for those fuels is reduced significantly by wind propulsion, reducing the total amount of fuel required and, potentially, the installed power required by vessels.

Increasingly, wind propulsion is also being integrated with weather routing software, the development of which has provided increasingly reliable information to help predict, plan and operationally adjust sailing routes to maximise the benefits from wind propulsion and minimise the effects of adverse weather conditions.

Amplifier, BAR Technologies and Reederei Nord first announced their plans in early 2020 but have said little since. Together, they have embarked on what Mr Schofield described as 'the final phase' of maturing and adapting the patented WindWings technology which – combined with route optimisation software – can, they believe, reduce fuel consumption on sea-going vessels by up an average of 30% over the course of a voyage, depending on whether the installation is retrofitted or on a newbuild with hull optimisation.

"We believe that achieving a 30% reduction in fuel use would be a significant improvement compared to most other devices, for which a reduction of 10-20 per cent is usually quoted," Mr Schofield said. Initially aimed at bulk carriers and tankers, variants of the concept for other ship types are expected in due course.

Yacht-racing spin-off

BAR Technologies was formed in 2016 to make available a wealth of design knowledge, technical skills and intellectual property developed through involvement in Britain's attempt to win back the America's Cup. It draws on the combined experience of a team of naval architects and experts in related disciplines. Chief executive, John Cooper, said he was especially grateful to Mr Oldendorff for giving the company the

opportunity to bring its technology from the patent office to the sea."

Mr Oldendorff is a marine visionary and has consistently given his backing to emerging technology. He is a leading figure in the Towards Net Zero consortium, which is pushing in the direction of a carbon-free future for shipping in the Baltic and North Sea. He told *The Naval Architect*, "when Simon and John explained what they were up to with WindWings and ShipSEAT, I instantly wanted to get involved.

"Whilst our partnership is officially with Amplifier, my colleagues at Reederei Nord are working closely with the BAR Technologies team in this initial phase of the project. We are completely immersed on a day to day basis and directing the project with regular steering committee meetings where we challenge each other and discuss new ideas, all on video calls of course. The IMO has set us a challenge for 2050, but the shipping industry needs to take action much sooner than that, and that effort should be determined and immediate."

To understand where WindWings came from, it's important to start with ShipSEAT, a suite of software that BAR Technologies uses to analyse the effectiveness of everything to do with drag reduction, be it different kinds of rudders, air bubbles, different aft bodies and so on.

A holistic approach

"There are many ways to reduce drag, but one feature that almost all of them have in common is that they are designed in isolation," Mr Schofield explained.

Simon Schofield: "our patented mechanism maximises power across a broad range of wind directions"

"ShipSEAT allows us to look at devices holistically, as we did with the America's Cup. It is a suite of tools that enables us to undertake like-for-like comparisons of different concepts and examine how they affect the design of a vessel and the way it operates as whole. There is a weather routing module in it, too, that enables us to predict the performance of a vessel on any route, in a range of conditions, and optimise it.

"We talked to Mr Oldendorff about his interest in wind propulsion and began to use ShipSEAT to analyse a range of concepts. We examined in detail what their effects would be on a vessel, not just in terms of how much thrust they might provide and how much fuel saving or emissions reduction they might achieve, but holistically.

"We wanted to understand the effect of wind propulsion devices on every aspect of a vessel and its operation – on a large vessel such as a bulk carrier, for instance, the effect of leeway angle on propeller performance. All of these individual effects need to be taken into consideration in the design of a wind propulsion system if it is really going to work for an owner.

Maximising power whatever the wind direction

"As a company which spun-off from one that designs high performance sailboats, we understand the mechanisms of wind propulsion very well. However, on a commercial vessel such as a bulker or a tanker the interaction of the variables represents a contrasting challenge.

"What we found was quite different to what we had expected, and obviously very different from a sailboat. We took that knowledge and applied it to the design of our own wind propulsion system, which became WindWings."

Mr Schofield said he cannot share a great deal about the actual design of WindWings but said that BAR Technologies would reveal more when the WindWings gets closer to build. "There are a lot of concepts but not a lot of hardware constructed. I can tell you that our concept maximises the power across a broad range of wind directions via the use of our patented mechanism," he explained. "We'd rather be 'producing' rather than shouting about what we are going to build for the next few months."

However, BAR Technologies has already undertaken extensive testing of the WindWings in a virtual environment and is confident enough of its performance to move to the next stage – installing a WindWings device on a vessel – without first undertaking any model testing.

The partners in the project are planning to gain class approval in principle and ultimately install the first WindWings on vessels in the near future, and the teams at BAR Technologies, Reederei Nord and Amplifier have promised to keep *The Naval Architect* informed throughout the project, so look out for exclusive news in the coming weeks. *NA*

BAR Technologies has applied experience gained in the yacht racing sector to a number of commercial projects

The development of copper-free antifouling coatings

Carl Barnes and Alan Guy of Tyneside-based Safinah Group discuss the development of copper-free antifouling coatings and the challenges faced in bringing new products to the market

Antifouling coatings are acknowledged to make a significant contribution to the operational efficiency of marine vessels, helping to maintain a foul-free and consequently a smooth underwater hull. These coatings can also deliver further benefits such as extending dry dock intervals and improving the reputation of the shipping industry via a reduction in emissions (via reduced fuel consumption). They also play an important role in preventing the translocation of invasive species, currently a major concern of the IMO.

Such coatings work by the release of active ingredients (biocides) from a polymer system deterring the settlement of fouling species which cause an increase in the roughness of the underwater hull and hence an increase in the frictional resistance of the hull. This means that to maintain a specific vessel speed there will be a requirement for an increase in power and hence an increase in fuel consumption and subsequent emissions.

Frictional resistance is essentially caused by the hull 'rubbing' against the water it is moving through and there are two main causes of roughness on vessel hulls: physical roughness caused by mechanical damage, coatings cracking, detachment and corrosion; and biological roughness caused by fouling.

The fouling problem

There are approximately 5,000 different fouling species found in the world's seas and oceans and these can be classified as either: micro fouling (slime fouling); or macro fouling (weed and animal fouling).

Slime fouling is always present to some extent on immersed surfaces, and whilst it is not a source of invasive species, it still has an impact on the performance of a ship's hull. The actual effect is not commonly agreed within the industry and values from a few percent up to 19% are quoted. Weed and particularly animal fouling (the major source of invasive species) has the greatest effect on ship performance. Examples of the adverse effects of fouling on ship performance is shown below in Table 1.

Controlling fouling on ships has been a requirement since water has been used as a means of transport. Historically, 'biocides' such as mercury, arsenic, lead, pitch/tar and copper were used to prevent the build-up of fouling. One famous use of fouling control occurred at the Battle of Trafalgar, where, in October 1805, the British fleet used copper cladding which controlled fouling and gave them much more manoeuvrability than their French counterparts.

In the 1970s tributyltin (TBT) was introduced; tributyl tin oxide (TBTO) was a well-known biocide, but expensive and the target was to bind TBTO to an acrylic polymer to make paints last longer and more cost effective. The innovation was a hydrolysing polymer which released TBTO and polished away itself – Self Polishing Copolymers (SPC) were born. However, negative effects on non-target organisms ultimately led to TBT being banned under the IMO AFS Convention in 2008.

Modern day biocidal antifouling coatings

Today, there are two main technology types of TBT-free antifouling technologies available:

- Self-polishing copolymers (SPC): commercially available types include, silyl acrylate, silyl methacrylate, metal (copper or zinc) acrylate. SPC antifoulings generally deliver the highest performance of the biocidal options.
- Rosin-based controlled depletion polymers (CDP), generally acknowledged as delivering entry-level performance at a lower cost base than SPC.

Blending of these two technologies by paint suppliers is common and these coatings are often termed 'hybrid' or self-polishing; they are designed to give intermediate performance at an intermediate cost base. However, this is a very complex sector with a wide range of products from all coating suppliers and the boundaries can become

Hull condition	Additional shaft power to sustain speed (%)
Freshly applied coating	0 (Baseline)
Deteriorated coating or thin slime	9
Heavy slime	19
Small calcareous fouling or macroalgae	33
Medium calcareous fouling	52
Heavy calcareous fouling	84

Table 1: Roughness and Fouling Penalties – Adapted from Schultz, 2007[1]

[1] *Schultz, Michael P. (2007) Effects of coating roughness and biofouling on ship resistance and powering, Biofouling, 23:5, 331-341, DOI: 10.1080/08927010701461974*

blurred between CDP and SPC technology.

The alternative option is foul release coatings (FRC), typically based on a silicone matrix; these products are characterised by their low surface energy and elastomeric nature which prevents fouling attachment. However, FRCs are generally more suitable for high activity, faster vessels although recently developed products claim improved performance at lower speeds. The application process for silicone based coatings can also be challenging due to the need for masking to protect surrounding areas from contamination and the use of dedicated application equipment which add time and cost to the operation.

Antifouling application

As a result, biocidal anti-fouling technology currently still accounts for around 90-95% of the fouling control coating market but there is increasing pressure to reduce the use of biocides. The European Union (EU) currently has the most stringent requirements when it comes to the application of biocidal coatings via the EU Biocidal Products Regulation (BPR). Signatories to the International Convention on the Control of Harmful Anti-fouling Systems in Ships (AFS

Convention) have also recently agreed to banning the use of the biocide cybutryne (Irgarol) from 2021.

Cuprous oxide

Today there are only a handful of main biocides that can be used in the formulation of an antifouling coating and the most commonly used biocide is cuprous oxide, typically used in >90% of all biocidal antifouling coatings.

Cuprous oxide provides a broad spectrum of activity against many fouling species, particularly animal fouling. Studies carried out at the Woods Hole Institute in 1950s showed that a copper release rate of 10μg/cm^2/day was effective at deterring barnacle settlement. In addition to cuprous oxide, the vast majority of commercial CDP and SPC formulations also contain organic or organometallic biocides to maintain effectiveness across the entire range of fouling organisms.

Copper-free antifouling

Increasing concerns over the accumulation of heavy metals in the environment have prompted regulators in some locations to set copper release rate limits as part of the registration process for coatings. For example, in California the maximum allowed copper release rate is 9.5μg/cm^2/day. In Washington, a ban on the use of copper based antifouling's on recreational craft is being discussed.

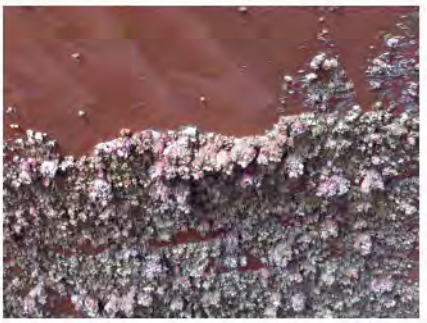
As a result of this pressure, considerable research has gone into the development of effective copper-free antifouling's.

There are many obstacles to be overcome in new product development and copper-free presents two major hurdles and many smaller ones, for the formulating chemist.

The first is to identify an alternative biocide that is:

- As effective as copper against animal fouling;
- Cost effective and;
- Globally registered.

At the present time, there are two commercially available materials that display anti-animal properties – medetomidine (Selektope) and tralopyril (Econea). Both have been incorporated into commercial deep sea antifouling's, but they are often used in combination with cuprous oxide rather than as a full replacement.



Heavy barnacle fouling

In formulations where cuprous oxide has been removed, the levels of other biocides have been significantly increased in order to be sufficiently effective, which brings additional potential health and safety issues due to the higher concentrations. It is possible therefore that new biocides may have to be developed before successful true globally available copper-free antifouling's can be formulated.

Formulating challenges

The second challenge for the chemist is uncovering the rules that govern formulating with new technology. Any new paint must have the required physical properties in the can and for application to the ship's hull. The dry film must also deliver the desired antifouling performance in service.

Cuprous oxide has a specific gravity (SG) of 6.0 and can make up almost 40% by weight of the liquid paint. Any replacement biocide is likely to have a significantly lower SG and the amount required to be effective in the dry film will be different to that of cuprous oxide. From this, it can be seen that a copper-free formulation will be considerably different to one containing copper.

Some of the properties of the liquid paint that may require adjustment are viscosity, Volatile Organic Compounds (VOC), hold up, in can stability and drying times. Mechanical properties of the film may be affected such as resistance to cold flow, an effect caused by flooding the dry dock too soon after application before the solvent has fully evaporated from the film. The bulk film then is subject to viscous flow when a continuous sheer stress is applied to the surface, i.e. when the vessels sails. New tie coats, which exist to ensure the antifouling adheres to the underlying anti-corrosive, may have to be developed. Within the formulation, the levels of additives required for storage stability, hold up and pigment dispersion will have to be adjusted. Critically, in the dry film the weight and volume ratios of the various components will have to be optimised to ensure the desired performance is achieved.

Ultimately, in addition to new biocides, new resin systems may be needed to produce viable, globally available, copper-free antifouling formulations that perform to the desired level in service.

New product development and collaboration

New product development is by its nature an iterative process. Experiments and testing develop the understanding of the interactions in a formulation because prediction is not possible in such a complex mixture. Most commonly, a very practical trial and error approach is adopted, using experimental design to minimise the number of experiments carried out, in combination with an extensive field and vessel trials programme. Timescales will inevitably be long, possibly 5-10 years assuming the materials are available, and will be longer if new biocides are found to be needed.

To convince shipowners and operators, new antifouling coatings must be proven in a range different environmental conditions over a significant period of time (typically >three years) on multiple test patches and full vessel applications. The cost of an antifouling failure to a shipowner is significant and they are very reluctant to use unproven technology.

Shipowners and operators will however continue to be under ever increasing pressure to control costs and to comply with emissions to air and sea. To meet these targets, they must rely on antifouling coatings that are compliant with national and international regulations.

Therefore, collaboration between shipowners/operators, regulators, coating suppliers and other industry bodies will be critical in helping bring new copper free antifouling products to the market in a timely and efficient manner. *NA*

Robotic technology aims to revolutionise hull maintenance

Jotun has launched its Hull Skating Solutions (HSS), which it claims will proactively remove fouling from a ship's hull before it affects performance and becomes a biosecurity problem

According to Jotun, the HSS covers antifouling, condition monitoring, inspection and proactive cleaning, technical services, and performance and service level guarantees. However, it is the solution's proactivity that Jotun indicates will contribute to reduced fuel costs, emissions and risk of invasive species transfer.

Using a reference case based on a 120,000dwt Capesize bulk carrier, travelling in what the company considers as 'challenging conditions', Jotun estimates that after 60 months of HSS service a vessel could save US$2,830,000 compared to the market average and reduce CO_2 emissions by 12.5% (17,600tonnes).

Jotun suggests that if all ships operating in challenging conditions switched to its HSS, there would be at least a 40 million tonne reduction of CO_2 emissions each year due to the improved efficiency of each vessel, with the company's internal analysis indicating that it currently has a 25% market share for such vessels.

The HSS's main component is the HullSkater, a robotic technology designed to proactively clean ships, developed in partnership with Kongsberg. It has been designed to work with Jotun's SeaQuantum coating to pre-emptively remove bacteria and biofilm before macro-fouling takes place, as Tom Evensen, sales director of hull performance solutions at Jotun, explains: "SeaQuantum Skate is an ultra-premium self-polishing antifouling which has been developed to work in perfect harmony with the Jotun HullSkater. It derives from the same 'family' as SeaQuantum X200 and is based on an inhouse developed silyl methacrylate binder technology."

Magnetic wheels, each equipped with electric motors for propulsion and steering, hold the device to the ship's hull. A 900mm wide, 226mm diameter motorised brush on the device's front cleans with up to

HullSkater, the main component of Jotun's HSS, proactively cleans a vessel's hull

450W power and 220rpm speed, without damaging or corroding the hull coating. The Hull Skater's power derives from lithium battery packs with up to 4kWh capacity and only minor downtime as it can recharge within up to two hours.

"The power consumption during operations is a function of the speed the HullSkater operates in, the rotational speed of the brush, level of currents and seawater temperature in addition to a few additional influencing aspects. All experience from live testing, which kicked-off mid-2017, indicates we have sufficient battery capacity for typical missions," says Evensen.

Connected to the operator control centre by a mechanically durable, polyurethane tether (an umbilical cable), the HullSkater can be handled remotely using a global 4G network. A series of in-built cameras and sensors provide data feedback, which assists with navigation and documents fouling on the hull. He adds: "It's always kept onboard the vessel and we operate the HullSkater using trained, Jotun-employed Skate Operators from a remote operating center."

Additionally, HullSkater can complete the inspection and cleaning of a ship's hull in between two to eight hours, depending on the vessel's size and condition. Evensen elaborates: "The inspection time is around two hours per 10,000m², followed by proactive cleaning which would be conducted at a rate of about 1,500m²/h. Given proactive cleaning, the area to be cleaned each time will be typically limited."

Kongsberg, Semcon, DNV GL, Telenor and shipping partners such as Wallenius Wilhelmsen, Berge Bulk and Maersk, have all been involved in creating HSS. Since its launch in March, Jotun has received enquiries from all segments within the maritime industry. "The project has entered a development stage known as 'the final verification stage' where we interact with carefully selected customers, under commercial terms, and in growing numbers roll out units and conduct extensive technical verifications," he adds.

The Hull Skater technology has undergone an extensive developmental process to reach its final verification stage and faced challenges during its two-year trial period on Wallenius Wilhelmsen's *Talisman*. "Any live testing of sophisticated technology will disclose a certain degree of challenges. We uncovered a range of challenges, areas of improvement, changes in configuration, etc. Much like major car manufacturers stress test their vehicles in artic climates we too had to test our HullSkater under conditions matching the environment it would be operating under," notes Evensen.

Interested parties can expect Jotun to own, operate and service the Hull Skater through Kongsberg Maritime's network, Evensen adds: "Leasing the HullSkater is not an option as the solution is based on combining high performance coating, high-end technical service, proactive condition monitoring as well as inspection and proactive cleaning. *NA*

Are biocide-free coatings the most important development since the TBT ban?

Nippon Paint Marine's biocide-free antifouling paint, Aquaterras, is reckoned by its makers to be the biggest advance in marine coatings since the worldwide ban on Tributyltin

Aquaterras is also, perhaps, a development that pre-empts any future revisions to MARPOL. Certainly, given increasing public scrutiny of the shipping industry's environmental footprint, particularly resonant in the divisive and inconclusive debate surrounding scrubber washwater, it is feasible that hull coatings will also find themselves in the IMO crosshairs.

Of course, copper and other biocide-containing coatings are unlikely to be banned any time soon, but what Nippon Paint Marine has achieved with this ground-breaking paint is to show the industry that biofouling performance can be achieved without detriment to the environment.

"Typically, ships' antifouling paints have contained some form of biocide – copper, tributyltin (TBT), co-biocides. But the use of biocides today is strictly controlled by both national and international regulations such as the BPR in the EU. And while there are no immediate plans to further regulate the use of approved biocides, we cannot rule out the possibility that copper in antifouling will be regulated in the near future," says Nippon Paint Marine director John Drew.

"We have always looked to develop systems that go beyond the regulations. And with Aquaterras our chemists have achieved a truly effective hull coating with long-term, self-polishing antifouling capabilities but without the use of biocides."

Polymeric material

Rather than using heavy biocidal pigments, active ingredients or silicone, Aquaterras incorporates a polymeric material designed to prevent blood clots during the creation of artificial hearts and blood vessels, and prevent biological substances adhering to surfaces.

Using this technology in marine paints has allowed Nippon Paint's patent-protected micro-domain SPC antifouling material,

Aquaterras being applied to the cruise ship *AidaCara*

based on a carefully formulated mix of these hydrophilic and hydrophobic components, to continuously self-polish. It also exposes active micro-domain structures to seawater to prevent biofouling build-up.

Initial market interest in the coating is indicative of the coating's wide potential, however, as with any new technology, market take up is slow, exacerbated by the impact of the Covid-19 crisis on some shipping sectors.

Nevertheless, Aquaterras already has a number of references and, to date, the company has full applications on two cruiseships, *AidaCara* and *Carnival Sensation*, of which the latter was applied in January. There are also test patches on several other vessels.

Since 2016 Nippon Paint Marine has tested the coating on over 20 ships including tankers, large container ships, ferries as well as cruise ships flying the Cunard, RCL, Disney, NCL Costa, AIDA, and Princess Cruises flags. "All patches applied have performed very well to date," Drew says.

Aside from the cruise sector, the coating also has received first references on two small Japanese-built bulkers. Operational data from these vessels have shown that use of the coating reduced ship's drag (frictional resistance) and, consequently, fuel consumption, by up to 10%.

Self polishing

"Aquaterras can achieve a remarkably glossy and smooth film is achieved," says Niko Yamanoue, director, Nippon Paint. "This smoothness is further enhanced by its in-service self-polishing. Unlike silicone types, Aquaterras can be applied simply without the need for costly and time-consuming masking. After application, surface roughness measurements were as low as 40μm and averaged 63μm, but since Aquaterras is self-polishing the overall hull roughness should become even lower as the vessel continues on its usual operations. Regular biocide containing SPC's generally have an Average Hull Roughness (AHR) of around 100μm."

Commenting on the higher price for Aquaterras, compared to regular hull coatings, Yamanoue says costs do continue to drive procurement decisions and remain the key consideration along with performance. "But the interest is there. The cruise industry has really honed in on this coating because of its green credentials. The sector sees huge potential in Aquaterras."

Nippon Paint is actively marketing the coating, but when cruiseships are being laid up, the scope of opportunity has retracted.

"We do have a number of tentative orders, coronavirus crisis dependent. But the cruise companies never planned to face such a scenario so their response in such a short time has been rapid but potentially very costly. Despite the investments made underwater by the cruise lines in terms of hull regular maintenance during the last few years, hull coatings and their condition is not the top priority when placing the ships into lay-up mode," says Drew.

In general, lay-ups in sun-kissed warmer waters will provide the biggest challenge for the ships' underwater areas as fouling organisms generally grow more rapidly, he adds. *NA*

Sustainable technology on the backburner, but not forgotten

An uptake of green solutions in the post-pandemic period is vital and antifouling products will be a key player, believes Philip Chaabane, CEO of global bio-tech company, I-Tech

Although momentarily overshadowed by the Covid-19 pandemic, the implementation of IMO's global sulphur cap, the transition to low sulphur fuels and scrubber installations are still ongoing, as are efforts to prevent invasive species transfer, which I-Tech CEO Philip Chaabane claims will all soon return maritime media limelight.

"At some point these headlines will come back into play and emphasise the need to become a cleaner, more environmentally friendly industry. It's clear that people have been seeing a different sky, and I doubt humanity will accept going back to what we had previously. There will be a social-political drive force stronger than before, to cut emissions and become more sustainable," he predicts.

Sustainable technologies need to be adopted by the industry to reduce emissions, Chaabane insists, comparing this uptake to global strategies used to combat the Covid-19 pandemic. "We need to 'flatten the curve' so to speak, we need to drop the number of cases and the spread. It's the same in our industry, we need to reduce emissions, and in shipping this is related to the introduction of new technologies."

Chaabane claims antifouling products, such as hull coatings that contain I-Tech's sole product, Selektope (see *TNA* January 2018, p.34), are important in the Covid-19 period, as a trend for longer idling periods is emerging due to reducing demands for transported goods. Extended idle times will have severe implications on hull resistance through water when the vessel's return to service, he says, as tertiary colonisers, namely barnacles, will arrive within weeks depending on seasonality and temperature.

Selektope is an active ingredient used in nine commercially available antifouling paints, Chaabane explains: "It's introduced into marine coatings to provide static performance in terms of resisting barnacles from settling on a hull surface. Barnacles settle on the static ships hence it is highly relevant for those who have longer idle periods and unpredictable trade routes."

Philip Chaabane

Chaabane comments that although I-Tech have found it difficult to determine the precise number of vessels currently idle, estimations from the last financial crisis suggest there were around 1,000 vessels reported to be at warm lay-up, a static period which can last up to six months. "And that's a significant amount of time when it comes to idling and biofouling. If the idling goes on for too long and there's no relevant protection, the hull will have severe fouling," he adds.

Biofouling was heavy even before the effects of Covid-19, according to drydocking data recorded by Safinah Group in an independent report commissioned by I-Tech. Chaabane points out: "We have seen through a report that many ships, aside from the idling that we're now talking about, are heavily fouled. Of a sample size of 200 vessels, 44% had over 10% coverage of barnacle fouling."

This has financial and sustainability implications, as light to medium fouling can have a profound effect on fuel consumption and emissions. Chaabane explains: "These (barnacles) create a lot of resistance and ONR, an academic institute linked to the US Navy, has quantified the impact of very severe fouling. At lower surface coverages of 10%, the increased power that needs to be applied to the shaft to maintain a 50knot speed is 36%, which is linear to the increased fuel consumption required."

Considering this 36% increase compared to normal conditions, Chaabane estimates that after 60 days sailing, a vessel consuming about 40tonnes of fuel daily could potentially save around US$190,000 by using an antifouling solution, even at an oil price of US$216 per tonne of fuel.

Within this short period of 60 days the customer would see return on investment, Chaabane explains, suggesting that despite oil prices posing a challenge for sustain-tech companies, short-term price fluctuations are unlikely to significantly affect the advantages of installing sustainable technology. He adds: "We have to look at these investments on a five-year horizon or more and in that case, low temporary oil prices will likely not play a role, that's what we hope."

Chaabane notes that the pandemic is another hurdle in an already unpredictable industry. "If it's not a trade war it's a virus, if it's not a virus it's oil price hiccups, there are a lot of things coming into play which make it difficult to predict trade routes and operating powers." *NA*

Switching to a DC grid is the best way to solve the power challenge

Direct current offers reduced fuel consumption, lightweight installation and a future proof solution for emerging power, argues Carlo Cecchi

A big weakness of conventional AC electrical systems on ships is that they're generally cumbersome, inefficient and potentially expensive to maintain. Switching to a DC grid based on state-of-the-art modular technology offers a unique degree of flexibility, improving energy efficiency and helping to curb fuel burn. It's a great way to reduce pollution right now while saving money in the long run. As new energy carriers emerge, future-proofing vessels for any type of power source is a shrewd investment. Compact size and lighter weight also make a DC grid the best answer from a vessel design perspective.

As we move deeper into the green shift globally, around 80% of vessels in the future will be either fully electric or powered by hybrid systems. Many will have multiple power sources in addition to main engine gensets running on diesel, LNG or a combination of both. Renewable power from hydrogen and potentially fuel cells, solar and even wind may increasingly be part of the mix as shipping adapts to the changing energy landscape to combat emissions. Other onboard power sources will include stored power from batteries, power from shore, and shaft generators converting mechanical power into electricity.

The art is in making the complex simple

Managing and distributing all that energy effectively is an intricate business amid a proliferation of load demands ranging from main propulsion and thruster drives to all sorts of electric auxiliaries, such as winches, cranes, pumps, chargers and other. Not to mention onboard data systems and hotel demand.

At Yaskawa Environmental Energy/The Switch, we believe we hit on the ultimate solution for power management that takes that complexity and simplifies it. Switching from an AC to a DC grid delivers better

Carlo Cecchi

fuel consumption and other cost savings, along with unbeatable reliability. Our DC-Hub can reduce fuel burn by 20% up to 35% – depending of course on the ship's operational profile and fuel hedging – while boosting energy efficiency resulting in less emissions. It also guarantees overall lower Opex and a reduction in maintenance costs of 10% to 20%.

Optimal design

A future-proof system requires components that can produce, transmit and consume energy as efficiently as possible. Our DC-Hub uses standardised independent power drives (inverter and rectifier modules) fully integrated into one coherent solution. The DC-Hub works with any power source giving new meaning to the word flexible. This is cutting-edge, multi-megawatt technology that's unique in the industry and helps owners achieve new levels of energy efficiency.

Frequency converters ensure a constant supply of power that is 100% reliable, which is absolutely essential for specialised tonnage such as offshore vessels and wind turbine service vessels using dynamic positioning for precise steady-state operations. Our innovative modular design offers unparalleled malleability in that module cabinets can be added in series to match changing requirements. Before, that would have needed a complete electrical redesign, now it's as easy as arranging Lego bricks and scalable to any number of auxiliaries.

The problem with AC

Power sources feeding in parallel into an AC system means you have to match frequency, voltage and phase to the running grid. That means an array of bulky components like transformers and gears, causing waste and losses in the system. The rectifiers in a DC system convert the AC generator voltage to the DC main bus voltage resulting in a very fast power-generation response.

DC-Hubs are also especially efficient for DC energy sources like batteries and fuel cells, minimising the number of conversions required. Managing stored electric power effectively is particularly important when vessels need to sail pollution-free, such as when it's in electric mode. This could be, for example, a superyacht sailing into a protected bay, ferries carrying passengers in emission-free zones or a cruise ship navigating an urban port.

Space saving and time saving

By reducing the number of bits in a conventional AC system, the DC-Hub is both lighter in mass and more compact, requiring less valuable space below deck. We offer an ingenious solution whatever the vessel type – even mounted in a deck unit if it's a containership, offshore construction or any vessel that has space for a container.

Another big advantage is that the control software is located in a separate control cabinet, not in the drive modules

themselves. That means each cabinet can, if necessary, easily be unplugged and replaced. A crew member can do this in under half an hour with no lengthy specialised training. This cuts down on not only wear and tear, but also the need for spare parts and downtime for maintenance – no need to call in a gang of electronics experts.

In my book, it's also a smart investment from a lifecycle perspective. Choosing a DC-Hub is guaranteed to extend the lifetime of vessels and ensure their residual value remains high. Fitting out newbuildings is obviously easier in terms of optimal design because you're starting from scratch. On a retrofit, you have to work with the space that's already there.

Whatever the vessel, we're calling them E-vessels, where the E stands for engineered. Our revolutionary permanent magnet (PM) technology complements the package to drive efficiency to a new level.

Don't be fooled by cheap options

Thinking about money, there are of course people out there touting solutions for variable speed frequency conversion for cheap. But I very much doubt if such suppliers can guarantee performance. While they might look good in terms of short-term Capex, such solutions in the long run will likely require a lot more TLC (tender loving care). Which means operating expenses go up, eating away at the profit an asset is generating. Surely it's wiser to spend money now on a more expensive, but robust, system that will make a ship cheaper to run over its lifetime?

I've also had quite a few conversations with shipping bankers who really like our approach. Some have told me it could be easier for owners to get a loan at preferential interest rates if they choose our technology. In other words, it can shine up an owner's bankability, to steal a word from the solar industry. That's a strong intrinsic advantage.

We're all in it together

But the main point is lowering a vessel's carbon footprint. The onus is on our industry to do all we can to curb emissions for a cleaner world. Helping to make that happen motivates all of us every day at Yaskawa Environmental Energy/The Switch.

Just like we're seeing with the Covid-19 threat, we're all in the same boat, and this is a communal effort. Forward-looking shipowners are already there, saving money in the long run. It's a win-win for everyone, especially the climate. *NA*

About the author

Carlo Cecchi is director of business development in the Asia Pacific Region for Yaskawa Environmental Energy/ The Switch.

DIARY

Disclaimer
Due to the rapidly changing nature of events all information is the best available at the time of going to press.

June 15-19, 2020
IMO Technical Cooperation Committee (TCC)
International forum,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre
Rescheduled - TBC

June 16-17, 2020
Cruise Ship Interiors America
International exhibition,
Miami Beach Convention Centre
Miami, FL, USA
www.cruiseshipinteriors-expo.com
Rescheduled to June 2021

June 17-18, 2020
Warship 2020
RINA conference,
Bristol, UK
www.rina.org.uk/WARSHIP_2020_Future_Technologies_In_Naval_Submarines
Rescheduled - TBC

June 23-25, 2020
Autonomous Ship Symposium
International conference,
Amsterdam, Netherlands
www.autonomousshipsymposium.com/en/
Rescheduled to June 2021

June 24, 2020
A guide to claims against Naval Architects
RINA/ITIC free webinar
Register online
www.rina.org.uk/claims_against_Naval_Architects.html

July 20-24, 2020
IMO Implementation of IMO Instruments Sub-committee
International forum,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre
Rescheduled - TBC

September 8-11, 2020
SMM
International exhibition,
Hamburg, Germany
www.smm-hamburg.com/en/
Rescheduled to February 2021

September 23-24, 2020
Full Scale Ship Performance
RINA conference,
London,
UK
www.rina.org.uk/Full_Scale_Ship_Performance_Conference_2020

October 7-9, 2020
Contract Management for Ship Construction, Repair & Design
RINA conference,
London,
UK
www.rina.org.uk/Contract_Management_October_2020

October 14-15, 2020
Smart Ship Technology
RINA conference,
London,
UK
www.rina.org.uk/events_programme

October 19-23, 2020
IMO Marine Environment Protection Committee (MEPC)
International forum,
IMO Headquarters,
London,
UK
www.imo.org/en/MediaCentre

October 26-30, 2020
Posidonia
International shipping exhibition,
Athens, Greece
www.posidonia-events.com/
Rescheduled date

November 4, 2020
Ice Class Vessels
RINA conference,
London, UK
www.rina.org.uk/events_programme

November 4, 2020
The Road to Maritime Autonomy
RINA/One Sea forum,
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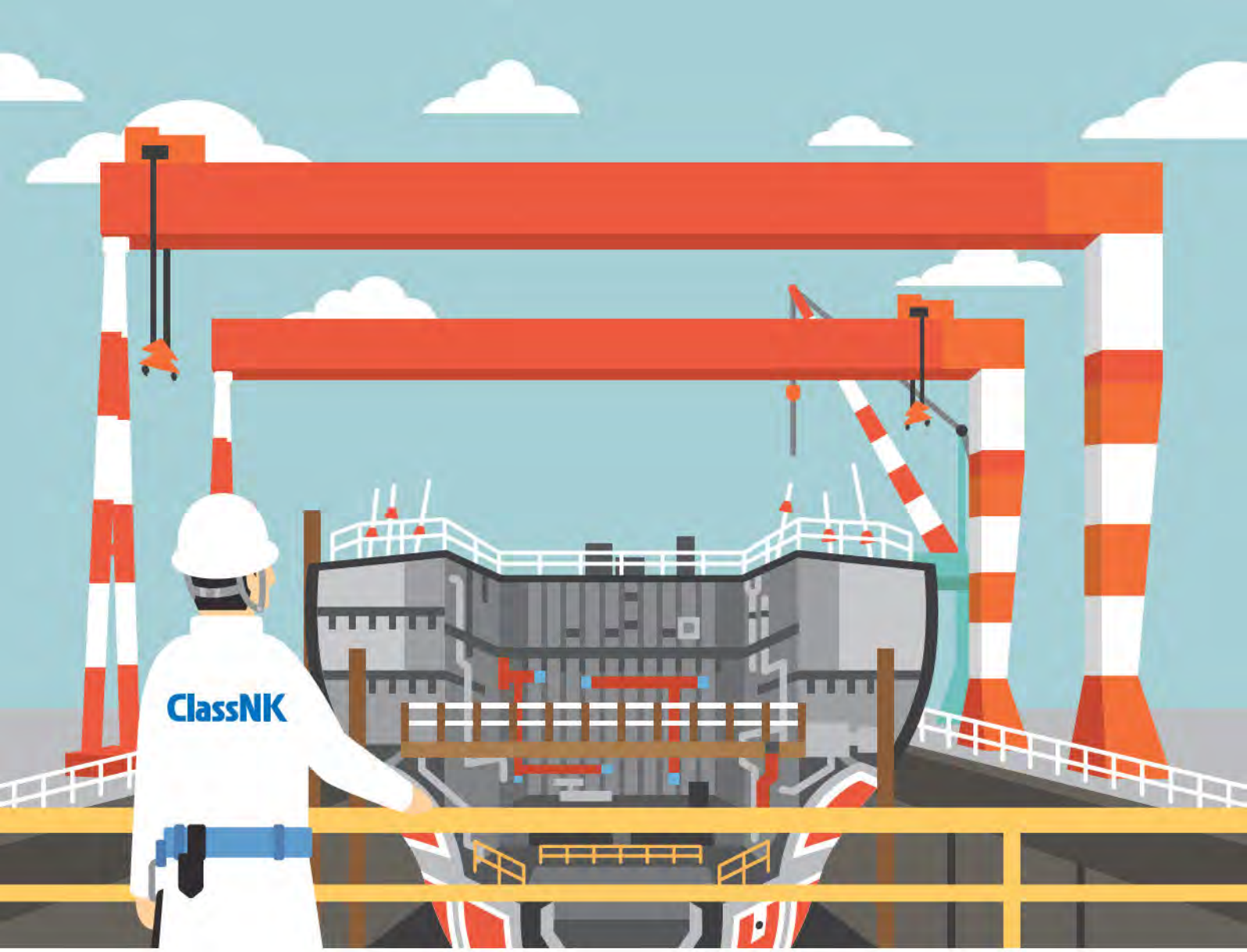

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