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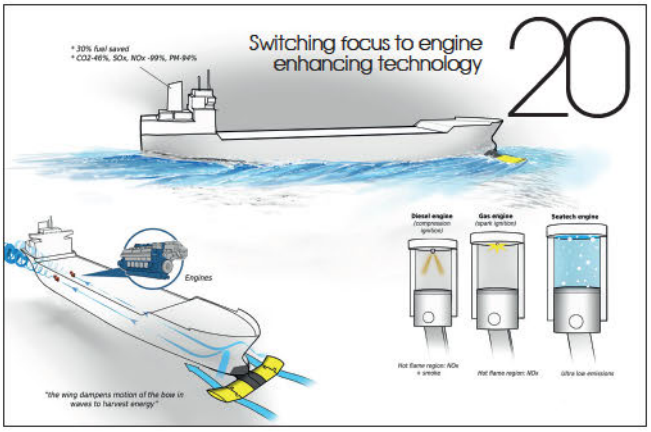

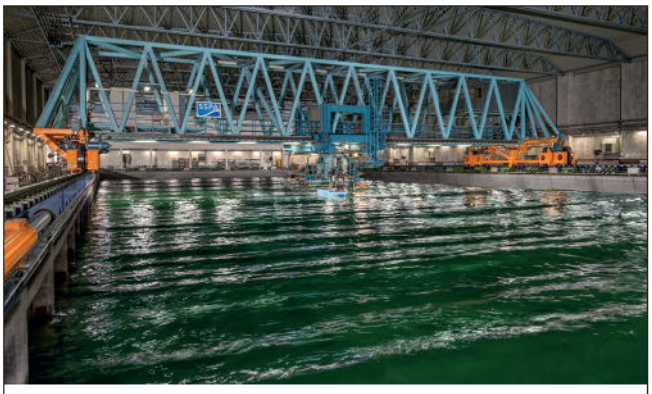

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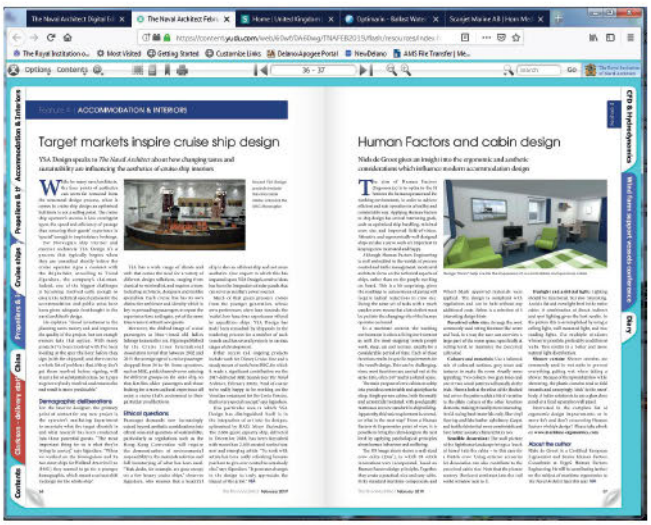

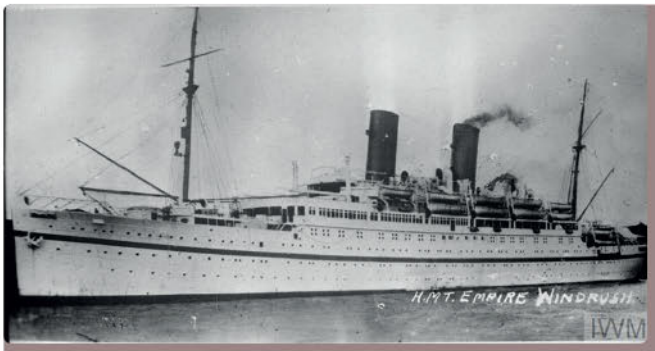

Equality should matter to maritime

HMT *Empire Windrush*, originally a German cruise ship (and later troopship) captured at the end of the war, carried the first West Indian immigrants to the UK in 1948

We all represent many different design iterations, none of which is optimum. Some would have it that the worlds of science, technology and academia are a meritocracy, that excellence will always be recognised, irrespective of race, gender or sexuality. In the best of possible worlds that would be true, but instead we live in one of considerable inequality and those disadvantages manifest themselves in so many different ways.

I realise that for many readers the issues surrounding the police killing of the black American George Floyd and the ensuing Black Lives Matter protests around the world will probably seem a million miles from the concerns of the maritime industry. But we're in the middle of a very unusual year, with the continuing pandemic and social distancing forcing us to remain separated from loved ones. Against that backdrop the concerns of achieving IMO's carbon goals or the challenges of adapting to the sulphur cap sometimes seem less of a priority (although I hope you'll find ample coverage herein).

So, in the interests of disclosure, I should say that I'm speaking as somebody of mixed race. As a boy, my father came to the UK from Trinidad in the early 1960's, part of what's become known as the Windrush Generation. He was the only one among his brothers and sisters to attend university, studying mathematics, and had a successful career specialising mainly in computing for some major companies.

It meant I enjoyed the advantages of a middle-class upbringing, but I've still suffered numerous racial insults over the years and once even a physical attack that saw me spend the night in an A&E having a gaping hole in my scalp stitched together. In truth, I've had it pretty light compared to some.

Let me be clear that none of this has occurred as any part of the 15 years I've been involved with the maritime industry and almost without exception I've found the maritime people I've encountered to be intelligent, good natured and without prejudice. Nor do I believe that maritime has any greater problem with racial discrimimation than many other industries. In fact, by its very international nature, possibly even less than some. But on the other hand, I've been to numerous maritime events over the years where, putting aside delegates from outside Europe, have only encountered a handful of non-white attendees.

> "All the protests in the world are meaningless if they don't lead us to a level playing field"

Is that a problem which maritime and engineering industries should feel any obligation to address? Well, there are certain issues that have more to do with the formative years of education and which it could be argued represent larger societal challenges. But when it comes to persuading young people from black, Asian and minority ethnics (BAME) that they should consider a profession in these industries could universities be doing more? Should, for that matter, professional organisations such as RINA be playing a bigger role? My personal view is yes.

I don't have access to figures on how many naval architects are British-born BAMEs – I would imagine that number to be exceptionally low – but the Royal Academy of Engineers says that 7.8% of engineering professionals of any kind are BAME, compared to 12% of the total working age population.

What's even more troubling is that it also says more than 25% of engineering graduates are UK-domiciled BAMEs. So where do they disappear to? Anecdotal evidence appears to suggest that many simply can't get a foot on the ladder after leaving university. Again, one must stress that this covers all engineering, but given the common problem of recruitment that ought to be a huge concern and the value of equal opportunities policies called into doubt.

Consider, for example, this scenario: a naval architecture firm has an entry-level position it's trying to fill. One applicant is a white male, perhaps he attended a minor public school before studying at Strathclyde and has a father who was also from an engineering background. The other is a black or Asian woman, from a comprehensive education, before becoming the first in her family to go to university, perhaps UCL, because it meant she could still live at home and keep costs down.

Assuming that both had achieved the same grade at university, whose face is going to 'fit better' with the typical employees of that firm? What meaningful instruments can you put into place to address an instinctive bias towards the white male? Unfortunately I don't have the solution, but if you're working for such a firm, or if you're recruiting for any position, then I believe it's a question that you have a moral obligation to find answers to. All the protests in the world are meaningless if they don't lead us to a level playing field. *NA*

Ro-pax

Deltamarin to design Finnlines Superstar Ro-pax

Naval architects Deltamarin will provide approval and detail design for Finnlines' Superstar 5,100lm ro-pax vessel project, after signing a contract with China Merchants Jinling shipyard (CMJL).

While design work will mainly take place in the company's Finland-based offices, Deltamarin notes that it has provided the CMJL shipyard with consultancy and contract design services earlier in the project.

Janne Uotila, managing director at Deltamarin, comments: "These new ro-pax vessels will be among the most environmentally friendly vessels of their type. Finnlines is at the forefront when it comes to sustainable shipping operations that also perfectly fit the values of our company."

Deltamarin has previously worked together with CMJL across numerous ro-pax projects. More recently, these include the E-Flexer ro-pax vessels for Stena Line and *Rosa dei Venti*, a ro-ro vessel for Giovanni Visentini Trasporti Fluviomarittimi.

This new ro-pox project strengthens Deltamarin's workload outlook over the coming 18 months and Uotila adds that the company is thankful to receive the contract in what has been an abnormal global business environment caused by Covid-19.

Ship design

Knud E. Hansen inspired by 1980s cruise ship design

Designed to accommodate up to 400 passengers and with a voyage range of around 6,500 nautical miles, the 150m long expedition cruise vessel, *Phoenix World Village*, is a smaller sister ship to the 1980s-designed *Phoenix World City*, which Knud E. Hansen says was ahead of its time and set a new standard for cruise ships.

Developed in-house, *Phoenix World Village* is aimed at the adventure cruise ship market as it provides an intimate experience visiting destinations otherwise inaccessible to other vessels, claims Knud E. Hansen. The vessel's unconventional layout includes separate forward and aft accommodation blocks on each side of its open deck and a unique observation lounge overlooking its engine room.

Equipped with a large battery bank, with a diesel-electric propulsion system that includes four medium speed diesel generators, *Phoenix World Village* will also appeal to the growing eco-tourism sector, says Knud E. Hansen, as it will travel with a minimised carbon footprint and reduced local pollution in protected areas.

The company also highlights the vessel's disease controls management, facilities and protocols developed in collaboration with leading healthcare operation experts Vikand. Vikand's Hygensea provides an airborne and surface disinfection solution, while the vessel's HVAC technologies are supplied by Hvacon and Halton.

Knud E. Hansen's new concept is a sister ship to *Phoenix World City*, originally designed in the 1980s

Covid-19

IRClass launches *Advaita* despite pandemic challenge

Floated out on 30 March, the 160m long, 22,200dwt cement carrier, *Advaita*, was under construction at Penglai Zhongbai Jinglu Ship Industry in China. Built under its classification, IRClass confirms that the vessel complies with the latest IMO conventions as well as codes for worldwide operations such as SOLAS, MARPOL and Loadline.

The society claims that the launch is significant as during construction it faced restrictions due to the Covid-19 pandemic. IRClass adds that its surveyors coped with constantly changing global and local restrictions, particularly concerning movement of manpower, which helped the vessel meet its float out schedule.

"I'm glad we were able to put into action and demonstrate our ability to adapt and respond quickly to the changing environment. This is a true test of IRClass' competence and I am extremely proud of our team for putting in the tremendous effort in the face of these challenges and continuing to soldier on even in such exceptional circumstances," says P K Mishra, head of operations at IRClass.

While IRClass stays committed to its members, will support their business needs and monitor the still

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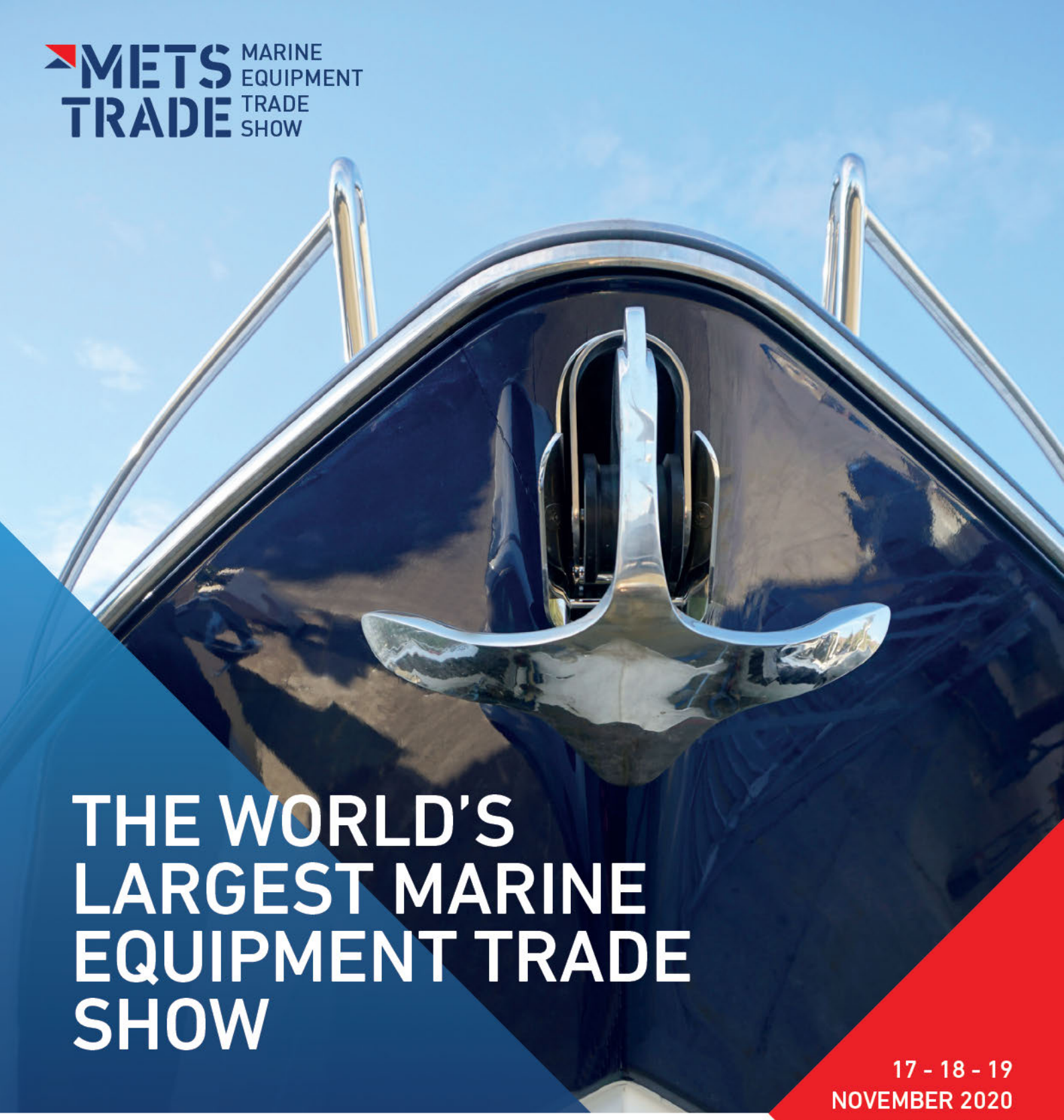

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changing circumstances relating to Covid-19, Mishra adds that: "The safety and well-being of IRClass' surveyors is the top priority for us and all safety measures and precautions are in place for them to carry out their roles."

LNG

Singapore's first LNG bunkering vessel sets sail

Launched on 28 May, the vessel was moved from land to water at Keppel Nantong Shipyard in China, and it will be the first of its kind to provide regular ship-to-ship LNG bunkering services in Singapore.

The 7,500m³ bunkering vessel is the product of FueLNG, a joint venture between Keppel Offshore & Marine (Keppel O&M) and Shell Eastern Petroleum (Pte) that aims to provide reliable LNG bunkering solutions in Singapore both through truck-to-ship and ship-to-ship operations.

Scheduled for completion in Q4 2020, the ship's MTD 7500U LNG design was developed by Keppel O&M's technology segment, Keppel Marine and Deepwater Technology, and is capable of running on both LNG and marine diesel oil. Various ships at heights between 3m to 23m above water level can be supplied with LNG by the bunkering vessel, which has an LNG filling rate range of up to 1,000m³ per hour.

In addition, due to its high manoeuvrability the vessel can supply LNG without the need for tug assistance, is compatible with a range of ship types, and features propulsion and power management systems to optimise its fuel consumption.

FueLNG's 7,500m³ bunkering vessel is the first of its kind to operate in Singapore

FueLNG claims that its ship will enhance the LNG bunkering infrastructure in Singapore beyond its current state and adds that this expansion will contribute to the wider LNG business in Singapore, creating opportunities in the country's LNG related ship design, construction, operation, repair and trade.

Hull cleaning

BIMCO pushes for hull cleaning standard

Shipping association BIMCO has moved closer to establishing a global standard for ship hull cleaning and is aiming for IMO approval within the next two to three years.

Currently still in its developmental stage, the association has sent its draft global cleaning standard to a reference group of scientists and government regulators. The approval standard was created by a working group of shipowners, paint manufacturers and hull cleaning companies led by Aron Sørensen, BIMCO's head of marine environment, and outlines the minimum requirements necessary to approve in-water cleaners.

Sørensen stresses the importance of settling on a global standard for hull cleaning: "If you don't have global standards, the shipowner can't know if a supplier in one country – the in-water cleaning company – has done a good job. Furthermore, the port authorities lack a common method to evaluate in-water cleaning companies."

BIMCO comments that a vessel suffering from hull biofouling can experience a fuel efficiency reduction of up to 35%, causing an increase in both cost and CO_2 emissions due to the ship's drag through water. Additionally, Sørensen explains that as drydocking space is limited for larger ships, the cost of deviating to Asian docks is extremely high, and this additional trip adds to existing GHG emissions, which can be avoided by utilising in-water cleaning of ships.

The proposed approval standard will be based on verified tests from accredited laboratories as well as certificates issued by internationally recognised classification societies. Its corresponding approval-based certificate will confirm that the equipment and procedures of the in-water cleaning is of high enough quality.

The association's next step is practically testing the standard on a hull cleaning company and a shipowner, which is due to take place in 2020. Sørensen adds: "At the stage we are now, we need to engage with industry experts, governments, scientists and port authorities before we finalise the in-water cleaning standard." *NA*

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Getting back to nearly normal business

Covid-19 still weighs heavily on shipping , writes Malcolm Latarche, with concerns about the impact on seafarers and IMO grappling with the challenge of online meetings

Just about every shipping body and international organisation such as the IMO and ILO have been pressuring governments to nominate seafarers as key workers and allow them to travel to and from ships as necessary. Some success has been reported but progress has been slow and in mid-June the ITF issued a statement saying it would assist any seafarers contemplating industrial action in support of their rights. The message to get recognition for seafarers as key workers has also been adopted as the theme for this year's IMO Day of the Seafarer Campaign on 25 June.

Another area that has been discussed is whether home working, online meetings and remote surveying will become the new normal once an end to travel restrictions and lockdowns becomes widespread. To a point that may be possible, but for major meetings such as the IMO's main committees – MEPC and MSC – where attendances can number over 1,000 delegates, Zoom and Teams platforms are hardly practical.

Though something will need to be worked out shortly as there are important matters such as the MEPC 74 changes to EEDI rules for large container ships being held up and potentially delayed beyond planned coming into force dates if the approvals cannot be given soon.

On a smaller scale, the IMO has managed to hold some online meetings and at one of these a new Global Industry Alliance (GIA) was launched to tackle biofouling. The GIA aims to accelerate the development of solutions to improve the management of marine biofouling by bringing together private sector companies from various industries affected by biofouling with the GloFouling Partnerships Project. The IMO points out that tackling biofouling addresses both invasive species and emissions since a badly fouled vessel will consume more fuel.

This was a development that had been expected with many industry observers believing that biofouling will likely become the subject of the next IMO Code or convention. At least this time, and unlike the 2004 Ballast Water convention, equipment makers and service providers have anticipated developments. Hull cleanings services have proliferated in recent years and new developments such as Jotun's HullSkater announced in March this year gives shipowners the means to meet likely regulation before it is even formulated.

News in June is usually dominated by announcements made at Posidonia but with that being postponed until October and SMM due in September delayed until February 2021, most equipment makers have been keeping their powder dry for a time when announcements of new products will have more impact. Often the news from exhibitions is of new ship designs and co-operations between class societies and shipyards.

However, the lack of any exhibition platform did not stop Stena Bulk from announcing its newest concept design for a chemical product tanker, the Stena IMOFlexMAX. Stena has been a serial innovator when it comes to tanker design with its V-Max and P-Max types setting the pace over a decade for wider bodied shallower draught ships.

Stena's IMOFlexMAX is a development of the current IMOIIMAX design and will be equipped with Flettner rotors and solar panels to harvest energy from wind and sunlight. Powered by dual-fuel engines, the design will be able to run on most fuel types and will be able to reduce greenhouse gases by at least 25% with a potential to reach up to 45% compared to modern product tankers.

In particular regard to the harnessing of wind power, the newest design harks back to Stena's 2009 concept vessel, the E-MAxair, which proposed the use of kite sails but that also envisaged an under hull cavity filled with air to reduce friction.

It remains to be seen whether an actual ship to the concept design will ever be built but Stena Bulk followed up the news of the design a week later by announcing that biofuel trials undertaken earlier in the year were successful enough for the company to offer a reduced carbon option for any of its customers from now on. In the 10-day trial, Stena Immortal completed a cross-Atlantic voyage using MR1-100 biofuel oil produced from used cooking oil and supplied by GoodFuels in Rotterdam.

The future options available for Stena customers will range from 20% to 100% biofuels based on an offsetting program where the biofuel is used within the Stena Bulk fleet. This allows customers to make use of low-carbon shipping options regardless of fuel availability on the specific route. It also guarantees that operation is performed without any disturbance to the shipment. *NA*

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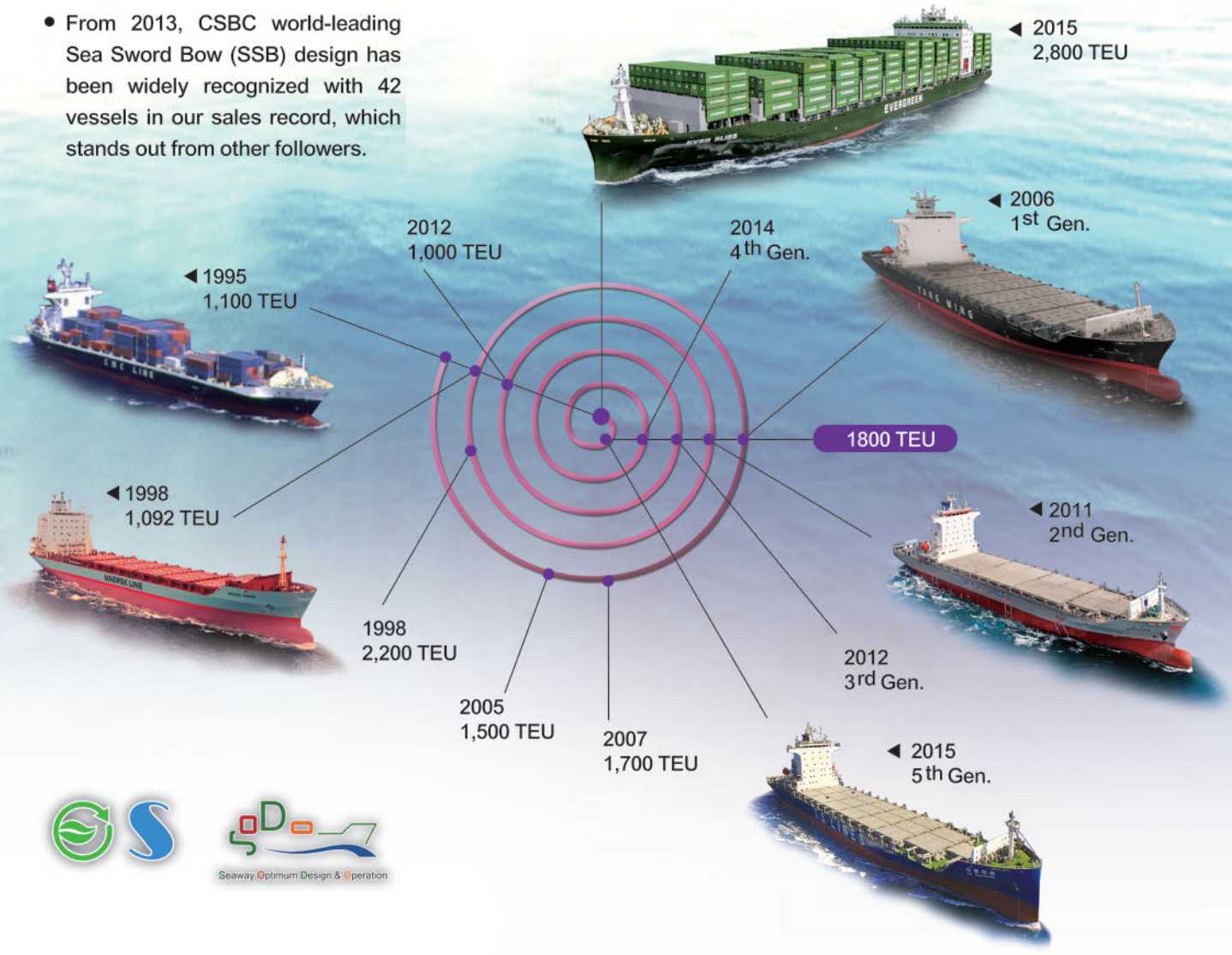

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Air lubrication system

Silverstream lands US$1 million deal

Silversteam Technologies has signed a US$1 million business deal with Carnival Cruises to provide an Air Lubrication Systems (ALS) for one of the cruise operator's vessels.

The company claims its ALS reduces fuel consumption by 5 to 12 % by pumping tiny bubbles via vents on the ship's hull, which reduces friction between the hull and water and helps the vessel glide through the sea.

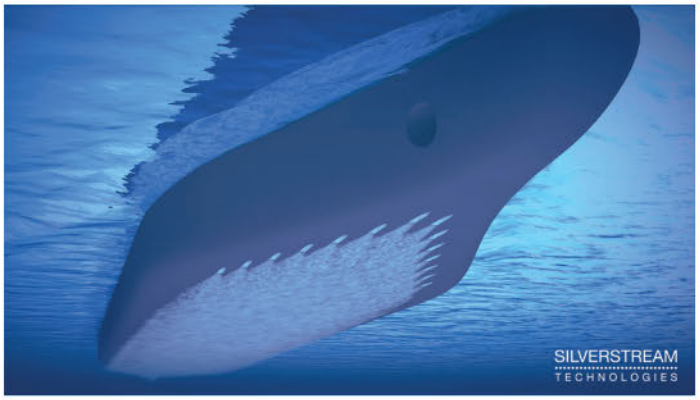
Noah Silberschmidt, CEO of Silverstream Technologies, comments: "Shipping is one of the 'hard to decarbonise' global industries so we have spent the last few years independently testing our system to support our claims. We want to become a standard on newbuild vessels in the industry and to be the 'new normal' for sustainable shipping."

Silverstream Technologies says it experienced significant international growth due to the support of the Department for International Trade (DIT), which it claims has opened networks and led to other industry deals with Grimaldi Group and Lloyd's Register.

While adhering to government guidelines during the Covid-19 pandemic, the company has remained at full operational capacity and has a further 15 ship deals in the pipeline to supply for vessels in Europe and Asia by the year's end. Silverstream adds that it anticipates its overall turnover to double due to the support from DIT and, with these increased installations, expects to see a subsequent reduction in carbon emissions and fuel burnt each year.

Silberschmidt explains: "Our trade advisor from the Department for International Trade has been instrumental in our recent success with this deal, as they know precisely the type of information that a business needs to tap into these key markets and reach these big companies."

Silverstream Technologies' ALS creates a 'carpet of micro-bubbles' on the vessel's hull



Propulsion

Voith launches all-electric propeller

The Voith Schneider Propeller (eVSP) is the company's all-electric marine propulsion system, featuring an electric motor that the company says ensures a more environmentally friendly and resource-saving operation.

Integrated into the new propeller is a permanent-magnet synchronous motor, which reduces the technology's complexities, minimises the required oil volume and increases its efficiency level, Voith states.

With no gears used throughout, the eVSP model has minimised noise and downsized, freeing up space for other equipment onboard a ship. Additionally, Vioth notes that the its dynamic responses and the absence of both gears and transmissions make its conversion of electrical drive power practically loss free.

The company comments that the eVSP is part of its electrification objective, and the new propeller brings together its VSP technology with knowledge the company has accumulated through its Voith Inline Thruster.

Dr Dirk Juergens, vice president of research and development for marine applications at Voith, explains: "With the electric Voith Schneider Propeller, we are making an important contribution to the electrification of the driveline in marine applications and thus to even more resource-saving shipping."

The eVSP is flexible both in its application across the industry and with its energy source, allowing shipowners to adapt to alternative power generation in the future, Juergens adds: "The new eVSP was developed for this purpose for all applications involved in the mobility revolution, such as offshore supply vessels, tugs and ferries."

Ballast water treatment systems

Alfa Laval signs BWTS frame agreements

Swedish technology specialists Alfa Laval has signed two frame agreements for its ballast water treatment systems (BWTS) to be completed in the next three years.

Valued at approximately SEK100 million (US$10.7 million), the two agreements comprise orders to deliver Alfa Laval's PureBallast 3 technology to 40 vessels and options for covering further 40 systems.

In addition to the PureBallast 3, the company's

third generation IMO and USCG approved BWTS, a number of orders also include Alfa Laval deck houses and booster pump units, which will all be booked in with the company's marine separation and heat transfer unit.

Sameer Kalra, president of the marine division at Alfa Laval, comments that the company has continued to maintain support for its customers despite the limitations imposed by the Covid-19 pandemic and these agreements are testament to that work. He adds: "We are proud to have secured these orders, especially in these challenging times. This confirms the PureBallast 3's status as a market-leading solution, while also proving that our focus on business continuity has been successful."

Propulsion

Schottel expands its rim thruster range

German propulsion expert Schottel has launched its SRT-R, a retractable variant of its existing Schottel rim thruster (SRT), an electric propulsion system with an electric motor stator located in its tunnel's outer section and propeller blades attached inside the rotor.

With a power range up to 500kW and 360degree thrust radius, the SRT-R is versatile and can be adapted to suit any operation profile requirements including dynamic positioning (DP) or as a take-home solution, says Schottel. The company adds that the variant is optimised by computational fluid dynamics (CFD) and no additional flow resistance is produced while in its retracted position.

Due to its hydrodynamic design, the SRT-R's internal propeller blades are resistant to cavitation and, as with the SRT, features low noise emissions and vibrations. The company notes that the equipment is particularly suited for passenger carrying vessel sectors such as yachts or cruise ships, where the minimised noise meet customer demands for a high standard of comfort.

In addition, the SRT-R can operate using biodegradable oils, and ships using the variant will be compliant with VGP regulations of the US Environmental Protection Agency.

For operations in shallow water, Schottel provides an additional variant, the SRT-RT, which also functions as a transverse thruster in its retracted position. The variant's resultant manoeuvrability enables an application range from brief docking and casting off in ports to continuous operation with DP. Schottel adds that SRT-RT is distinctive due to its short steering command response time, which allows for easier precise DP.

Marine software

ABB supplies Roll Group with OCTOPUS software

ABB will supply its marine software, the Ability Marine Advisory System – OCTOPUS, for Roll Group's 146m long, 12,285DWT module carrier, *BigRoll Biscay*, the eighth vessel in the company's heavy lift specialist fleet.

According to ABB, the OCTOPUS currently supports an estimated 90% of semi-submersible heavy lift ships in operation and its business with Roll Group began with its first contract for OCTOPUS, which was signed in 2009.

The company says its digital solution, based on weather and forecasted vessel motions, improves the safety and efficiency of ship operations by optimising its route. Considering the value of Roll Group's heavy loads onboard its ships, protecting the cargo using motion monitoring and forecasting is crucial, comments Joep Janssens, senior project engineer at Roll Group.

He explains: "OCTOPUS provides advice that helps us avoid sea areas where excessive vessel motions are likely to occur, protecting our cargo from damage. While minimising the environmental forces, motion-based route optimisation also decreases fuel consumption and helps cut emissions as a result."

ABB will also provide *BigRoll Biscay* with access to its Ability Marine Fleet Portal, which allows Roll Group to track its vessels continuously and download data for further analysis. Janssens explains: "The combination of OCTOPUS and Marine Fleet Portal means that we maintain full visibility of the asset and get up-to-date data that allows us to improve our operations." *NA*

Roll Group's *BigRoll Biscay* will be equipped with the ABB digital solution

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World's largest LNG bunkering vessel launches in China

CSSC's Hudong-Zhonghua Shipbuilding Group (H&Z) has delivered its 18,600m³ LNG bunkering ship, the world's largest of its kind

Delivered on 30 April, the 135m long LNG bunkering vessel *Gas Agility* is fitted with sufficient facilities to fully supply fuel for the world's largest LNG powered 23,000TEU container ship, which is capable of sailing 19,500 nautical miles at a time, covering the round-trip voyage between Europe and the Far East. Its specialised bunkering services covers the entire LNG fuel system process, including cold cabin, inertion, refuelling, heating and purging. At the same time, the ship can also be utilised for filling up various other types of dual-fuel powered cargo ships.

CSSC H&Z's *Gas Agility* is the first LNG bunkering vessel to feature the Mark III Flex membrane system for containment and insulation, which is designed by French LNG engineering company GTT. According to reports, the vessel is also the world's most advanced bunkering ship as it uses boil-off gas as its main fuel, which can be efficiently used and processed under various working conditions while achieving zero loss due to boil-off gas.

The vessel's features can be characterised by three main points. Firstly, its refuelling operations. The 18,600m³ vessel is equipped with high capacity refuelling facilities as well as reliquefaction equipment, and its LNG filling rate range can reach up to 1,600m³/h. CSSC H&Z's ship can also realise quick large flow filling operations while there is a low differential pressure between the bunkering vessel and the ship receiving fuel.

Secondly, its services cover a wide range of functions. The ship has a large displacement gas combustion unit (GCU) installed as well as a nitrogen generator. Aside from its LNG filling function, the vessel can also deliver specialised services for the entire fuel process from cold storage to purging. For LNG powered ships, it can provide full management, including daily fuel replenishment, docking maintenance and initialising of the undocking procedure.

The 18,600m³ LNG bunkering vessel's delivery signing ceremony

Thirdly, the ship's manoeuvrability and operational performance. The vessel is fitted with both two fully rotational thrusters and one bow side thruster and is capable of completing an autonomous horizontal berthing operation in windy conditions. It can also realise 'door-to-door delivery service' through autonomous berthing of all types of ships receiving LNG fuel.

According to CSSC's H&Z, which is based in Shanghai, the construction and promotion of LNG bunkering ships has experienced many difficulties in light of the Covid-19 pandemic, as the commissioning service of many foreign service providers failed to arrive in Shanghai on schedule. The H&Z construction team adapted their approach in the face of such difficulties, carrying out in-depth 'cloud-based commissioning' using online video contact with their foreign providers and communicating with its domestic service providers to identify potential alternative supplies. Utilising the support and cooperation of shipowners and service providers, the team guaranteed on schedule delivery of the LNG bunkering vessel.

At the time of publication, there are only nine vessels with a capacity over 1,000m³ in operation across the world with the sole purpose of LNG bunkering, with a maximum hold capacity record of 7,500m³. There are a further eight LNG bunkering vessels under construction, as well as more than 300 LNG dual-fuel ships awaiting construction globally. Thus, it is clear that the current LNG bunkering vessels will be fundamentally incapable of meeting the supply requirements of future LNG-fuelled ships.

The company states that with the implementation of IMO's global sulphur cap in January 2020, the demand for LNG-fuelled ships is still increasing and it also expects promising market prospects for LNG bunkering vessels, adding that the company will work hard to further its achievements in the field. *NA*

Japanese joint project explores shipping's road to 2050

Feasibility of innovative technologies and alternative fuels surveyed, with concept designs for zero- and low-emission ships

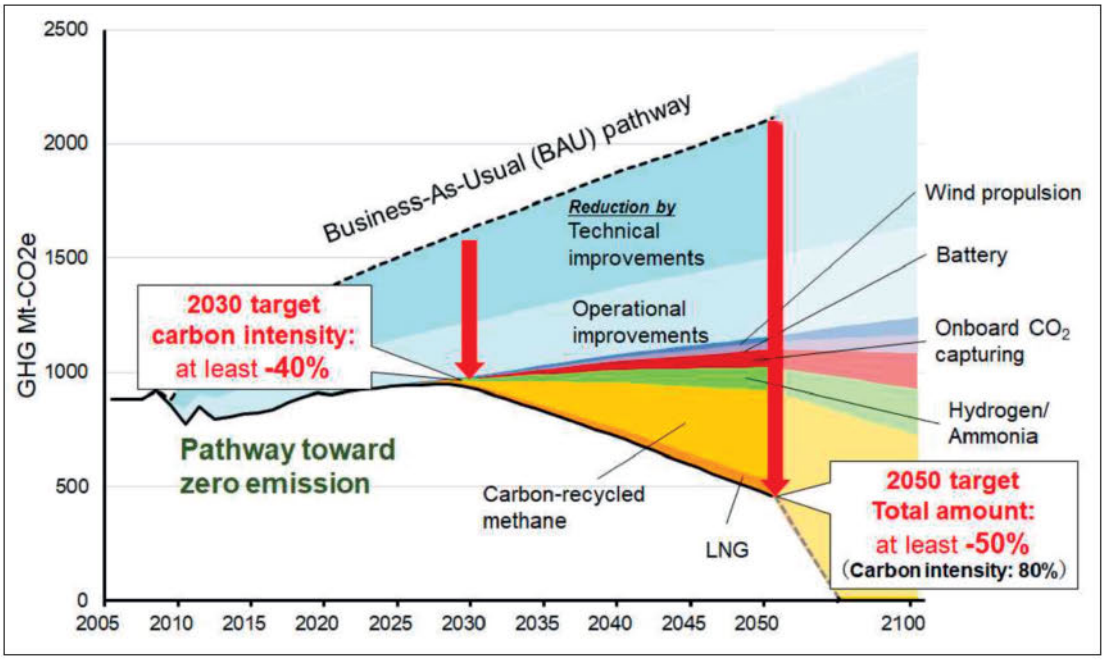


Fig 1: The emission reduction pathway from LNG to carbon-recycled methane

In March this year, the Japan Ship Technology Research Association (JSTRA) and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), in collaboration with the Nippon Foundation, formally launched the joint Shipping Zero Emission project. The project, which is outlined in a report (recently made available in English) considers the measures being taken to achieve IMO's 2030 carbon targets, before looking at the emission pathways and the roadmap toward zero-emission vessels for 2050 and beyond.

Last year, the Japanese government proposed developing an energy efficiency existing ship design index (EEXI) to IMO's Marine Environment Protection Committee (MEPC). Under EEXI, which would use an index equivalent to EEDI, existing in service vessels would need to achieve a required level or implement efficiency measures such as engine power limitation, installation of an energy saving device or other verifiable means. Vessels which already meet the required EEXI will not need to take additional measures.

The proposal is not without its critics, with some believing the carbon reductions would be just a fraction of that, with the effectiveness of energy saving devices open to question and power limitation difficult to police. However, Japan estimates that if adopted by IMO by 2023 then the goal of achieving a 40% reduction in carbon intensity levels (compared to 2008 levels) could be comfortably achieved by 2030.

Emission pathways

Given the uncertainty concerning future energy supply, the Japanese report proposes two different feasible emission reduction pathways to 2050 assuming seaborne trade continues on a business as usual (BAU) basis. One option would be to transition from LNG to carbon-recycled methane; i.e. synthetic gas. This could be phased in as a drop-in fuel in the latter part of this decade and, according to the report's projections, eventually grow to represent around 39% of marine energy consumption by the middle of this century.

Alternatively, it may be preferable to embrace hydrogen and/or ammonia as the best option and the report estimates they could represent 44% of energy consumption by 2050, including both engines and fuel cells. But in either instance, it anticipates that fossil-based LNG will still represent the second-largest share in energy consumption, at 35-36%.

The different fuel and technological options, research and development (R&D), and trial projects will become the focus of the next few years. To avoid R&D duplication, the project advocates the setting up of joint ventures or, alternatively, the establishment of international schemes with an appropriate funding framework (one obvious example would be the International Maritime Research Fund proposed by the International Chamber of Shipping and others).

It further states that it will be essential to develop hydrogen and ammonia-fuelled engines by 2024, apropos trialling them on dual-fuel coastal vessels by 2026

Fig 2: The C-ZERO concept designs

and achieving delivery of a first generation zero-emission vessel by as early as 2028.

Concept designs

As an extension of this, the project has developed concept designs for a variety of different C-ZERO, low or zero-emission vessels based on alternative fuel option. The background research for which is extensively detailed in the report's appendices.

Hydrogen-fuelled: Designs were created for two different sizes of liquified hydrogen-fuelled ships. Firstly, an 80,000dwt bulk carrier of 229m length, one-way cruising distance of 7,000nm and a 4,000m^3 liquified hydrogen tank located above deck at the stern. Second, a 20,000TEU container ship, 399m length with a cruising distance of 11,500nm. This design features a 30,000m^3 fuel tank. The assumption was made that bunkering would be available in at least five major ports around the world and that the vessels would be equipped with dual-fuel main engines.

Ammonia fuelled: Also an 80,000dwt bulker but specifically based on the premise that it would serve the Japan-Australia route. The duel-fuel engine would allow for the use of a small quantity of pilot fuel such as methanol or LPG. The 1,550m^3 tank would also be situated above deck, to control leakage and release into the atmosphere in the event of emergency.

LNG & wind: This concept, for a 229m 102,000dwt bulker, would achieve an 86% reduction in CO_2 by maximising the synergy of LNG and other technologies. These include a hybrid contra-rotating propeller, hullform improvements, wind assistance and an air lubrication system. A similar concept was also developed for a 400m 27,000TEU container ship.

Carbon capture: This dual-fuel vessel, also a 400m 20,000TEU container ship, would operate between the Far East and Europe, powered principally by methanol stored in a 13,200m^3 tank. Onboard carbon capturing systems, using the liquid amine absorption method, remain hypothetical at this stage but should be capable of capturing 85.7% of CO_2. A set of two 6,400m^3 CO_2 tanks would be located amidships. *NA*

The full report can be downloaded at: www.mlit.go.jp/common/001345627.pdf

Wärtsilä led consortium combines technologies for fuel efficiency

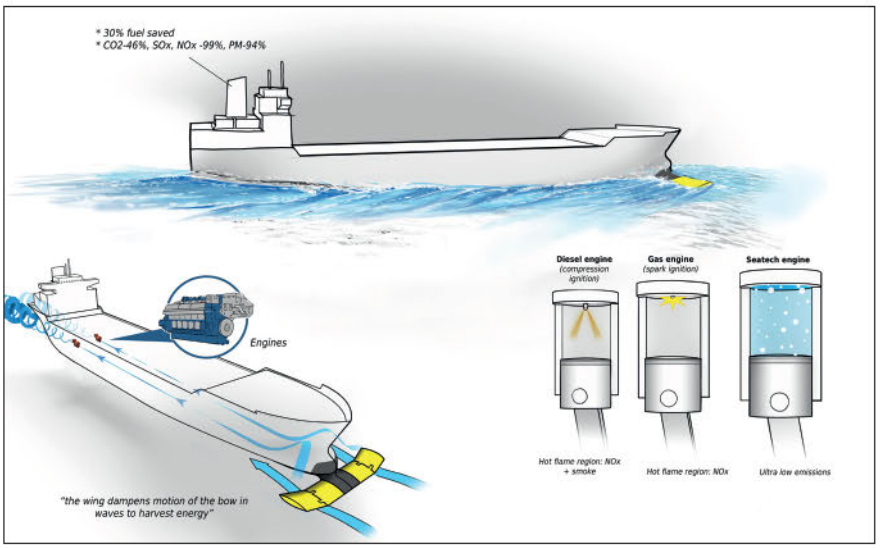
The EU-backed Seatech project will explore precise engine controlling when used in symbiosis with a dynamic bow wing

Efficiency has become such a buzzword in shipping that one could be forgiven for forgetting what it actually means: achieving the maximum possible energy conversion. Like many engine manufacturers, technology group Wärtsilä, which already boasts the world's most efficient four-stroke diesel engine with the Wärtsilä 31, accepts that the mechanics of engine design is coming close to peaking. Instead, the emphasis is increasingly turning towards how additional technologies and engine control can further augment propulsive performance.

In March this year, Wärtsilä announced it, together with a consortium of six other industry and academic partners, had been awarded EU funding for a project that's aiming to achieve significant efficiency gains. Known as SeaTech, the project will simultaneously develop two symbiotic ship engine and propulsion innovations: a precise engine controlling system and a biomimetic dynamic wing mounted on the ship's bow. When used in synergy, the project believes it could reduce both fuel consumption by 30% and drastically cut SOx, NOx, CO_2 and particulate matter emissions.

Project owner Jonas Åckerman, director of research and technology development for Wärtsilä, tells *The Naval Architect* that the project has been in planning for some time. "The two technologies may look completely different, and of course they are, but from an operational point of view by combining them in the same ship there are certain advantages. In general, at Wärtsilä we're always looking into fund projects which are suitable and whether we have anything in the pipeline which we could utilise."

The idea of a biomimetic bow wing, which is being developed by other partners in the project, is to augment propulsion in moderate and heavy sea conditions by capturing the wave energy. It's a concept which has previously been mooted for cruise ships as a means of dampening ship motions, but for the most part has been consigned to academic papers (the consortium's partners include the National Technical University of Athens, the University of Southampton and the Arctic University of Norway).



SeaTech's bow-mounted biomimetic dynamic wing

However, Wärtsilä's involvement puts the emphasis squarely upon upscaling into a commercially viable solution. Åckerman explains that the Seatech engine being developed, which is based on existing dual-fuel technology, adopts: "A concept from combustion physics that is providing great advantages from an emissions point of view and overall performance, especially when operating on part load."

Among the project partners is Norwegian tanker operator Utkilen AS and the synergistic benefits of the two technologies could be of significant value to the shortsea sector, although ultimately it is hoped that commercialisation would expand into deep-sea shipping. The technology will be suitable for newbuilds but also retrofits, where it is estimated that the return on investment could be as much as 400%.

The project officially launched with an online kickoff meeting in June. Anders Öster, who is leading the project for Wärtsilä, admits that the requirements for an EU-funded project can take some adjusting to. "There's quite a big rule book about running the project… we have a very detailed plan with tasks, deliverables and milestones. We also have more contact with potential customers, shipyards, classification societies and all these big players. But for the EU it's about bringing more jobs to the market and increasing knowledge by sharing the information we produce."

But for Wärtsilä the goal is as much about achieving sustainability in a business environment. Although SeaTech is being developed with the expectation that gas will become the dominant marine fuel in the coming years, the technology would also be applicable for some of the emerging alternatives, which the company is actively exploring with other research initiatives.

"As a company we see LNG as a bridging fuel, but bio and synthetic fuels, such as synthetic methane, are coming. In the longer term similar concepts could be developed around ammonia. As such, this project is far from limited," says Åckerman. *NA*

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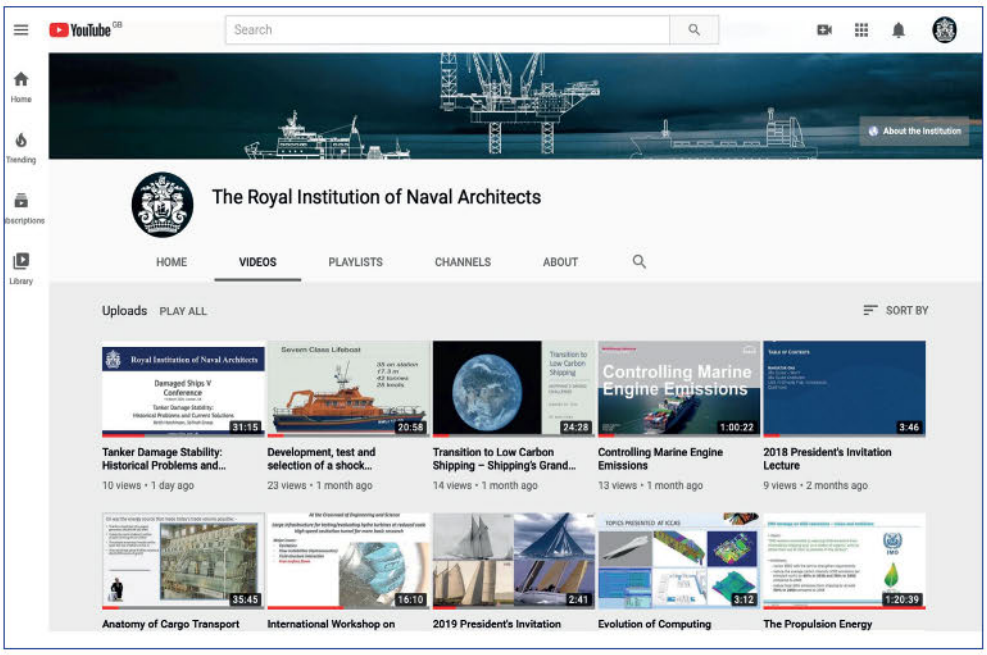

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How much is enough? EEDI rules and 'minimum propulsion power'

Since the introduction of the EEDI almost a decade ago, slow steaming and the wish to reduce bunkering costs have resulted in a trend towards less powerful engines. To avoid vessels becoming underpowered and unsafe, IMO has published guidance on the 'Minimum Propulsion Power to Maintain the Manoeuvrability of Ships in Adverse Conditions'. A group of seakeeping experts from SSPA Sweden AB explains the rules

The terrors of a lee shore

The Energy Efficiency Design Index (EEDI) is a measure of the amount of carbon dioxide a ship emits in relation to its transport work. It is required that most newbuilds have an EEDI smaller than a prescribed value, which in turn is based on statistics and will gradually be lowered over time.

An obvious, easy and very effective way to reduce CO_2 emissions is slow steaming and the installation of a smaller engine. To ensure that EEDI compliant vessels can still leave coastal areas before a storm escalates IMO requires all ships to have an engine large enough to sail straight into waves of a certain height and at a certain minimum speed. The rules are summarised in the binding, albeit controversial IMO Interim Guideline MEPC.1/Circ.850/Rev.2.

Two assessment levels

The IMO guideline gives two alternative methods to determine this 'minimum propulsion power'. First, a 'Level 1 assessment' that is simple, conservative and based on installed power of existing ships. It uses deadweight and ship type as the only input.

Secondly, a 'Level 2 assessment' that is more advanced and takes main dimensions, rudder size, and windage area into account. It assumes that ships with sufficient power to advance in waves will also be able to keep course. Compliance is shown in two steps:

1. Calculation of the required advance speed in pre-defined head wind and waves
2. Assessment whether the installed power is sufficient to achieve this required advance speed

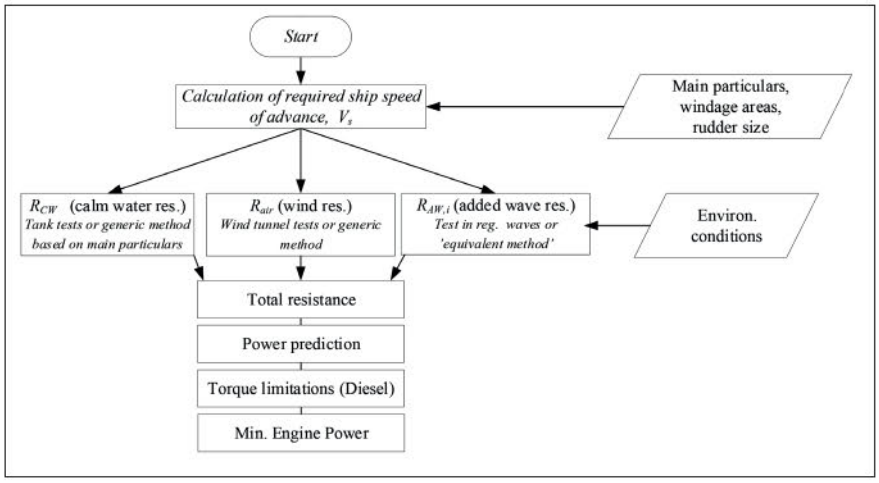


Figure 1: Simplified flow diagram illustrating the Level 2 assessment from MEPC.1/Circ.850/Rev.2

Step 2 involves a speed-power prediction and requires detailed knowledge of the various resistance components, namely calm water, wind, and added wave resistance. Figure 1 illustrates the procedure schematically.

Case study

In this article the 'KVLCC2' (a generic VLCC developed in Korea) is used to illustrate how IMO minimum power is calculated. For this purpose, two models, one large 7m 'resistance' model and a smaller 4.7m 'seakeeping' model were built and tested at SSPA.

Required speed of advance. According to IMO the minimum ship speed of advance, V_s, depends on ship design and varies between 4 and 9knots. Vessels with e.g. larger rudder areas will be able to keep course with less powerful engines and at lower speeds. For the KVLCC2 this minimum speed turns out to be 4knots.

Adverse weather conditions: *One wind speed, several wave periods*. The guideline specifies the environmental conditions, under which the ship should be able to sustain 4knots by means of the wind speed Vw and JONSWAP wave spectra, see Table 1.

Table 1: Parameters defining 'adverse conditions'

Ship length	Vw	Hs	Tp
Lpp <200m	15.7m/s	4.0m	7s-15s
200m ≤ Lpp ≤ 250m	Linearly interpolated		
Lpp>250m	19m/s	5.5m	

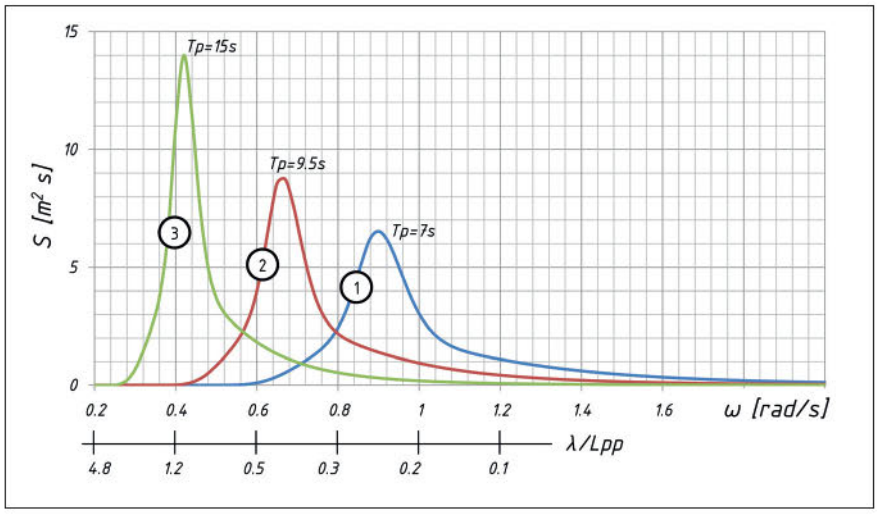


Figure 2: JONSWAP spectra with a significant wave height of Hs=5.5m and three different modal periods Tp

It is remarkable that IMO does not define a single wave condition but a range of sea states with spectral peak periods varying from 7s to 15s as 'adverse'. As a result, not one but several power predictions need to be carried out. The highest value calculated during this process determines the engine size. For a large ship like the KVLCC2 (L_{pp}>250m) three example spectra are shown in Figure 2.

In order to verify that a particular engine can provide enough power to sustain the minimum speed of V_s = 4knots in these waves, the total resistance of the KVLCC2 is split into calm water, wind, and added wave components. Following the IMO Level 2 assessment these are determined as follows:

Neglecting wave-making resistance and hull roughness IMO works out calm water resistance based on the wetted surface area of the ship, *S*, the frictional resistance coefficient, C_F and the form factor *k*.

$$R_{CW} = (1+k)\cdot C_F \cdot \frac{1}{2}\rho S \cdot V_s^2$$

While CF can be calculated from the generic 'ITTC 1957' correlation line it is recommended to determine the form factor k from model tests. Using the large 7-metre KVLCC2 model for tank tests and analysing the results using 'Prohaska's Method' we find for a ship speed of 4knots:

k=0.232; and

R_{CW}=126kN

Wind resistance is calculated as:

$$R_{air} = C_{air} \cdot \frac{1}{2}\rho_{air} \cdot A_{FW} \cdot V_{w,rel}^2$$

where C_{air} is the aerodynamic resistance coefficient, ρair is the density of air A_{FW} is the frontal windage area of the hull and superstructure and $V_{w,rel}$ is the relative or 'apparent' wind speed (sum of ship speed and true wind speed). The IMO-guideline recommends finding C_{air} by wind tunnel testing, alternatively the generic value of 1.0 can be used. From tests with similar VLCCs we find:

C_{air}=0.96; and

R_{air}=306.6kN

The third resistance component, added resistance in waves, is more difficult to work out. The IMO-guideline suggests model testing in regular i.e. harmonic waves to obtain the quadratic transfer function of added resistance. The total added resistance under the 'adverse conditions' is then derived based on the principle of superposition:

$$R_{AW} = 2\int_0^\infty \frac{R_{AW,reg}(Vs,\omega)}{\zeta_A^{\,2}} S_\zeta(\omega)\, d\omega \quad (1)$$

Where $R_{AW,reg}$ (Vs,ω) denotes the added resistance values from the model tests at different discrete wave frequencies ω, $S_\zeta(\omega)$ is the wave energy density spectrum and ζ_A is the wave amplitude.

Extreme care during testing required

In order to determine the quadratic transfer function of the added resistance, tests in regular waves need to be conducted. Because of the low speeds involved (4knots for the KVLCC2) such tests cannot be carried out in ordinary towing tanks. In order to 'outrun' wave reflections from the tank walls the facility needs to be about 30m wide. Consequently, tests were conducted in SSPA's 40m wide seakeeping basin, Figure 3. The smaller of the two KVLCC2 models was towed trough the basin using a combination of long stiff lines and soft springs. This setup allows the model to surge in a more or less unrestricted way and dampens out violent wave induced jerks. The total towing force (= resistance) is determined from the line forces.

Figure 4 summarises the results from these tests. For the analysis added resistance $R_{AW,reg}$ was determined by subtracting the resistance in calm water from the mean resistance in regular waves. The coefficient of added resistance due to waves plotted in the figure is defined as:

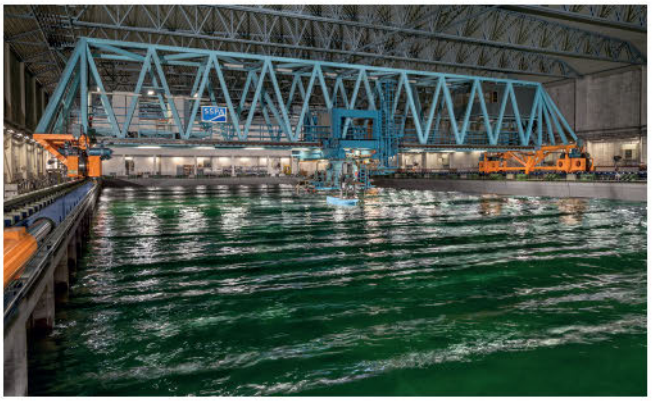


Figure 3: Seakeeping test in SSPA's Maritime Dynamics Lab

$$C_{AW}(Vs,\omega) = \frac{R_{AW,reg.}(Vs,\omega)}{\rho g B 2\zeta_A{}^2/L_{pp}}$$

Using the measured C_{AW} function and integrating with the spectra from the IMO-guideline yields one unique R_{AW} value for each spectral peak period. Focusing on the three example spectra from Figure 2 one obtains:

$$R_{AW}① = 810.0kN$$
$$R_{AW}② = 840.1kN$$
$$R_{AW}③ = 657.2kN$$

Total resistance dominated by added resistance

Once calm water, air, and added wave resistance are known, the total resistance can be calculated as the sum of these components, Figure 5.

Power prediction

Now that the total resistance has been calculated power predictions can be made. According to IMO these should be based on the 'K_T/J^2 method' from the '1978 ITTC Performance Prediction Method'. A method, that besides propeller open water data also requires knowledge of the 'wake fraction' w and 'thrust deduction factor' t. The IMO guideline gives generic expressions for these two factors and for the KVLCC2 we find:

$$t_{generic}=0.245$$
$$w_{generic}=0.350$$

CFD calculations and values from the literature however show that particularly t=0.245 is very high. For the present case study of the KVLCC2 the following values from SHIPFLOW calculations at 4knots are:

$$t=0.177$$
$$w=0.351$$

To better understand the influence of t and w on the minimum propulsion power two scenarios, one conservative, one optimistic were investigated.

Scenario A (conservative): t=0.245; w=0.300
Scenario B (optimistic): t=0.120; w=0.351

Based on this and with the resistance values calculated above, power predictions can now be made. The results are illustrated in Figure 6. As expected, point 2 – having the largest total resistance – requires the highest power, P_D=7.5 MW. This corresponds to

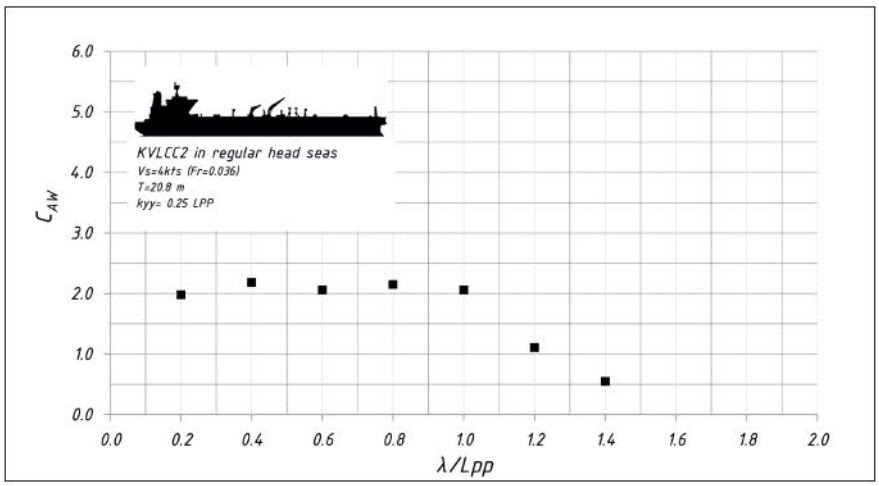


Figure 4: Added resistance coefficient as function of non-dimensional wavelength (QTF). KVLCC2 at 4knots

'Spectrum 2' with a T_p of 9.5s. To maintain a speed of 4knots in the other spectra requires less power.

It can also be seen from Figure 6, that varying thrust deduction factor and wake fraction within the A-B range from Figure 6 significantly influences the results of the power prediction. This is illustrated by the corridor between the dotted lines. Depending on the choice of w and t the power demand can differ by about ± 1MW. Also shown is the minimum power according to the 'Level 1 assessment'. With over 25MW it is literally 'off the chart'.

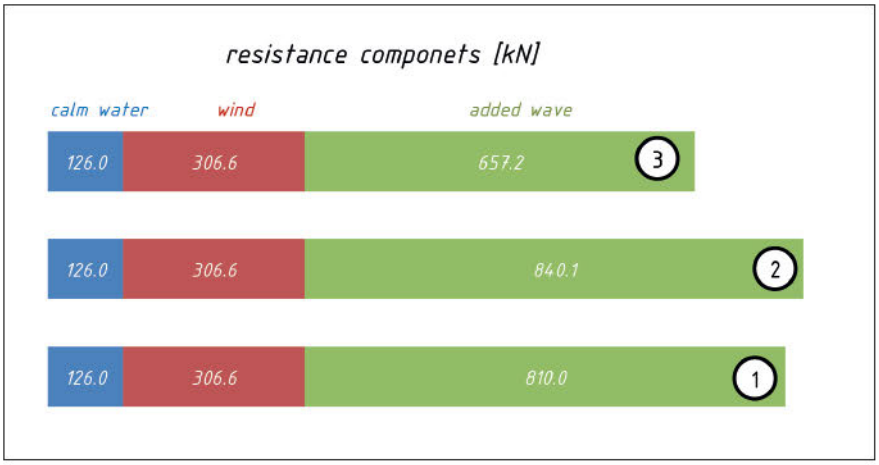
Diesel engines, fixed pitch propellers and torque limitation

Finally, in the case of direct diesel drives, it remains to be checked that the chosen engine can actually provide the required power at the calculated rpm values from the power prediction. Figure 7 plots the operational points 1-3 (i.e. power/rpm combinations corresponding to wave spectra 1-3) into load diagrams for two diesel engines.

Engine 1, with an MCR of 24MW at a rate of revolution of 75 1/min, is a typical VLCC-engine (green solid line). It can bring the KVLCC2 up to a design speed of 15.5knots in calm water with a sea margin of 15%.

Engine 2 (red dash-dotted line) is much smaller (12MW @ 69rpm) and can be considered a 'slow steaming' option. It will propel the ship at about 12.2knots in calm water with the same sea margin as the larger engine.

Figure 5: Comparison of resistance components for example spectra 1-3, KVLCC2 at 4knots



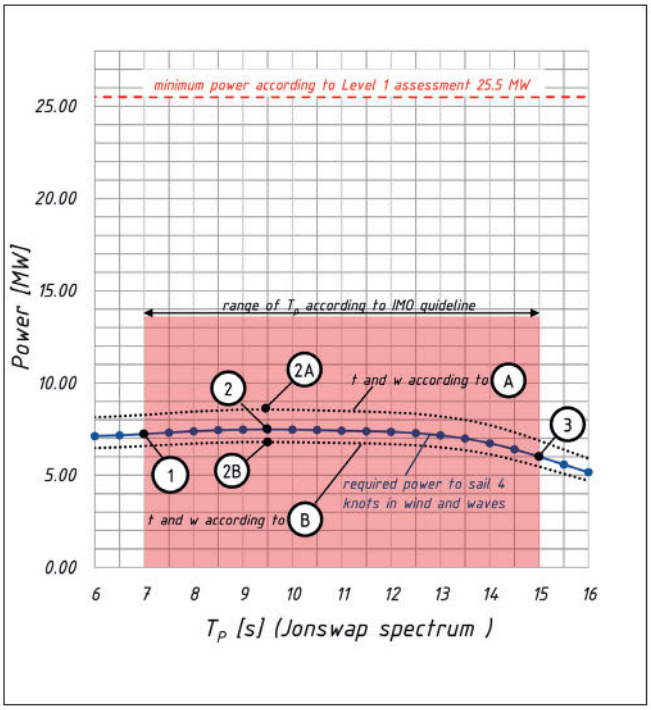


Figure 6: Required power to maintain a speed of 4knots in wind and waves as function of modal period T_p

It can be seen that the larger engine will deal effortlessly with all the situations the KVLCC2 might encounter under the 'IMO adverse conditions'. This is because all the operational points (1, 2, 3, 2A and 2B) end up below the torque limit line (solid, green curved line). Here the latter two points correspond to variations of point 2 with a conservative (2A) and an optimistic (2B) choice of t and w.

Things are different for the smaller engine, where an optimistic choice of thrust deduction factor (2B) can prove that the ship complies with the IMO regulation while the 'best guess' (point 2) shows that the engine will just be able to provide the required torque for V_s = 4knots. Point 2A even ends up outside the operational range for Engine 2.

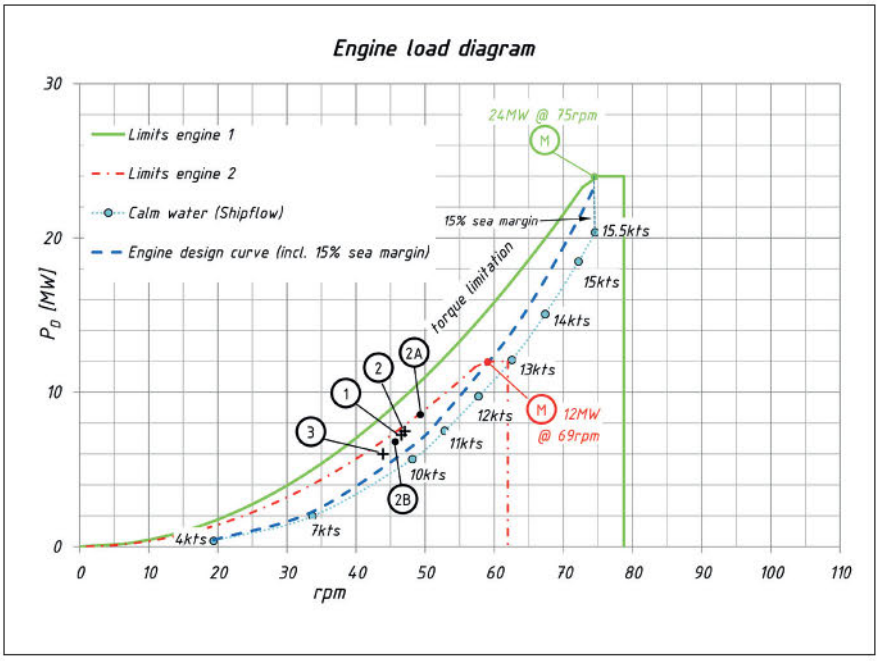


Figure 7: Load diagram for two diesel engines

Bottom line

- The simple Level 1 assessment from the IMO-guideline yields that the minimum installed power to sustain the required ship speed of advance of 4knots in wind and waves is 25.5MW.
- According to the more advanced Level 2 assessment this power reduces to 7.5MW.
- It is important to consider the torque limitations of diesel engines because in adverse weather the propeller is highly loaded. In the present case this increases the minimum installed power from 7.5 to 12MW.
- An analysis of the individual resistance components shows that, under the wind and wave conditions from the IMO-guideline, the total resistance consists of about 10% calm water resistance, 24% wind resistance and 66% added resistance.
- The fact that added resistance dominates the power prediction leads to the conclusion that it is particularly important to predict this force component correctly. Because of the low tests speed (4knots) and the issue of tank wall reflection it is important to carry out added resistance tests in a wide basin, not a narrow tank.
- During the Level 2 assessment of the KVLCC2 it became obvious that the choice of the thrust deduction factor t is not well defined in the guideline but has a huge influence on the outcome.

About the authors

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Container lashing: taking the strain for a bigger problem

The recent loss of more than 40 containers in an incident off the Australian coast, classed as an act of pollution, has raised questions about how safely secured they were, but lashing is just one factor amid many commercial pressures

On 28 May, *APL England*, a 5,510TEU container ship, was detained by inspectors for the Australian Maritime Safety Authority (AMSA) at the port of Brisbane. The vessel's previous few days had been eventful ones; en route from Ningbo to Sydney on 24 May it had suffered a temporary loss of propulsion during heavy seas and the resultant rolling caused several stacks to collapse and somewhere in the region of 40 to 50 containers to be lost overboard.

Upon boarding, AMSA's inspectors found, in contravention of SOLAS requirements, that lashing arrangements for cargo were inadequate, while the securing points for containers on the deck of the 2001-built ship had been heavily corroded. The following day charges were laid against *APL England*'s master for failing to ensure the vessel was operated so as not to cause pollution or damage to the Australian marine environment, as well as discharging garbage (i.e. the containers) into the sea, which between them carry penalties of up to Aus$300,000.

APL England was only finally released to return to China, under the command of a new master, on 19 June after its insurers Steamship Mutual had agreed that it would pay fines and other costs arising the incident, a bill which could reach Aus$22.5 million.

Lashing failure?

Lashing failures are regularly cited in container ship incidents and ship insurers send out regular reminders to members to ensure that cargo, be it containers or other equipment, are well secured while at sea. But are they really the cause? Not directly, according to John Southam, a former master mariner and now loss prevention executive for P&I club North.

John Southam

Southam says: "Rarely, from a technical point of view, is it a single failure of lashings. The only time I can think in [relatively] recent history when a single lashing problem caused loss of boxes was with the first iterations of fully-automatic twistlocks which did not work fully as they intended, but it was very often just a single box and they subsequently solved the problem. As with most things it's a combination of problems and when you boil it down lashings usually fail because of weight distribution."

Gillian Clark, North's senior executive for claims, agrees: "When you look at the majority of container casualties that have stow collapses you'll see that stows generally tend to go en masse; i.e. one whole column will go. That suggests that lashings aren't so bad overall but it has more to do with general issues. As John says that's often because of poor weight distribution caused by commercial pressures, such as last-minute boxes arriving."

IMO's Verified Gross Mass (VGM) certification, introduced in July 2016, made it a SOLAS requirement for containers to be weighed prior to boarding and has helped to alleviate the problem, but much still depends on the diligence of cargo planning.

"When we see an incident such as the *APL England* the first thing we'll ask for is the weight distribution of the affected bay and the Cargo Securing Manual, because those two will show you virtually immediately. I would say 95% of the ones I've looked at with Gillian and the claims team were down to heavy boxes up high combined with the vessel's GM [metacentric height]. This causes the acceleration forces of the stack onto the lashings to increase, so it's not a failure of the lashings as such, rather that they're being operated outside the boundaries of their design specifications," notes Southam.

The weight distribution of a container ship is, of course, contingent upon its design. Every vessel's cargo securing manual will show the maximum allowable weight distribution, bay by bay, tier by tier and row by row. Heavier boxes should ideally be stacked towards the middle and each bay and stack will have a maximum GM. Weight higher up in the stack risks placing stress on the lashing bars, and while the twistlocks generally prove equal to the task the bars themselves may be subject to failure.

Southam compares it to the 'Swiss cheese' model: "Most of the time when we get to look at the plans you can immediately see a heavy box sat quite high up the stack. So if I can see it, there's no way that others wouldn't have been able to if that plan had been checked thoroughly… Often we'll see reports talking about synchronised rolling and things of that nature, which is

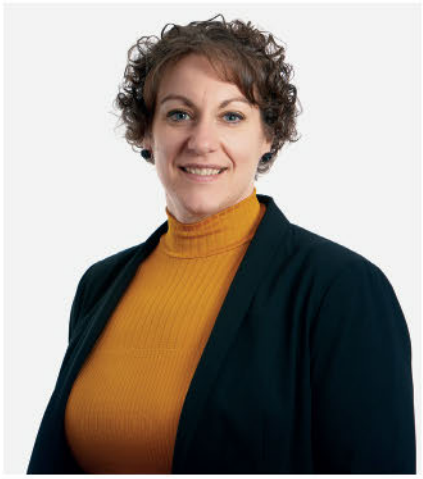
a contributory factor. But if the stability is correct, the GM is correct for the lashing and weight distribution, and if the vessel course has been altered as needed then, in my opinion as an ex seafarer, wave formation isn't the root cause."

Size problem

It's perhaps tempting to think that the upscaling of container ships has exacerbated the problem but the available evidence suggests it's more that a greater number of containers are being transported nowadays. Clark notes that where, 20 years ago, a 4,000TEU vessel losing a stack of six or seven containers wouldn't have been considered internationally newsworthy, a vessel losing the proportional number would amount to 20 or 30 boxes.

The World Shipping Council estimated that in 2016, the last year for which it published figures, 568 containers were lost at sea. But Clark thinks it's difficult to determine an exact number given there is no standardised reporting. "We only get a snapshot and although we have all our members information it often gets duplicated. The shipowner might be with one club, the charterer with another and the sub-charterer with another."

Larger boxships, which typically operate on liner routes between Asia and Europe, are also more likely to call at major hub ports such as Rotterdam. These will have more advanced facilities than smaller ports which, arguably,



Gillian Clark

apply less stringent checking. The role of commercial pressures across all ship operations cannot be understated. While even a smaller vessel might once have had a crew of up to 30, today it's likely to be between 16 and 20.

Southam says: "Shipowners and operators don't want to do restows because they cost money. You start to avoid moving weight around because you don't want to take a box off and put it back on again because it's not for this port. Twistlock boxes themselves are a 20 or 40 foot container and they're one hell of a weight; if you stick one of those on top of a stack all of a sudden you're over your weight limit."

Pending the investigation report it's unclear what sort of systems and alarms may have been in place onboard the *APL England* during loading and while in transit. Southam observes that many such smaller, older vessels don't have the same sophisticated software, making it an effort to calculate the acceleration forces on the lashings for so many stacks. However, given the overload of onboard alarms with today's vessels there's no guarantee those alarms would be heeded. "Alarm management across the whole vessel is a huge problem. If something is beeping and annoying me and I have the facility to make it stop therein lies the problem a lot of the time."

Smaller vessels also often have more complex lashing requirements than larger ships and not all crew may be familiar with the manifold variations, nor their maintenance. "On a big box ship you'll have three or more of the bottom rows held in almost by structure in the form of lashing platforms. When I first went to sea the big boats were only around 4,000TEU and they had long bars and short bars, for this kind of box and that kind of weight," says Southam.

"Maintenance spans every facet of a vessel during its working life; whether it's engines, lashings or bridge gear. In our FD&D [Freight, Demurrage and Defense] department, one of the first things we ask the lawyers is whether there's a planned schedule when there's an allegation of lack of maintenance. Lashings have a maintenance regime and because the hatch lid is part of the vessel structure the lashings themselves have to be counted, checked, greased and all those sorts of things."

Remedial action

As with so many facets of ship safety and stability, container loading and securing resides in something of a catch-22. The vast majority of vessels, whether safely loaded or not, operate without any incident or loss of cargo and therein lies 'proof'

More than 40 containers were lost from *APL England* in May's incident. Source AMSA

that the rules and regulations work well enough. Southam thinks the SOLAS VGM requirements, which stipulate the master should be provided with the verified container weight "sufficiently in advance", is ambiguous enough so as to have limited impact on last-minute loading.

Clark concurs, pointing out: "By the operator accepting to load it's almost vindicating that there was indeed ample time because they've taken the box. Ideally, you want to take away those pressures and make sure people stick to the cutoff times, but you're talking about major stakeholders and the pressure is huge on those lines. It's a tough market at the moment so they can't afford to be so strict. It's a trade-off, and we all want to see that stopped from a risk point of view, but it's a toughie to expect members to do it, to be honest."

Southam highlights that the class societies, notably Lloyd's Register and DNV GL, have been attempting to address the commercial aspect with some of their products and services. As well as updating its rules and calculation methods to reflect larger ships and the latest cargo securing techniques, DNV GL's StowLash3D free software enables the user to reproduce a real lashing case without conservative simplifications. LR's LashRight tool provides a similar function, consistent with its own rule requirements.

Heavier containers stacked high risk compromising the vessel's GM and placing stress on the lashing bars

But he says the first, simple steps that can be taken is for all parties to be checking the stowage plan against the Cargo Securing Manual and working within the boundaries of the ship's design. "It won't cure things 100% because, as we've discussed, there are so many layers to this problem, but that's not a bad start." *NA*

Ultimate strength performance of a damaged container ship

Presented during RINA's Damaged Ships V conference held in London this year, Shen Li's co-written paper may provide insights beneficial for improving the structural safety of container ships

The continuing development of the container shipping industry in recent years gives rise to the concern on the structural safety of container ships. During the service period, ship-ship collision may occur in some of the busiest sea routes and canals due to various unexpected operational errors. For instance, two container ships collided in Suez Canal in 2014. No causality was reported as a result of this accident, but a 65ft long dent was left on one of the container ships.

More recently, a collision took place between a ro-ro ferry and a container ship in the Mediterranean Sea, causing breach of side shell of the container ship. Generally, these accidents will lead to significant structural damages on the side shell of the vessels, which can reduce their safety levels in the remaining journey. For making an evacuation decision, a rapid evaluation on the residual strength is highly important.

A case study is reported in this article to investigate the ultimate bending strength performance of a 10,000TEU container ship with side shell damages. A series of analyses are completed by applying the simplified progressive collapse method with validation using nonlinear finite element method for some scenarios. The results and insights developed from the analyses would be useful to improve the structural safety of container ships of similar class.

Methodology

As the most fundamental safety assessment for ship structures, a variety of methodologies have been developed to predict hull girder strength. Generally, the ultimate hull girder strength can be calculated using one of the following: 1) Empirical formulae; 2) Presumed stress distribution-based method; 3) Structural segment collapse strain-based method; 4) Simplified progressive collapse method (SPCM); 5) Idealised structural unit method; 6) Nonlinear finite element method (NLFEM).

In this article, the analyses are completed using the SPCM, which was originally proposed by Smith [1] and has been now codified in the classification society guideline for longitudinal strength assessment [2]. The SPCM follows an efficient procedure where the cross section of the vessel is first sub-divided into a set of structural segments with pre-defined stress/strain relationships. Vertical curvature of the hull is assumed to occur incrementally, and the corresponding incremental element strains are calculated on the assumption that plane sections remain plane and that bending occurs about the instantaneous neutral axis of the cross section.

Element incremental stress is derived from incremental strains using the slopes of stress-strain curves. Element stresses are integrated over the cross section to obtain bending moment increments. Incremental curvatures and bending moments are summed to provide the cumulative values. The development of the SPCM has been a research subject for over four decades. Recent advancements include differing formulations [3-5] and extensions for biaxial bending [6], multi-frame collapse [7], torsion [8] and cyclic loading [9].

For a few damaged scenarios in this article, the NLFEM is applied to validate the computation by the SPCM. The application of NLFEM to perform collapse analysis on ship structures was initiated by Chen [10] and it has become a commonly adopted approach in the research community. For example, the NLFEM was applied to analyse the progressive collapse of a bulk carrier in alternate hold loading condition in [11]. The investigation on the *MOL Comfort* accident was conducted by applying NLFEM to predict the ultimate collapse strength [12]. Nevertheless, the NLFEM still requires a substantially considerable computational time and sophisticated analyst expertise for modelling, which therefore is not yet a practical choice for the ship structural design in the initial phase.

Case Study Model

The case study is conducted on a 10,000TEU container ship with various side shell damaged scenarios. As shown

Table 1. The principal of the case study 10,000TEU container ship

Principal particular	Dimension
Overall length, *Loa*	352.25m
Perpendicular length, *Lbp*	336.40m
Overall depth, *D*	24.1m
Overall breadth, *B*	42.8m
Frame spacing	791mm
Design load	**Magnitude**
Still water bending moment *SWBM*	5.69 GNm
Vertical wave bending moment *VWBM*	13.66 GNm

in Figure 1, three major cases are analysed where the vertical extent of the damaged zone is extended from the deck (Case 1), from the centre of the side shell (Case 2) and from the lower deck (Case 3) respectively. For each case, the vertical extent is varied from 0.1z/D to 0.8z/D at an increment of 0.1 z/D and the transverse extent of each damaged scenario is 0.5y/b where z represents the vertical damage extent and y corresponds to the transverse damage extent. As the damaged extent is the same in the case of 0.8z/D for each group, a total of 22 damaged scenarios are analysed. The same case study model was utilised in previous studies, see [13-14] where global wave loads were estimated and the safety margin of the intact vessel was evaluated.

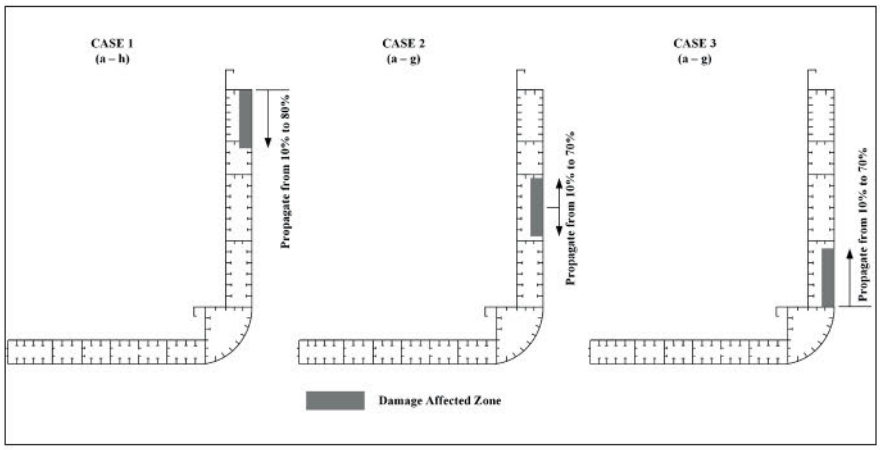


Figure 1. Damaged scenarios of the case study container ship

Progressive Collapse Behaviour Under Vertical Bending

The progressive collapse behaviour of ship hull girder is usually represented by a vertical bending moment versus curvature curve. Typically, the response curve is predominately linear in the initial phase and transits into a nonlinear behaviour with reducing stiffness after the onset of elastoplastic buckling. The peak in the curve marks the ultimate bending strength of the vessel. After attaining the ultimate strength, there is normally a decline of the capacity. An example of the vertical bending moment versus curvature relationships predicted by SPCM and NLFEM is compared in Figure 2, and the results of the intact cross section is included.

It is apparent that a higher ultimate ship hull strength and the elastic bending stiffness are predicted by NLFEM. This may be attributed to the difference in the assumed characteristics of stiffened panel imperfection. In an intact status, a relatively considerable post-collapse drop in strength can be found when the ship is subjected to hogging load, whereas the cross section can still resist a large bending moment after the collapse in sagging. This feature of sagging collapse behaviour is also observed in the damaged cross section.

However, a different collapse behaviour in hogging appears for the hull girder with damage which is similar to the collapse behaviour in sagging. As illustrated by the NLFEM plots, at the sagging collapse state the torsion box experiences a gross yielding failure. Buckling nucleation is observed in the inner and outer side shell panels. The deformation primarily nucleates at the middle bay. Meanwhile, due to the rotation of neutral axis, yielding occurs at the undamaged side of the bottom panels, whereas the bottom panels at the damaged side remains elastic. At hogging collapse, a gross yielding failure is observed at the side shell panels. The buckling deformation occurs at the undamaged side of the bottom panel and nucleates to the transverse bay near the model boundary.

Residual Ultimate Strength versus Damaged Extent

The computed residual ultimate strength of the case study container ship is illustrated in Figure 3 for different damaged scenarios. Only the ultimate hogging strength is presented since this is the most relevant structural performance index for a container ship which is loaded predominately in a hogging state. It can be seen that a considerable strength reduction is induced in Case 1 even with relatively small damaged extent, whereas the strength reduction in Case 2 and Case 3 is negligible until a large damaged zone is presented. As highlighted in the Figure 3, this is due to the fact that the torsion box has been damaged in all Case 1 scenarios while the torsion box is still intact for Case 2 and Case 3 when the vertical damaged extents (z/D) are smaller than 0.6 and 0.7 respectively. Thus, it may be concluded that the torsion box has a significant contribution to ultimate strength of container ship against longitudinal bending. If the torsion box has not suffered from any damage, the ultimate

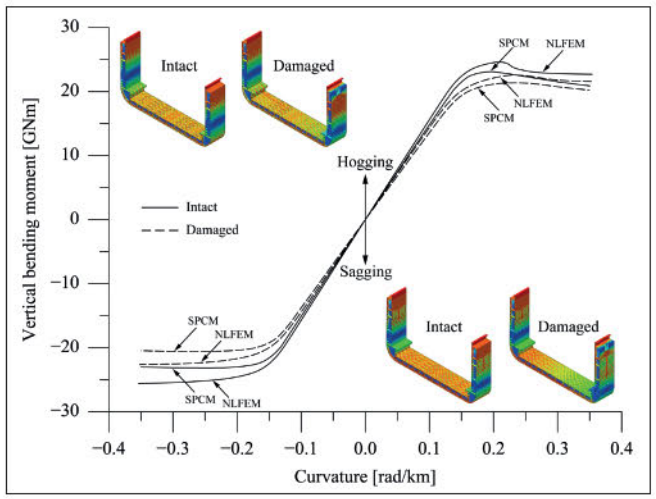


Figure 2. Vertical bending moment versus curvature curves (Damaged scenario: propagated from the upper deck with z/D = 0.1)

bending strength of a container ship may still be adequate.

Conclusions

The article presents a case study evaluation on the ultimate strength performance of a 10,000TEU container ship with side shell damages. A variety of damaged extent and locations are considered. The insights developed from this evaluation are summarised as follows:

- The post-collapse behaviour of the case study container ship in sagging exhibits a response plateau where no significant decline of the load-carrying capacity is shown;
- The collapse of an intact container ship in hogging experiences a gradual reduction of post-collapse strength. However, it becomes similar to the sagging collapse behaviour if the side shell panels are damaged;
- The torsion box of the container ship has a dominating influence on the residual ship hull strength. If the torsion box is still intact, the hull girder retains sufficient strength against longitudinal bending. Conversely, the residual strength may be inadequate if the torsion box has been damaged.

A variety of damage extents and locations have been analysed in the present study. For future work, it is necessary to examine the effect of the longitudinal damage extent on the ultimate ship hull strength. In addition, the consideration of torsional bending and local bottom load may also be important as they could introduce further detrimental effect on the ultimate strength performance of the container ships.

About the author

Mr Shen Li is a PhD candidate at Newcastle University UK. His primary research focuses on the buckling and ultimate strength assessment of ship-type thin-walled box girder structures. The paper's co-authors include Professor Zhiqiang Hu, who holds the position of Lloyds Professor of Offshore Engineering at Newcastle University UK and Dr Simon Benson, a lecturer in naval architecture at Newcastle University UK and served as the member of the ISSC Ultimate Strength Committee. *NA*

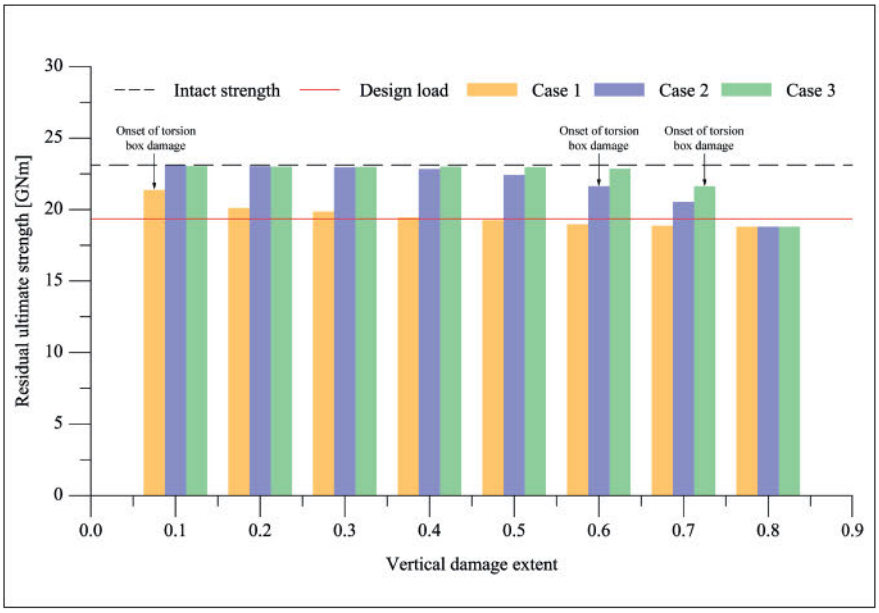


Figure 3. Residual ultimate strength versus damaged extent in hogging

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Six months on: has shipping met the mark with the IMO 2020 0.50% sulphur fuel switchover?

Lloyd's Register's Tim Wilson, principal specialist for fuels, lubes and emissions, looks at trends, challenges and considerations since the IMO's sulphur limit came into force on 1 January 2020

The implementation of MARPOL Annex VI Reg. 14.1.3 dominated industry discussions leading up to the end of 2020; with much of the conversation focused on the uncertainties of switching to Very Low Sulphur 0.50% Fuel Oils (VLSFO) and questions raised about availability, quality, pricing and operational safety compared to the 40-year continuity of using HFOs.

Further concerns centred on whether the enforcement of the regulation across the globe would be uniform and fair, as some of the non compliance clearly looked like a commercial advantage. If that was not challenge enough, the industry was faced with the unprecedented Covid-19 pandemic only a short time after implementation.

Nevertheless, within these first six months the shipping and oil supply industry has lived up to the challenges despite these concerns, and the strong emphasis on good preparation and cross-industry collaboration before 2020 has resulted in a relatively smooth transition. Ironically, Covid-19 brought about a limitation on ship inspections and a more pragmatic approach, which in turn provided the time for ships to settle into a routine of using VLSFO and maintaining a compliant mode. From Lloyd's Register (LR) data we have seen, for fuels as loaded, sulphur non-compliance dropping to around 2% from 8% when VLSFO's were starting to be loaded back around September 2019.

But it has not been plain sailing for all. Some companies have reported issues, with pressures on crews to deal with the wider variability of these new fuel formulations over the diversity of the viscosities, generally higher paraffinic contents and increased tendency of sludge deposition. This has placed further demands on those onboard to be more aware of how these fuel characteristics are best addressed to mitigate any adverse impact on their storage, treatment and combustion.

Cold flow vs viscosity temperature management

After six months of bunkering, the analysis data is confirming, as predicted, that VLSFOs are generally proving to be more paraffinic (with higher wax content) than the HSFOs of the past. On the upside, paraffinic fuels have very good ignition and combustion properties but, conversely, they can be challenging in temperate or cooler climates for storage and handling. They require additional temperature management, considering ambient conditions, to prevent fuels from becoming unpumpable in storage and mitigating the wax crystal sludge deposition during purification and filtration.

This anomaly of temperature management is further accentuated by the diverse fuel viscosity ranges of these VLSFOs being delivered, governing the means to control transfer and fuel injection viscosities. Noting that, over 90% of the pre-2020 HSFO's delivered were over 380cSt, whereas about 85% of the 2020 VLSFOs are being delivered between 20cSt and 180cSt (V50). This viscosity variance means managing an increasing temperature differential range from the HSFO of 50°C to as much as 100°C for VLSFO's and at the same time considering the wax disappearance temperatures, which can range from about 20 to 100°C.

It is therefore particularly important where the viscosities of the fuel are less than 80cSt @ 50°C to pay attention to the temperature management of these fuels through the system. In addition, the fuel ought be maintained at least 10°C above the pour point temperature in storage and consider that temperatures may have to be higher than those recommended by the purifier manufacturers to ensure the any wax crystals have resolved back into the liquid of the fuel. If these temperatures are not reached the wax can fall out during purification, causing excessive sludging in the bowl and filter blockages in the fuel system.

Tim Wilson, LR's principal fuels specialist

Impact on machinery

According to LR's fuel oil bunker analysis and advisory service (FOBAS), some ships, using VLSFO, reported problems at various points of its fuel machinery system, such as unpumpable fuels in storage, blocked fuel filters, sludging at separators, loss of pressure at pumps and excessive wear of engine cylinder components. For the most part this was attributed to the lack of awareness by the crew or limitation of the fuel system to effectively condition the fuel. Potentially in some extreme cases, this could lead to machinery failure and loss of propulsion, a potentially hazardous outcome.

Initially, reported cases of cylinder and piston ring damage has been perceived to

be due to VLSFO combustion performance. However, for the most part it has been found to be due to the complexity of finding the right formala for cylinder lubricating oil feed control, which requires additional efforts on the crew to periodically monitor cylinder ring condition and cleanliness through scavenge port inspections.

To avoid such problems, a ship's crew needs to be proactive in managing the fuel from order through to its consumption. Firstly, crew need to have information about the quality of the fuel coming onboard and then make fuel system adjustments to suit the fuel's characteristics for smooth operation. Monitoring the performance of the fuel newly in service has become more important to enable a proactive fuel management approach to sustain safe and reliable operations.

Long-term fuel storage

When the question is raised, 'how long can I store these VLSFO's?' there will be a ring of silence from the industry, but for the statement 'load it and then use it'. We have seen few cases where VLSFOs stability have been compromised within three months of storage.

Owners must think about the challenges associated with VLSFOs, as already alluded to, when considering any extended storage periods and possible layups, being mindful that the diverse blend formulations, increased paraffinic contents and their limited stability reserves are accentuated by the sensitivity to thermal fluctuations. All of this can contribute to destabilisation of the fuel and even stratification between the heavier and lighter blends.

By monitoring and controlling storage conditions, avoiding overheating, and taking into account the sensitivities of these VLSFO blends, a period of at least three months should be achievable. If longer storage times are anticipated, then expert advice should be sought based on the specific fuel in storage at the time.

Moving forward

To help the wider industry build knowledge on problems with VLSFOs and prevent or reduce the likelihood of further issues occurring, we would encourage shipowners and crew to share their experiences with LR and the wider industry. Operational issues and observations should also be discussed with suppliers and fuel testing providers.

This will help accelerate industry learning and understanding about formulations of VLSFOs, which will in turn assist suppliers with scrutinising the consequences of their applied blending practices, improving the overall integrity of the bunker supply chain. Not least, feedback much needed for the ISO committee to consider what more can be included in the ISO 8217 marine fuel standard for its next revision, intended for 2023.

Six months on from this unprecedented change in marine fuels we are beginning to see the light at the end of the tunnel for the normalised use of VLSFOs. *NA*

CSR software updates support industry for vessel design

A program of continuous updates enables vessel designers to address the latest regulatory requirements, writes Daniel Cronin, VP standards and digital class, ABS Technology

The IACS Common Structural Rules (CSR) continue to stand as a ground-breaking initiative; the first comprehensive rule set developed and maintained by IACS. As a result, the structural design of oil tankers and bulk carriers needs to meet the same standard regardless of the class society, providing commonality for designers, shipyards and owners.

IACS introduced Common Structural Requirements to ensure uniform application and interpretation of the structural rules by all classification societies. They also help owners to be confident that there is no difference between class societies on the basis of steel weight used in vessel construction.

The most recent set of amendments will come into effect in July 2020, including a number of changes focused on satisfying IMO Goal Based Standards comments concerning access, ergonomics, and ventilation. One of the structural changes that the software addresses is related to shear force adjustment to give more reasonable results at the foremost and aftmost cargo hold.

Software solution

Common Structural Rules Software LLC (CSRS) was formed as a joint venture company by ABS and Lloyd's Register (LR) to provide class and regulators with a straightforward and effective way to evaluate vessel designs and apply very complex structural requirements in a consistent and logical manner.

The software includes a prescriptive portion that carries out hull girder calculations, simplified fatigue analysis of stiffeners and local structural checks.

The CSR prescriptive analysis software is aimed at requiring only essential user input of the appropriate data of ship design. The outputs are visually clear, straightforward, and easy to read, intended to give maximum transparency to users. A summary report provides required and offered scantlings with

Daniel Cronin

graphic representation of any deficiencies. An intermediate report summarises governing criteria of each structure and guides the user to the appropriate rule chapters. A report provides data for every parameter value.

There is also a finite element portion that applies cargo and environmental loads to a Finite Element model, determines stresses and verifies these stresses against yielding, buckling and fatigue criteria.

The check method of models and applicable loads are monitored on screen. The outputs are presented by colour contours and tabulated numerical values. A summary report helps to precisely check the results of each structure's items for both designers/shipyards and class surveyors approving the designs.

PA and FEA functionality

In March this year, CSRS released an updated version of the software with new functionality added to both the Prescriptive Analysis (PA) and FE Analysis (FEA) applications.

The CSR PA functionality allows users to directly import NAPA cross-sectional structural data, meaning that users can quickly create new ship models using an existing NAPA model. CSR PA also includes features to model multiple small openings within transverse primary supporting members. The transverse assessment will take into consideration these openings while performing various calculations.

The CSR FEA software function is now capable of carrying out local model analysis; this allows a fine mesh model to be built outside of the global vessel model so that multiple engineers may work on a design simultaneously.

Developed from the technical strengths of LR and ABS, the CSR Prescriptive Analysis and CSR FEA software is now employed by over 600 users with new users added regularly. Further updates will continue to improve functionality and address rule changes.

ABS worked with Lloyd's Register and the CSRS team to ensure the tools it provides continue to evolve and meet the needs of clients, keeping pace with technological developments in the maritime and offshore industries. The latest release offers many improvements over earlier versions.

The partnership continues to improve functionality, integration and modularity of the software to ensure that the industry has the best tools available when applying CSR. The software was subject to cross-checking by IACS and both products demonstrated very high accuracy.

Previous improvements to the software have allowed assessment of whole vessel structures – including new bulk carrier and oil tanker designs – using compliance information for the current CSR, which entered into force in 2015, as well as for the rule changes that came into effect on 1 July 2018.

Reports summarise dominant criteria for each structure as well as data for every parameter value. A new user interface for CSR FE Analysis software enables automatic picking or manual selection to display the stress readout point for Cruciform Flange, Cruciform Web and Bracket Toe hotspots. Results are added to verification results for Fatigue Assessment. *NA*

Innovation in the age of Covid-19

The pandemic has turbocharged digitalisation across the entire industry, says DNV GL, as it launches its maritime specific infection prevention certificate programme

DNV GL's 'Certificate in Infection Prevention for Maritime' (CIP-M) is an adapted certification in cooperation with the classification society's healthcare division. Luca Crisciotti, CEO for DNV GL Business Assurance, defines the CIP-M as: "a kind of tool which is allowing us, through the companies, to monitor infection risks as well as to mitigate measures for treatment onboard if an outbreak occurs." CIP-M will make its world first debut for Genting Cruise Lines' *Explorer Dream*, which the classification society says is one step towards restoring industry and passenger confidence in a sector so adversely affected by Covid-19.

Infection prevention work is not new to DNV GL, Crisciotti points out, as since its beginnings DNV GL Healthcare has accredited 630 hospitals worldwide and has dealings with 3,500 healthcare organisations globally. He says that creating the sector specialised CIP-M was a collaborative effort, in which every protocol issued is heavily customised. "That's extremely important. It's only by combining expertise of the industry with the knowledge of infection prevention that you can deliver a good service to your customers."

Crisciotti comments that creating trust and confidence in the infection prevention response with employees, customers and stakeholders relies upon having its foundations in robust knowledge and experience, which DNV GL Healthcare has been gathering for the past 12 years. "Our approach to organising infection prevention is exactly in the wording 'prevent', when we started this business, we wanted to innovate the way that hospitals are assessed by companies like us. Our methodologies are focused on preventing incidents from happening, rather than mitigating the effect of something that's already happened."

Luca Crisciotti

The CIP-M combines of all of DNV-GL's experience and the technology known within the healthcare with ISO 9001, the international standard that outlines specific requirements for a quality management system, Crisciotti explains. The programme also incorporates national and international requirements, is of hospital grade and integrates the specific standards of the industry.

The certification programme, which has been adapted for the maritime sector, was originally issued last year prior to the Covid-19 outbreak and has since been validated by several authorities. "This is something which is compatible with recommendations that have been issued by the US Centers for Disease control and Prevention (CDC), WHO, OSHA as well as CMS," notes Crisciotti. He adds that not only is the certification specifically adapted for the maritime industry, but its application for each customer is also customised, and as a result, the broad cost of meeting CIP-M requirements is difficult to confirm.

Although the CIP-M is a comprehensive document, its skeleton structure can be summarised into nine main points: quality management, project management, medical staff, case management, staffing management, medical infirmary patient rights, medical record services, physical environment and the infection prevention and control system service delivery. The vessel's operation, management of physical distancing requirements and PPE usage by crew and passengers are all checked through CIP-M, but Crisciotti emphasises this does not cover the CIP-M's extensive contents.

According to DNV GL, the cruise ship industry is a natural starting point as the vessels are, in effect, small towns in their own merit and could have as many as 6,000 individuals living onboard with numerous different types of services offered. However, DNV GL states that there is interest from other passenger segments such as ropax, and it envisages a simplified version of the programme for more general vessel sectors in the future. There is also potential for class societies or flag states through IMO to impose minimum industry requirements for infection prevention, says the classification society, but for now it hopes to inspire other businesses with its CIP-M model.

DNV GL issues an e-certificate every four minutes and customers achieving CIP-M will be supplied with a document that features a QR code and will be uploaded into a blockchain. The decision, Crisciotti notes, came into effect months ago to combat a trend of fake certificates: "We're also a notified body certifying medical devices and have seen an increased amount of fake certificates, where people are scanning documents and using them to sell fake products." Although analogue methods to check authenticity still exists, he insists that blockchain is the best technology to guarantee a true document and provide the certificate with a traceable, digital identity. *NA*

Ammonia: the good, the bad, and the unknown

Class society Bureau Veritas (BV) is working hard on the technology issues for alternative fuels and one of the leading candidates for a decarbonised future fuel is ammonia. BV's Gijsbert de Jong, marine marketing and sales director, provides an insight into ammonia's potential for the shipping industry

Shipping has quickly realised that there is no silver bullet to decarbonisation. Rather, there are various future fuels which could have an important role to play.

One of the most frequently touted future fuels is ammonia which, alongside hydrogen – and from which it may be derived – is an option that could be carbon free, as opposed to carbon neutral options such as biofuels and synthetic methane.

The debate is polarised and lobby groups, service providers, suppliers, NGOs and shipowners are getting behind their preferred choice. Classification societies must assess the pros and cons of any fuel – and we have been doing this with ammonia, to give an understanding of the risks, as well as helping to provide the rules, guidance and support required if ammonia is to emerge as a safe, viable and scalable energy source for ships.

Gijsbert de Jong

Burning issues

Ammonia's toxic and corrosive properties are well known. In addition to its toxicity and corrosive properties, ammonia is a lot harder to use as a fuel. In order to make it burn, it needs to be mixed with other pilot fuels, something which heavy fuel oil doesn't require. For ammonia to be carbon-free, you cannot use a carbon-neutral or a fossil fuel as a pilot fuel. The logical conclusion is that you will therefore have to burn it with hydrogen which, while having similar chemical properties, faces questions surrounding storage.

The by-products of ammonia combustion include N20 which is estimated to be 300 times more harmful as a GHG than carbon dioxide. NOx is also a factor and will need mitigation measures such as selective catalytic reduction (SCR). Additionally, shipping needs to appreciate the potential for ammonia slip from the combustion process, which is harmful to the environment, and find effective measures to prevent this.

Furthermore, given the relatively low energy density of ammonia, it requires more storage space than conventional fuels. Notably, ammonia requires approximately three times more space to contain the same amount of energy that heavy fuel oil offers.

Crucially, while significant amounts of ammonia are produced, it is not the correct type that the shipping sector can use for its decarbonisation process. The common form of ammonia, called black ammonia, is a side-product of the chemical industry and not suitable as a carbon-free fuel for shipping as it leaves a significant CO_2 footprint in the fuel supply chain.

What is required is 'green' ammonia, produced from renewable electricity, at scale. Questions remain regarding its availability and the appropriate infrastructure. There is no doubt that the creation of this will be a considerable challenge and will require substantial investment that should not be overlooked.

A potential solution could be using multi fuelled engines while the infrastructure or fuel availability for ammonia is lacking, enabling the vessel to switch to another fuel. However, we must acknowledge that is not a long-term solution.

Regulatory requirements

Shipping could be excused for thinking that ammonia would require a substantial legal framework to mitigate these issues raised. On the contrary, the IMO's International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (the IGF Code) offers an existing regulatory framework into which ammonia could be incorporated. Additionally, ammonia

has been transported by sea and land for many years, so codes related to its safe carriage are already available.

But specific attention is required if ammonia is going to be become a viable marine fuel. It is these areas where HAZID workshops, such as that hosted by BV earlier this year, bringing together stakeholders from across the shipping and marine fuel supply chain can identify these areas where existing guidance may be lacking.

While internal combustion engines work well with ammonia, the prospect of using ammonia within fuel cell technology could further entice shipowners and financiers to back the fuel. Ammonia, when incorporated into a fuel cell, can offer higher efficiency and a lower emission profile compared to a combustion engine.

In particular, the solid oxide fuel cell will be a boon for ammonia. Planned trials on the *MSC Europa* are expected to produce interesting results with the 50kW Solid Oxide Fuel Cell theoretically offering 60% electrical efficiency with no NOx emissions, and it is compatible with ammonia. However, the fuel cell is in its early stages of research and development with its life expectancy remaining a significant variable.

Not for retrofit

Due to the research and development timetable for ammonia, it is unlikely that it will be a suitable retrofit option for existing oil fuelled vessels, given the likely costs. In particular, making the case for the retrofitting and securing the finance required for older ships will prove difficult.

However, there's potential for liquified petroleum gas (LPG) carriers to be a viable pathway for ammonia fuelled shipping. The engines and the containment system used by LPG are similar to ammonia. Shipowners who are considering vessels for LPG today could run on ammonia in the future with limited adjustments and thus cost, as long they are designed for future use of ammonia.

There is no easy answer to the shipping decarbonisation challenge. Clearly shipping needs a fuel – or multiple fuels – with the potential to help the sector reach the IMO's 2050 goal. What is apparent is that ammonia is one of the very few options that is carbon-free and viable as a marine fuel.

As highlighted above, it faces significant hurdles prior to being deployed, ranging from its toxicity to the relative infancy of its technology. Nevertheless, shipping must not be daunted by ammonia's hurdles but instead should seek to address the obstacles that will enable it to join shipping's future fuel mix. If shipping can harness the benefits of using ammonia as a marine fuel, while addressing relevant technical and safety challenges, it could become an effective fuel pathway for shipping to successfully decarbonise. *NA*

It's time for a change of mindset on cyber risk compliance

Unprecedented change, with shifts in physical events, technology and policy, is acting on shipping and ports in almost equal measure, says Tore Morten Olsen, president for maritime at Marlink

The enduring change is that digitalisation and decarbonisation will impact the industry's future; the pace of these effects will increase in velocity over time as barriers to entry fall and demands for performance improvements increase.

Regulatory agenda is another driver of this platform for change. Regulation is about to become much more important for all owners deploying any kind of IT or digital systems. It will demand a far higher level of compliance and disclosure, whether vessels have a basic network or complex ship-wide systems.

Just as all shipowners that want to maintain their competitive position and improve efficiency will need a plan for digitalisation and sustainability, they will require one for cyber compliance too.

Research conducted for Marlink found that large parts of the maritime industry consider themselves 'digital-ready'. However, only 30% of them believe they were well-advanced in progress with their digital transformation strategies. In other industry sectors where digitalisation is taking place, the figure is closer to 60%.

Cyber security continues to be an issue of concern within the industry, despite progress in raising risk awareness from the chief executive to the chief mate. It was not long ago that IT departments were lobbying for the resources to build a cyber secure business infrastructure based on expected threat rather than experience.

A series of cyber attacks changed all that, not least that the world's largest shipping company could have its operations all but halted as collateral damage to a cyber attack aimed elsewhere.

The IMO has adopted cyber security related amendments to the International Safety Management Code (ISM Code) while the tanker sector has already made similar requirements part of Tanker Management Safety Assessment (TMSA) version three.

Tore Morten Olsen

While the first represents mandatory regulation, the second is a 'licence to operate' for owners carrying hazardous cargoes. The ISM Code will require demonstration that action has been taken to address cyber security, whereas TMSA will require shipowners to show that they have the latest available IT operating system and other software updates as well as specific security patches either as part of a Port State Control inspection or in pre-qualifying a vessel to carry cargo.

The industry's largest, long-term players are likely to already meet these requirements but for an operator with limited IT outfit, they present an unwelcome burden. For one with a sophisticated network encompassing IT and OT, it presents an additional series of tasks for crew unless it can be managed with a minimum of additional administration.

Compliance with voluntary cyber security guidelines until now have tended to succeed or fail on the basis of the human element, relying on an intention to do the right thing. It is precisely this lack of transparency over how the tasks are performed and updates recorded that the regulation seeks to change.

Marlink estimates that at least 50% of software updates are still performed by the collection of physical media such as a CD for manual update with the balance performed 'over the air' and automatically applied.

Companies should implement risk control processes, measures and contingency planning. In particular they should develop and implement activities necessary to detect a cyber event as well as plans to provide resilience and restore systems necessary for shipping operations or services impaired due to a cyber event.

At Marlink we think that the answer is not to burden mariners further but instead consider how to detect risks and be prepared for them. Threat intrusion and detection is one of the key functional requirements of the IMO's Cyber Security Guidelines so Marlink's Cyber Detection service identifies incidents designed to stay under the radar and alerts owners to breaches of IT policy.

Our IT Link service enables shipping companies to develop, test and deploy IT solutions fleetwide. This framework can extend from operating system patches or upgrades to applications and complete enterprise resource planning systems. This enables owners to transfer tasks away from crew towards specialists onshore who can develop and implement the programs they need, test them for robustness and share them across a fleet with a single click.

Regardless of short-term disruptions, the course ahead for the shipping industry is set. In the medium term, as owners engage with more complex IT network requirements, they will be able to enjoy expanded access to cloud-based applications and storage, increasing asset connectivity and bringing 'virtual' systems and applications onboard. *NA*

Standalone navigation alternatives are vital to ship safety

With modern reliance on satellite and electronic technology, system failure can lead vessels into danger, Mark Jones of ScanjetPSM discusses the importance of contingency planning

Ancient mariners were experts in positioning using the stars and reading the weather, applying their skills alone over long and challenging journeys. The development of the sextant in the 18th century, an instrument developed to measure angles, would assist ships' navigators over hundreds of years, with a design that has remained remarkably unchanged to this day. With the advent of GPS and ECDIS, the sextant has steadily slipped out of everyday use, accompanied by a decline in the practice of celestial navigation.

Although highly effective, GPS systems are subject to failure, just like any other equipment with well-documented examples of the potential outcomes. No matter how sophisticated the technology, malfunction or even total breakdown must always be a possibility. Unintentional signal jamming leading to loss of signal has occurred in the past. More recently, cybersecurity threats have also increased in the form of system hackers and computer viruses.

While loss of navigation at sea can leave vessels stranded, GPS malfunctions can be equally disastrous in port, with the inability to accurately check or verify positioning data leading to collisions and grounding with the danger of cargo spillages. For offshore drill ships reliant on dynamic positioning, loss of GPS navigation could lead to pipe disconnections or fractures, again with the risk of environmental contamination and loss of valuable cargo.

Growing recognition of the need for backup has led to the reintroduction of celestial navigation as part of crew training procedures by individual navies including the USA.

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), now ratified by 164 nations accounting for over 99% of world shipping tonnage, also calls for at least one sextant as part of navigational equipment. This must be maintained in line with manufacturer requirements and safely stowed when not in use. The STCW also requires that selected bridge team members be proficient in the use of celestial navigation to determine position and compass errors, with observations recorded in an appropriate format.

There remains a cultural barrier to overcome within the industry, with a reluctance to waste money on equipment and in-depth training as a contingency which is perceived as unlikely to be needed. In the event of a failure however, crews may be left with working with unfamiliar mechanical instruments, to gather the necessary data to feed into the ship's ECDIS.

Sextant positioning can be complicated and time-consuming using traditional equipment and needs extensive familiarity with celestial charts, good time keeping and manual plotting using maps. Simplicity has been a key driver behind the first ever digital sextant.

The new sextant has been developed as replacement for traditional manual sextants, using the latest computerised technology to eliminate the need for complex calculations and additional equipment.

The digital sextant enables accurate identification of position with longitude and latitude readings providing and recording the location within seconds. Once the readings have been made, the display immediately shows the position. If the vessel is moving, the heading and speed can be entered. No manual calculations are needed with the attendant risk of errors removed. Powerful algorithms offer automatic position analysis and global position calculation with easy self-zeroing calibration. The embedded design incorporates a built-in chronometer, with access to the astronomical details of 67 celestial bodies (the sun, moon, etc).

Scanjet's new digital sextant is designed to provide accurate and near instantaneous vessel positioning information

Requiring no specialist training, the digital sextant displays accurate positioning data within one second following sighting, compared to the more usual 20-30 minutes.

Digital technology offers significantly improved accuracy at distances less than one kilometre, with traditional sextants by comparison typically delivering accuracy from 18.5km outwards. Error measurements in altitude have been halved from 250mm/10 inches to just 125mm/5 inches.

Crucially, whilst it is electronic, the digital sextant is stand-alone and not reliant on any other external sources or systems, therefore providing guaranteed navigation in the event of a failure or disruption to the ship's standard GPS navigation systems. Between uses, the digital sextant, which is CE and FCC certified, can be stored for protection in an optional robust case that provides complete EMP shielding.

Ongoing evolution in ship systems is as inevitable as it is vital. Ensuring effective backup is readily available and easy to adopt is essential in gaining industry buy-in to contingency planning to ensure safety at sea. *NA*

Maritime Research and Innovation UK

An industry-government partnership aims to establish a UK maritime network and help realise the sector's 2050 targets, writes Richard Westgarth

As an island nation with a long seafaring tradition, the UK has an enviable heritage in technology and innovation in the Maritime Sector. It's a sector that continues to grow and is now looking for potential benefits from the adoption of Fourth Industrial Revolution technologies. This is accelerating as we begin to look to recover from and increase our long-term resilience to, the Covid-19 pandemic.

In order for the UK to capitalise on these developments, it has been recognised by both industrial and academic communities that a more collaborative approach was required for research and innovation in the sector. A core group of UK companies and universities have been working to generate national scale funding.

Alongside this, in 2019 the UK Government Department for Transport published its first long-term strategy for UK maritime sector in a generation: 'Maritime 2050: Navigating the Future'. It sets out the UK ambition to be world-leading on safety, technology, skilled people, and the environment. The strategy contains a wealth of recommendations and provides the UK with a real opportunity to regain a position as a leading innovator in maritime science and technology.

The publication of the strategy has encouraged Industry and Government to jointly fund the establishment of a research and innovation hub, Maritime Research and Innovation UK (MarRI-UK). This initiative addresses these recommendations and provides a focus for Research and Innovation in the sector bridging academia, industry, and government.

The aim of MarRI-UK is to establish a network of regional, industrial and academic communities to overcome the challenge of fragmented and incoherent research and innovation in the UK. This recognises that other industrial sectors have created centres or hubs to coordinate research that attract significant levels of industry and Government funding.

MarRI-UK is an open consortium, formally established in July 2019, aimed at attracting Government investment into the maritime sector for innovation by demonstrating industry/academic willingness to cooperate and co-invest. The founding members are BAE Systems, BMT, Babcock International, Lloyd's Register, QinetiQ and Shell, together with the universities of Newcastle, Southampton, Strathclyde & UCL, and the Society of Maritime Industries.

Its focus is on mid-Technology Readiness Level (TRL) Innovations that address the 'valley of death' between 'discovery and research' and 'commercialisation' with a focus on technology and systems. It will provide coordination across the diverse UK Maritime industry. Providing an opportunity for much needed collaboration and synergy nationwide to meet challenges and opportunities in the maritime sector.

MarRI-UK will be a hybrid physical and virtual working structure, encompassing a range of centres to be announced across the UK and which already exist, with a small core team based at the University of Strathclyde. It is developing a shared research and innovation programme driven by industry needs.

MarRI-UK is now open for membership to all UK companies irrespective of size. We aim to make MarRI-UK a large enough critical mass and regional spread that it persuades Government to pay attention and prioritise resource for the maritime sector to achieve the 2050 vision. We believe this is more likely to happen if we cooperate across the UK.

Three tier levels for industry membership is available to suit a wide variety of companies. By joining MarRI-UK, members can propose research and innovation agenda items and projects. The objectives and planning of MarRI-UK activities is based on company needs and will direct the development of maritime research and innovation planning. This will be a significant opportunity for members to engage in multidisciplinary research to achieve practical, effective solutions for members' technological challenge through strong integration between industry, representative organisations, and academia.

With funding from the Department for Transport, MarRI-UK have already administered two research and innovation calls within mid TRL (TRL 3-7) aligned to the Maritime 2050 Strategy:

Clean Maritime Call

£1.5M funding was available to finance technology, process innovations or services that offer significant improvements to systems, timings, processes or technology for clean maritime services and operations, and align with Maritime 2050 Zero Emission sub-theme and/or the Clean Maritime Plan. Following the competition, funding to a total value of £1.4M was awarded to 10 projects. For full details visit: www.marri-uk.org/funding-opportunities/clean-maritime-call/clean-maritime-call-winners

Technology and Innovation in UK Maritime Call

£1.5M funding was available to fund innovative maritime technologies that demonstrate potential applications for innovative technology or for proof of concept of new ideas that offer benefits to maritime services and operations. This call has now been closed and successful projects will be announced shortly.

To find out more about MarRI-UK and how to get involved, please visit www.marri-uk.org or contact info@marri-uk.org

About the author

Richard Westgarth, BEng, CEng, FIET, FRINA, has been active in developing the MarRI-UK initiative for a number of years. He has over 40 years of experience in the defence and maritime sectors as an innovation strategist and business adviser. He is currently Head of Campaigns at BMT. *NA*

What does it mean to be a retrofit ship of the future?

Green Ship of the Future's 'The Retrofit Project' promotes a potential 21.7% fuel saving by utilising energy optimisation-based retrofits

While Green Ship of the Future's (GSF) vision for the industry's future includes all aspects of working towards emissions free maritime transport, its aptly named 'The Retrofit Project' investigates the potential benefits of investing in existing technologies. Frederik Schur Riis, Head of GSF, explains: "Our climate cannot wait for technologies to scale and for the entire global fleet to transition to these neutral means of propulsion. For years to come, the largest driver of positive impact on the climate agenda will come from minimising the consumption of GHG emitting fuel. Energy optimisation, as studied in our Retrofit Projects, is vital for our vision of a greener shipping industry"

Based in Denmark, GSF is financed by its 51 members, 20 of which were involved in the retrofit project and three of whom feature their vessels as the project's case studies. First, *Maersk Tianjin*, a medium range (MR) oil/chemical tanker built in 2016 in South Korea. Second, *Hafnia Lise*, another 2016-built MR oil/chemical tanker, and finally DFDS' *Victoria Seaways*, a ro-pax vessel built in Italy back in 2009.

Schur Riis comments that originally the project was much smaller and focused on Hafnia's MR tanker alone, but after interest from the industry and GSF members this was expanded to include a further two shipowners. Although the case study partners were selected by GSF, he notes that the individual vessels used were chosen by the shipowners themselves, based on each company's strategic considerations such as fleet composition. For each vessel studied in the retrofit report, which began in January 2019 and ended April 2020, the respective shipowner applied a customised selection of energy optimising retrofits ranging from BWTS and hull antifouling products to LED lighting and propulsion upgrades.

A fuel consumption improvement of 27.1% could be achieved on the *Hafnia Lise* according to the report

While the case studies cannot be directly compared, four common areas of significant optimisation potential were identified. Lack of available data (particularly the absence of steam consumption data), wasted energy consumption due to excessive electricity production and inefficient lighting, benefits of products such as lube oil cleaning and anti-fouling overlooked due to their expense, and finally the application of digital solutions, specifically machine learning and AI.

Results and applicability

For Hafnia, the project's overall findings are doubly beneficial. "One is the retrofit side in order to be in compliance with regulation coming up to 2030 and thereby also not using more bunker than needed, but equally important is that findings are in cooperation on the newbuilding side when making specification and contracts going forward," explains Jørgen Thuesen, Hafnia's OS fleet, newbuildings and projects technical vice president.

More specifically, the data generated is of particular interest, he explains: "We are already working on different topics from the findings in the report. One of the learnings from the project is that data is needed for the operation pattern and load profile for different equipment onboard of the vessel, not big data, but defined data."

Aside from the report's general findings, GSF's project manager highlights that a lack of cooperation between the purchasing and operation/maintenance departments was an area of interest observed, as focus is often placed on the individual newbuilding's price and less so on future operational costs. While Thuesen points out that closer cooperation between departments is beneficial, it's not a clear-cut issue. "We at Hafnia, as well as other owners, work to achieve the best balance between purchase price, specification, makers, commercial requirement, maintenance and opex cost, as well as future requirements, etc on all projects, so this is rather complex and not

Victoria Seaways' retrofit case study finds that the vessel's CO_2 emissions could be reduced by 7,350tonnes annually

black and white," he states.

Thuesen notes that the role of retrofitting in Hafnia's decarbonisation strategy has not significantly changed as a result of the report, it instead acts as a support moving forwards to best meet upcoming industry targets. He adds: "It is always difficult to look into the future but we will expect that in a year or two we will see the first take-off on existing vessels that gradually will improve in bunker consumption and lower the environmental footprint towards 2030, which will be the first major milestone."

Energy optimisation data

Optimisation data calculated for each retrofit technology is accumulated into overall potential fuel and emission saving figures for each case study. Although the lowest fuel saving potential of 11.1% is recorded on DFDS' *Victoria Seaways*, its CO_2 reduction was the largest with an equivalent of 7,350tonnes per annum saved each year compared to Hafnia's 5,208tonnes and Maersk's 2,425tonnes.

This lower figure is largely due to *Victoria Seaways'* operating route between Kiel and Klaipeda, and therefore the vessel's longer operational hours per year compared to the two MR tankers, comments Schur Riis. He explains: "In short, it [*Victoria Seaways*] has a lot more hours and miles sailing per year than the tankers, and it's likely to also sail at higher speed [burning more fuel per mile] than the tankers as its revenue is based on how many cars and passengers is can bring back and forward between the destinations in a given period."

The highest potential fuel saving while upholding the three-year ROI was 27.1% on the *Hafnia Lise*, but this figure is dependent on the inclusion of route optimisation. Without it, its fuel savings drops by almost a third to 17.5%. Whether this 27.1% is possible in reality, Schur Riis cannot confirm, but hopes that the report's findings could be utilised by ship operators and shipowners managing long-term charters to debate energy optimisation in future contracts, regardless of who owns, charters and operates the ship.

"By putting the numbers out there, it is easier for companies' operating on a charter to talk to their individual charters, as they have something concrete as a focal point of discussion. Personally, I believe that many charters will do what they can, within their control, to allow for measures like this, as they are just as aware of our climate issues as we are and they are likely seeking measures to reduce their own negative impact on it," he explains.

Although the project claims that whether charterers could and should use route optimisation as a daily planning tool is open for discussion, Hafnia's case study states that the vessel is subject to limitations of operating in a pool as well as its charterers restrictive instructions, and Thuesen admits that route optimisation is a roadblock for efficiency, as the nature of *Hafnia Lise*'s operations will remain unpredictable. He adds: "Route optimisation is an issue for potential time and bunker savings, and thereby the environmental footprint. However, it is difficult to define the actual savings as we cannot predict what voyage a tanker like *Hafnia Lise* will do here and now, or in the future."

Investments and savings

The report's findings were analysed on their potential to deliver a full ROI within three years, which Schur Riis says is the timeframe that suppliers are often faced with when talking to shipowners and likewise that shipowners' technical departments are often confined to.

However, he points out that: "The ROI needed is dependent on the individual shipowner, their liquidity and access to capital and strategic considerations. Though, objectively speaking, anything with an expected payback that is shorter than the expected remaining life of a vessel, including a buffer to account changes in fuel price, would make sense."

Significant additional potential savings are possible without the three year ROI

requirement, and Schur Riis hopes that the report will encourage shipowners to look at cases individually rather than locking in on a specific ROI, an approach he believes to be flawed due to the volatile nature of fuel prices. He adds: "A calculation today will look different tomorrow. We have especially seen this in connection to the 2020 global sulphur cap requirements and the large decrease in prices because of Covid-19."

Sample fuel prices used in the report to calculate optimisation figures were all taken from 2018 but differed as they reflected each company's independent records specific to their own vessel operations. While Schur Riis admits the volatile nature of fuel prices could deter shipowners from pursuing retrofits, he argues that the regulatory and environmental benefits outweigh this.

"A lot of companies are experiencing liquidity issues, which limits their ability to invest and the business case of energy optimisation has become worse due to the large decline in fuel prices, but the climate issue has not changed and regulation looks to only be speeding up the coming years. Retrofits that might drive costs up today are likely to be a license to operate in the near future as more regulation is put in place."

The case for retrofitting

Breaking even on retrofitting investments on a vessel within three years may be uncertain, but Schur Riis insists that the long-term benefits of the retrofit project's findings will weigh heavily in the future. "Retrofitting is a great way of minimising our impact on the climate in a financially sustainable manner and something that down the road will likely lead to large competitive advantages as all of the neutral means of propulsion are forecasted to be more expensive than today."

Even after a GHG neutral fuel is implemented, energy optimisation remains vital, the project claims, and Schur Riis adds that the report's applicability in shipping's greener future, where vessels could be running on alternative, future fuels, depends on the technology and solutions at hand. He concludes: "It is difficult speculate on how vessels will be designed in the future, but many of these suggested changes are very time resistant. While there will likely come more updates to the technology suggested in the report, from where we are now there is no reason to believe any of the solutions will become complacent in the near future unless something radical happens to the way we design vessels." *NA*

For more information, visit:
greenship.org/project.2019-retrofit-series

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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 16-20, 2020
IMO Maritime Safety Committee (MSC)
International forum,
IMO Headquarters,
London, UK
www.imo.org/en/MediaCentre

November 30-December 2, 2020
Postgraduate Research in the field of Maritime Technology
International conference,
Kuala Lumpur,
Malaysia
www.icep.com.my/ipmc

December 2-3, 2020
Historic Ships
RINA conference,
London,
UK
www.rina.org.uk/events_programme

December 7-11, 2020
IMO Council
International forum,
IMO Headquarters,
London,
UK
www.imo.org/en/MediaCentre

2021

February 2-5, 2021
SMM
International exhibition,
Hamburg,
Germany
www.smm-hamburg.com/en/
Rescheduled date

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cav2021.org

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