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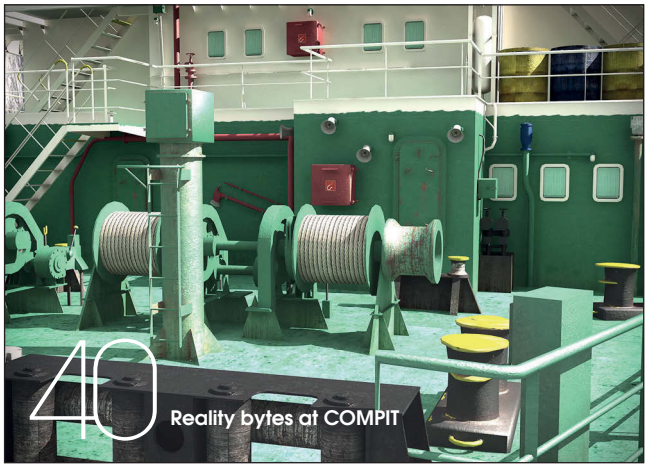

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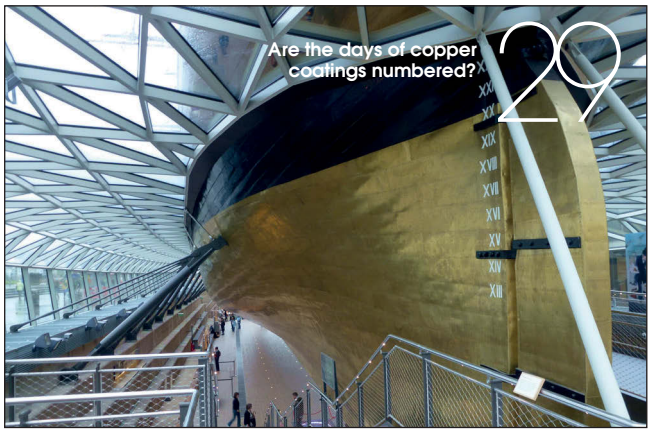

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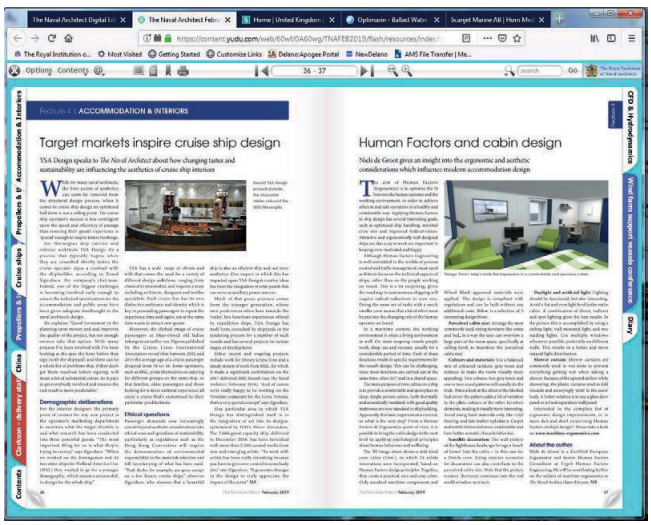

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South Korean mega merger may come at a heavy cost

HHI's acquisition of DSME would create a leviathan among shipyards

When it was announced in March that Hyundai Heavy Industries (HHI) had signed a deal for the formal acquisition of fellow South Korean yard Daewoo Shipbuilding & Marine Engineering (DSME) from its majority shareholder Korea Development Bank (KDB), there was good reason to think that it would incur the wrath of antitrust authorities both at home and abroad. After all, the KRW2.16 trillion (US$1.94 billion) deal would place more than a fifth of the global orderbook in the hands of a single entity – an unprecedented figure in the modern era.

However, there's been hitherto a muted response from rival shipbuilding nations. China, South Korea's only true rival in terms of the title of the world's largest builder of ships, has made no official statement. While Japan, which last year took its grievances to the World Trade Organisation concerning the unfairness of Seoul's subsidies for its shipbuilders (in particular DSME), has so far held its tongue. In all likelihood both countries, as well as some European nations, are scrutinising the implications with a view to making formal objections via he recognised channels later in the year.

One might cynically suggest they would be better off letting the merger go ahead. History tells us that mega mergers in other industries are seldom a resounding success; companies often prove to have misaligned philosophies and working practices, and what works well for one may be like fitting a square peg into a round hole for the other.

Ever since the Asian financial crisis of 1997-98, DSME has been under KDB's majority control and therefore effectively state owned. This has fostered a more conciliatory, technocratic style of management and experts say that its shipbuilding facilities on the southern island of Geoje are the most organised and best designed in the country.

Admittedly, one could point out that the same culture might have contributed its history of financial mismanagement, and indeed a high-profile fraud case in 2017 that led to the jailing of its CEO. However, KDB is known to have passed on previous attempts to acquire the yard by the likes of POSCO until such as a time as it could achieve the best possible deal.

By contrast, management at HHI is a little more bellicose. As a privately held company it's been more accustomed to making hard, commercial decisions, such as the closure of its Gunsan yard in 2017, and mothballing its offshore facilities in Ulsan the following year (DSME, on the other hand, has kept its offshore division active, despite the sector's prolonged depression). In other words, the two companies may make for awkward bedfellows.

South Korean shipbuilding's particular specialism has long been gas carriers and both yards have exceptionally healthy orderbooks; as of the end of April DSME had contracts for 37 LNG carriers, while HHI has 36 (fellow 'Big Three' yard Samsung also has about 30 carriers on order). Given the typical two-and-a-half year turnaround period for construction these orders will keep them occupied until around 2022-23.

All of which could be said to vindicate the South Korean government's subsidisation strategy and ensure they stay well ahead of China's comparatively fledgling LNG shipbuilding ambitions. On the other hand, in the context of Korean shipbuilding it could be argued this is all so much low-hanging fruit.

The question is at what price? In April, DSME's new president, Lee Sung-keun, appeared to warn against overconfidence when he emphasised the need to secure yet more orders and be prepared for sudden changes in the business environment. Reading between the lines it carries the suggestion DSME's capabilities are close to breaking point and the HHI acquisition will only partially alleviate that pressure.

In a story published by Reuters last year, it was estimated that Korean yards could build an LNG carrier for as little as US$175 million, whereas an equivalent vessel might cost a Japanese yard in excess US$200 million. Some of that derives from Korea's greater experience and superior production processes, but there is also a long-established practice of enforcing pay cuts and wage freezes on workers to drive down costs.

Last month, workers at both DSME and HHI made their feelings about the merger clear, with an escalating series of protests in which they were joined by workers from Hyundai Motors. Union leaders warn that HHI, which is proposing to split its business into separate holdings and business firms after the merger, will almost double its debts and that job losses are inevitable.

A comparative monopoly over LNG carrier construction may give the South Koreans some leverage over prices but that will count for little if these disputes aren't resolved quickly and lead to delays or even cancellations. Whether approved or not, the merger, like South Korean shipbuilding's resurgence, could yet prove to be pyrrhic victories. *NA*

Fuels

Babcock to fit first LPG newbuild with cargo handling system

Babcock's LEG business has been awarded a contract for the LPG cargo handling and Fuel Gas Supply System (FGSS) for the world's first newbuilding vessel to use LPG as a primary fuel source.

Expected for delivery in January 2021, the 86,000m^3 carrier – one of a series of two – is being constructed by Shanghai's Jiangnan Shipyard for Exmar.

For this design, LPG will be stored in a deck tank and Babcock's FGSS will integrate the cargo handling system for transfer between the two systems during voyages. The company worked with MAN Energy Solutions, the vessel's engine supplier, to ensure the correct LPG fuel delivery conditions for the FGSS to the main engine.

The vessel's cargo handling system will also be equipped with Babcock's Vent Gas Cooler technology, which is currently in operating on 80 LPG carriers. The company states the technology is capable of increasing cargo handling capacity and improving efficiency at lower operating costs.

In addition to this newbuilding order, Babcock is to conduct a Front End Engineering Design (FEED) study into an LPG fuel system upgrades as a retrofit on Very Large Gas Carriers.

Ro-ro's

First LNG mega ro-ro vessel design unveiled

Danish naval architects Knud E Hansen have revealed their design concept for the first generation of LNG-powered ultra-large ro-ro vessels for the newly-established shipping company Wallenius-SOL.

The 27,000dwt, 1A Super ice-classed vessels will have a length of around 242m – making them largest in the class – with a capacity of 5,800 lane meters and be capable of reaching speeds of 20knots. According to Kund E Hansen, they will also be the first mega ro-ro vessels in the world to run on LNG.

Knud E Hansen's design for the first LNG-powered mega roro

Four vessels have been ordered from Yantai CIMA Raffles Offshore Ltd., China, which will be the first ships the Swedish-based company – launched by Wallenius and Swedish Orient Line (SOL) in April – will operate.

Knud E Hansen will provide the engineering package for the construction and approval by classification and flag state authorities.

This latest design is the fourth series of ultra-large ro-ro vessels developed by the consultancy since 2016, resulting in more than 20 of these vessels being built in the coming years.

The concept indicates that during port calls the vessels will run on green electricity from shore connections or LNG.

Once delivered, the ships will transport forestry products and other goods across shipping routes in the Gulf of Bothnia, the Baltic Sea and the North Sea.

Emission reduction

IMO and Norway unite on new environmental project

The IMO and the Government of Norway have embarked upon a new international project to reduce greenhouse gas (GHG) emissions from shipping.

The project, named GreenVoyage-2050, will promote global efforts to demonstrate and test technical solutions for reducing emission.

Launched on 13 May, the first day of the IMO's 74th session of MEPC, it aims to support the initial goal of cutting shipping GHG emissions by at least 50% by 2050 compared to 2008.

IMO secretary general, Kitack Lim, said the project was a direct response to the need to support technology transfer and promote green technology uptake aimed at reducing GHG emissions throughout the maritime industry.

Set to run for an initial two years, the project involves the participation of more than 50 countries in 14 sub-regions worldwide. It will also help build capacity in developing countries to ensure they are able to meet their climate change commitments and energy-efficiency goals for global shipping.

To start, eight countries from five high-priority regions (Asia, Africa, Caribbean, Latin America and Pacific) will take on pilot roles to pursue and undertake actions at the national level.

The Government of Norway offered US$1.1m for GreenVoyage-2050 and intends to continue funding the project beyond two years, subject to government approval, to achieve the overall goals.

Eventually, GreenVoyage-2050 will be scaled up to demonstrate more technological developments, accelerate the implementation of the initial IMO GHG strategy and expanded across more countries.

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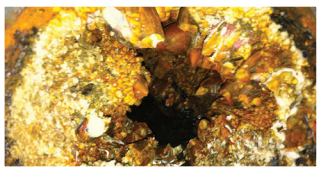


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Partnerships with the private sector and existing programmes, such as Norway's Green Shipping Program, will also be explored.

Ship recycling

Verifavia and KR secure 100-vessel IHM certification

Zeaborn Ship Management has contracted Verifavia Shipping and the Korean Register (KR) to perform Inventory of Hazardous Materials (IHM) preparation and certification for over 100 vessels.

The vessels under control of the German ship management company – a consolidation of E.R. Schiffahrt and Rickmers Shipmanagement – are required to be IHM compliant to meet the terms of both EU Ship Recycling Regulation (EU SRR) and the Hong Kong (HK) Convention.

The EU SRR bans or limits the installation and use of hazardous materials onboard ships and states that ships must carry a certified IHM listing the quantities and location of those materials. The Convention, meanwhile, aims to reduce the negative impact of ship recycling on human health and safety, and on the environment.

KR has granted Verifavia approval to act as a service supplier for IHM, meaning Verifavia can conduct IHM investigations for vessels independently and KR will verify and certify their results.

According to Verifavia, its IHM process includes document collection, onboard sampling checks, and laboratory analysis. Additionally, it contains report preparation that is shared with the class society for final cross-checking and certification.

Green fuels

Vessels selected for methanol study

The consortium Green Maritime Methanol has selected nine ships for research on the use of methanol as marine fuel.

The chosen vessels vary in length between 40-160m, with tonnage ranging from 300-23,000dwt and in installed power from 1-12MW. The individual operating profile of each ship will provide the group with insights on the feasibility of methanol for certain ship types, their sailing route and cruising speed.

The study will first work out the cost of implementation and use of methanol fuel systems for the various ships. Additionally, it will determine the most attractive technical, operational and economical configurations. Green Maritime Methanol stated that the results of the project will later be compared with low sulphur marine diesel.

During this phase of the study, cargo vessels, ferries, dredgers and coastal water support vessels will be evaluated. The ships, consisting of new designs, newbuildings and existing vessels, were selected from companies including Boskalis, Van Oord, the Royal Netherlands Navy and Wagenborg Shipping.

The Green Maritime Methanol consortium launched earlier this year

The project, which aims to further develop methanol as a transport fuel for the maritime sector, is supported by TKI Maritime and the Dutch Ministry of Economic Affairs and Climate Policy, and runs until December 2020. Its partners include: LR, Port of Amsterdam, Wärtsilä, Damen, and Royal Netherlands Shipowners' Association among many other stakeholders.

Class society

LR awarded RO status in Italy

Lloyd's Register (LR) has achieved Recognised Organisation (RO) status by the Italian flag Administration, meaning it is now authorised to issue statutory certification on its behalf to all seagoing ships sailing with the Italian flag.

The British-based class society will soon establish an Italian branch of the LR Group so that it will be able to support Italy's shipowners.

With its RO status, LR will be in a stronger position to work with the wider Italian shipping community.

Theodosis Stamatellos, South Europe marine and offshore manager at LR commented: "This is a significant milestone in LR's history of classification. Our new RO status demonstrates our wide range of classification, consultancy and technical services to owners who have Italian-flagged ships. LR is now in a stronger position to support existing and potential Italian-flagged shipowner clients." *NA*

Survey for naval architects

Faststream Recruitment is conducting a Salary Survey and Employment Review in Naval Architecture and would like you to contribute. For further information visit: www.surveymonkey.com/r/NASURVEY2019 The survey should take no longer than five minutes to complete. We will be publishing the results in September's edition of *The Naval Architect*.

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The Maritime Innovation Award seeks to encourage such innovation by recognising outstanding scientific or technological research in the areas of hydrodynamics, propulsion, structures and material which has the potential to make a significant improvement in the design, construction and operation of marine vessels and structures

The Award is made annually to either an individual or an organisation, in any country. Nominations for the Award may be made by any member of the global maritime community, and are judged by a panel of members of the Institution and QinetiQ. The award will be announced at the Institution's Annual Dinner.

Nominations are now invited for the 2019 Maritime Innovation Award. Individuals may not nominate themselves, although employees may nominate their company or organisation.

QINETIQ

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Nominations should arrive at RINA Headquarters by 31st December 2019.

Queries about the award should be forwarded to the Chief Executive at
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Tackling 2020 issues and more

Slow steaming for carbon reduction, fast-tracking EEDI and, inevitably, the sulphur cap informed the agenda at MEPC 74, writes Malcolm Latarche

With the introduction of the 0.5% global sulphur cap on fuels a little more than seven months away, the IMO's MEPC 74 meeting could have been devoted to that issue alone but there was much more on a packed agenda that delegates had to contend with.

In the run up to the meeting, there were the usual announcements from shipping bodies and environmental lobby groups over numerous issues. But this year, there seemed to be some agreement over future direction, notably in the area of slow steaming. However, it is fair to say that the motive behind the calls were quite different.

Environmental groups see slow steaming as a way to rapidly reduce the carbon emissions from shipping but for those from the shipping industry who are advocating for it, the driving factor appears to be competitiveness after 2020. Ships with scrubbers can continue to burn cheap HFO and run at higher speeds while those without are forced to burn more expensive fuels and maintain a lower speed. During the event, MEPC rejected any immediate action but did pass the matter over to a working group to consider along with other emission reducing ideas.

There was much more discussion over what should be done about ships needing to take non-compliant fuels in the event of no permitted fuels being available after 1 March 2020, when the ban on carrying non-compliant fuel comes into effect. It seems that too little thought has been given to the practicalities involved.

Ships will be allowed to load non-compliant fuel if nothing else is available but what are they supposed to do with any surplus once they reach the next port? Very often the next port is not known until a day or two before arrival; ships need a safety margin in case of bad weather or other problems, compliant fuel at an intermediate port that can be reached only by a deviation may be available one day but not the next.

The question of what to do with surplus non-compliant fuel has not been resolved. Debunkering is one option but that is not a usual practice and there may not be facilities available in any case. Should the vessel be permitted to use the fuel? If not, how long can it be stored onboard, where its very presence might make taking compliant fuel impossible because of the fuel contaminating tanks.

IMO will be issuing a circular giving guideline for port state control but PSC regulation is outside the remit of the IMO and the MEPC, so shipowners may be faced with a plethora of different rules and potential penalties for a situation ultimately beyond its control.

Not surprisingly, scrubber washwater was once more under discussion after having been a major talking point at sixth meeting of the Pollution, Prevention and Response subcommittee (PPR 6) earlier in the year. Whether scrubber washwater is a pollutant or not is at the heart of the debate, although many thought it was settled even before the IMO allowed scrubbers as a means of reducing SOx emissions several years ago.

At MEPC 74, the environmental impact of washwater discharges from open-loop scrubbers was referred back to PPR, which was tasked with evaluating and possibly harmonising the rules and guidance on the discharge of washwater from scrubbers. However, this is not likely to deter many owners who are keen on installing scrubbers as the results of any deliberations are not expected to materialise until 2022, at the earliest.

Another agenda item, that has been on the cards for some time, was bringing forward the next phase of EEDI reductions for some ship types. Phase 3 of the EEDI rules were scheduled to come into effect in 2025 and would have required a reduction of 30% over the initial baseline figure.

It is now proposed that the next reduction for gas carriers, containerships, general cargo vessels, LNG carriers and cruise ships should be brought forward to 2022. Furthermore, containerships will be subject to much higher reduction rates than was previously the case.

The issue of the EEDI changes is now with a working group and are planned to be adopted at MEPC 75 in April 2020. As things stand the changes will affect gas carriers above 15,000dwt, general cargo ships above 3,000dwt, LNG carriers above 10,000dwt and cruise ships above 25,000gt.

For containerships, the new date will be 2022 and although the original reduction of 30% remains for ships between 15,000 and 40,000dwt, ships above 40,000dwt will be subject to a sliding scale of more stringent reductions up to 50%. There are also changes to some of the formula calculations for other ship types including a new factor for high ice classed ships. *NA*

Propulsion

Schottel wins hefty propulsion system contract

German manufacturer Schottel has scored a contract with the Russian shipyard Krasnoye Sormovo to supply propulsion units for 11 new built cargo vessels.

Designed by the Russian company Marine Engineering Bureau, the 141m long ships will each be equipped with two SRP 340 FP rudderpropellers, delivering 1,200kW, and one STT 170FP transverse thruster with an output of 230kW.

The main propulsion of the multipurpose dry cargo vessels will consist of a pair of diesel engines, each driving a SRP 340 FP with an input power of 1,200kW at 1,000rpm for a free sailing speed of approximately 10knots.

Moreover, the new 11,200m³ capacity vessels are characterised by a particularly high block coefficient, ensuring the best combination of speed, load capacity and required propulsive power.

Once complete, the vessels will be deployed in regional dry cargo trades and inland waterways including the Russian rivers Volga and the Don as well as the Mediterranean, Black and Caspian Seas.

Eleven new dry cargo vessels will be equipped with Schottel's propulsion units

Coatings

Jotun releases next gen biocidal antifouling range

Norwegian-headquartered chemicals company Jotun has revealed the latest line up of its SeaForce biocidal antifouling coating.

This new generation of coatings, which was developed in-house, features Hydractive technology. According to the company, the Hydractive technology slows down the water uptake of the antifouling, meaning that biocides are released in a more predictable pattern over the lifetime of the coating.

"With our proprietary Hydractive technology we can deliver a 'best in class' solution for long-term clean hulls and protection," said Erik Risberg, Jotun Marine Coatings' global marketing director. "That translates to competitive advantage for both our customers and us. We're excited to see industry reaction to what we regard as a significant step forward in antifouling performance within this market segment."

The three new products which make up the range are: SeaForce Shield, for protection; SeaForce Active, for actively safeguarding hulls even when a vessel is not in use; and SeaForce Active Plus, for premium protection. Both of the 'active' coatings include a triple biocide package, one of which is the same biocide combination used in Jotun's SeaQuantum portfolio.

The SeaForce range was first unveiled in 2004 and has since been applied to 27,000 vessels worldwide. All of the company's products are TBT free and comply with IMO antifouling regulations.

Ballast water treatment

Alfa Laval awarded USCG type approval for largest BWTS

The US Coast Guard (USCG) has granted type approval for Alfa Laval's largest PureBallast 3 reactor size, 1500m³/h, meaning vessels can now deballast in US waters.

Part of the Swedish company's third generation of ballast water treatment system (BWTS), the 1,500m³/h reactor was launched late last year for vessels with large ballast water flows. It is optimised for 50% more flow than the previous largest reactor size, which enables a more streamlined and cost-efficient system configurations, according to the maritime equipment manufacturer.

The 1,500m³/h reactor means a reduction in the number of reactors used by PureBallast 3 for large flows. A 3,000m³/h system can now be achieved with just two reactors, for example, while a 1,500m³/h system needs only one reactor instead of two.

Having previously received IMO revised G8 type approval, the technology can be used worldwide, even after 28 October 2020. When operating in US waters, vessels with PureBallast 3 may deballast after a holding time of 2.5 hours.

"Today's UV ballast water treatment systems are already smaller and more cost-effective to install than electrochlorination systems for large flows," said Peter Sahlén, head of Alfa Laval PureBallast. "Being able to configure a PureBallast 3 system with even fewer reactors further reduces complexity and cost."

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PureBallast 3 reactor range includes 170, 300, 600, 1,000 and 1,500m³/h sizes.

Earlier this year, the Oslo-based Bulkship Management AS selected Alfa Laval PureBallast 3, signing a fleet agreement that included 30 systems.

LNG containment

GTT scores Korean tank design orders

Engineering company GTT has received orders for the design of LNG carrier tanks from the Korean shipyards Samsung Heavy Industries (SHI) and Daewoo Shipbuilding & Marine Engineering (DSME).

Both orders concerned tank designs for new 174,000m³ LNG carriers.

SHI placed the request on behalf of Japan's Nisshin Shipping Co. for one new carrier, while DSME commissioned GTT for the tank design of two new ships for the Greek shipowner Maran Gas. The vessels are expected for delivery in 2022 and 2021, respectively.

GTT stated the tanks for SHI will be fitted with the Mark III Flex containment system – a cryogenic liner composed of a primary metallic membrane positioned on top of a prefabricated panel.

With the uptake of LNG, the French LNG containment system specialist has seen a steady increase in business. It saw a record level of 50 new ship orders in 2018 compared to 21 in 2017, and a consolidated revenue of €246 million (US$273 million).

In the first quarter of 2019, the company reported it had received orders for 14 LNG carriers and one LNG bunker vessel.

Smart maintenance

WinGD predictive maintenance project awarded

A collaboration between WinGD and ship management company Enterprises Shipping & Trading has proven the potential of WinGD's Integrated Digital Expert (WiDE) predictive maintenance technology.

The pilot project, which began at end of 2018, saw the WiDE system installed on the crude oil tanker Energy Triumph, a 157,000dwt vessel powered by a WinGD 6x72 engine. It demonstrated the technology's condition-based monitoring, diagnostic advice and engine optimisation capabilities.

The achievement was recognised last month at the Marine Propulsion Awards 2019, after if was awarded the Intelligent Monitoring & Maintenance Award.

WiDE is an integrated system of digital solutions which enhance the operation efficiency and crew decision-making accuracy related to engine and ship operations. The system is able to provide real-time, on-demand monitoring of engine status and condition through the collection and analysis of engine and machinery data.

The gathered engine data is analysed through three different levels of analysis: thermodynamic, know-how-based and machine learning. Thermodynamic analysis monitors engine performance based on a detailed process model of the engine; a 'digital twin', custom-produced for each vessel engine.

This 'reference' engine is then able to perform possible engine operation settings, ambient conditions and fuel type. The model is tuned separately for each individual engine and is validated using sea trials data.

Safety technology

ABB boosts cruise line's operational safety

Finish cruise operator Eckerö Line will retrofit its *MS Finlandia* with ABB's situation awareness technology to improve safety during docking and manoeuvring.

ABB Ability Marine Pilot Vision, which shows real-time sensor-generated visualisation of a ship and its surroundings, will be installed onboard the cruise ferry.

According to the Swiss technology group, a virtual model of the ship is superimposed on real surroundings measured using multiple sensor technologies. This gives the captain and crew the ability to monitor the ship and its environment from multiple different views "beyond the capabilities of the human eye."

As well as providing a mechanical interface, ABB Marine & Ports Digital Service teams will support the crew to maximise the value from the system and integrate the additional tool with their current bridge team operations. *NA*

ABB will deploy its situational awareness technology on Eckerö Line's *MS Finlandia*. Source: Eckerö Line

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Transitioning to zero emission vessels

A study by Lloyd's Register and UMAS examines three key energy pathways to help identify actions required for the shipping industry to transition to a zero-carbon future by 2050

Authors

Dr Nishatabbas Rehmatulla
& **Jean-Marc Bonello**[i]
UMAS

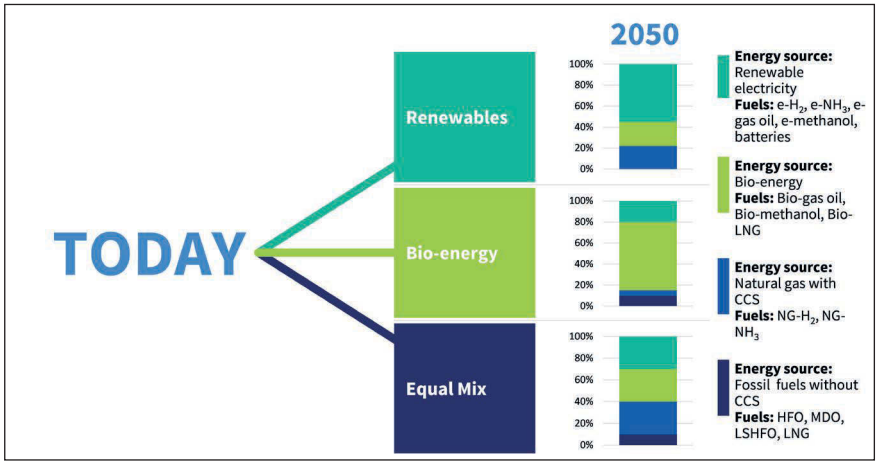


Figure 1: Fuel pathways to zero carbon in 2050

In April 2018, the shipping industry committed to a sector wide target of reducing GHG emissions by 'at least' 50% by 2050 compared to 2008 whilst stressing the need to phase out GHG emissions this century. Achieving this ambition will require a combination of short, mid and long-term policy measures that enable the sector to both decrease its carbon intensity and to switch to zero carbon fuels and zero emission vessels (ZEVs), which need to enter in the fleet as early as 2030.

The study published in early 2019 by Lloyd's Register (LR) and University Maritime Advisory Services (UMAS) seeks to address key questions on ZEVs, such as how alternative fuel supply infrastructure needs to develop and what the global fleet will need to look like to achieve the decarbonisation goal. It considers key milestones, barriers and enablers over 2020 to 2050, considering cost implications, ship operating profiles and how policy measures such as carbon pricing could influence the outcomes.

Previous studies by UMAS have shown that, to achieve even the lowest level of ambition of the IMO's Initial GHG Strategy (i.e. a 50% reduction in GHG emissions by 2050), ZEVs need to be entering the fleet around 2030. A significant portion of newbuilds will have to be zero emission to compensate for the emissions of the existing fleet. It is important, therefore, to evaluate the competitiveness of ZEVs versus fossil fuelled ships and analyse how the dynamic between these two groups pans out. This new study looks at economic viability of ZEVs operating on zero carbon fuels against conventional Heavy Fuel Oil (HFO) across five ship types (bulk carrier, containership, tanker, cruise and ro-pax) and size categories in three hypothesised fuel pathways. The analysis of economic viability includes considerations for voyage costs, including fuel, additional cost of onboard machinery and storage, loss of revenue due to loss of cargo capacity and possible future carbon pricing.

Figure 1 illustrates the projected fuel mixes for the pathways with further details found in Table 2. The zero carbon fuel options considered in this study (Table 1) include a range of biomass, renewable electricity and natural gas-based fuels both in liquid and gaseous form.

Key findings

Our analysis shows that in all pathways, batteries play a minor role as a primary energy store/source onboard ships because of their limitations regarding the high cost and relatively low energy volumetric density. The storage costs for batteries outweighs the potential benefits even when factoring in a reduction of bunker capacity by 30%. Batteries are only seen to be viable in short-sea markets or if used as hybrids and for on-shore power supply.

Zero-carbon fuels					
Energy source	Methanol	Gas oil	Hydrogen	Ammonia	Electricity
Natural gas with OCS			NG-H_2	NG-NH_3	
Biomass	bio-methanol	bio-gas oil			
Renewable electricity	e-methanol	e-gas oil	e-H_2	e-NH_3	batteries

Table 1: Zero-carbon fuels considered in this study

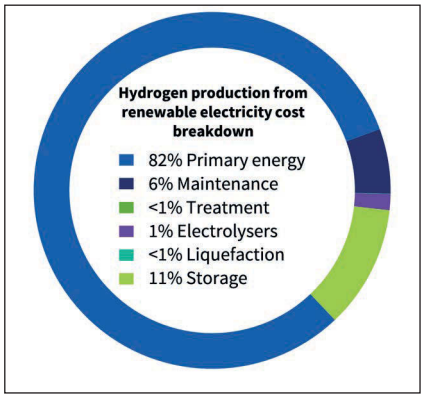


Figure 2: Electro-hydrogen production cost breakdown

Pathway	Description
Pathway 1: Renewables dominate	This pathway sees a rapid ramp-up of renewable electricity based marine fuels in the form of hydrogen, ammonia, e-methanol, e-gas oil and electricity for use in batteries. These electro-fuels will be increasingly taken up at the expense of fossil fuels used without Carbon Capture and Storage (CCS) technology. Like electro-fuels, although to a lesser extent, bio-based fuels will gradually enter the fuel mix, as well as hydrogen (H_2) and ammonia (NH_3) produced from natural gas with CCS as they have a share of the overall energy production.
Pathway 2: Bio-energy dominates	This pathway assumes bio-energy based fuels to be largely available and gradually taken up in shipping. Electro-fuels also enter the fuel mix but to a lesser extent, as well as H_2 and NH_3 produced from natural gas with CCS. Shipping is not a complete zero emissions system in 2050 as conventional marine fuels based on fossil fuels will still be used mainly because they would be blended with biofuels.
Pathway 3: Equal mix	This pathway assumes both a ramp-up of renewable electricity-based marine fuels and bio-based fuels. However, alongside these fuels, also H_2 and NH_3 produced from natural gas with CCS gradually enter the fuel mix.

Table 2: Fuel pathway description

During the 2020s, the development of electro-fuels will need to continue and grow exponentially, to provide the initial incentive for further cost reductions through research and development. By 2030, renewable electricity will need to be available at a price of approximately US$19/MWh in locations such as Latin America and the Middle East, where cheap electro-fuels will start to be produced and transported to major bunkering hubs as known today. This lower electricity price would make electro-fuels competitive, for example e-hydrogen could reach US$400/HFO equivalent (US$1.2/kg H_2) as over 80% of hydrogen production costs are linked to the renewable electricity price (Figure 2). Collateral issues, such as the availability of water in these locations, may be prohibitive and would need to be resolved at a relatively low cost. Hydrogen production infrastructure, specifically electrolyser costs, will need to be below US$500/kW in 2030 and gradually decrease over time till reaching US$250/kW which will further decrease the final fuel price and make it competitive against conventional marine fossil fuels. Due to the development of electro-fuels supply infrastructure, in many of the bunkering hubs, electro-fuels prices will need to be of the order shown in Figure 3.

Figure 4, which shows the relative competitiveness of a ZEV using electro-fuels, indicates that for a small to medium container vessel, e-H_2 can be a viable option in a scenario with low electricity and electrolyser costs. For a larger ship travelling a longer distance, the revenue loss due to the storage space requirement may be high and the reduction of storage and machinery costs would not be sufficient to compete with other options such as e-NH_3 and e-methanol.

Concluding remarks

We find that in all pathways, easy to store zero-carbon fuels (such as sustainable biofuels and methanol) are currently more attractive, but their use must not hinder efforts on electro-fuels, which as a result of continued investment in RD&D and policy could become viable from 2030 onwards. Electro-fuel prices are strongly linked to renewable electricity prices, which could be further reduced through efficiencies in renewable electricity generation and electrolyser costs. A price on carbon, for example, of US$80 per tonne of CO_2, would make investments in certain ship types and size viable under best-case scenarios for cost of storage and main machinery of electro-fuels coupled with low renewable electricity prices.

The key conclusions of this research indicate that in the next decade up to 2030 the industry needs to consider:

- Full-scale prototypes and pilots need to be undertaken now in order to create technology readiness and consequently to reduce costs.
- Easy to store zero-carbon fuels (such as sustainable biofuels and methanol) may be more attractive now, however, their use must not hinder efforts on electro-fuels.
- Batteries in short-sea markets or if used as hybrids and on-shore power supply will play an important role in reducing the dependency on fossil fuels.

Looking further afield, the 2030s will be the decade of scaling up of zero-carbon solutions and may be expected to comprise of:

- A clear signal on the evolution of the energy system that will influence marine fuel production
- Availability of cheap renewable electricity
- Finding overlaps with other sectors' supply chains will be increasingly important characterised by consolidation of dominant technologies onboard
- Ships may require a fundamental change to their operating profile
- LNG assets will need to find a way to remain competitive as they risk becoming stranded

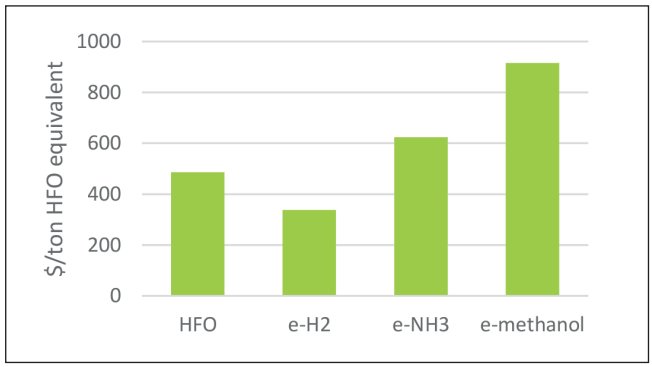


Figure 3: Backcasted electro-fuel prices in 2030 based on small-medium container vessel

In order to promote these outcomes, policy makers must establish collaborative joint ventures involving public-private partnerships (e.g. fuel technology companies and energy developers) to overcome cost related barriers (for onboard technologies and infrastructure). A rapid development of policy, standards and rules are required to provide further certainty on future costs and safety in operations. That said, first adopters are likely to be driven not only by economic and policy pressure but also by consumer pressure e.g. in the container sector and coastal shipping.

The complete set of reports covering transition pathways, fuel production pathways and safety implications can be found at: www.lr.org/zev. *NA*

[i] Carlo Raucci, Domagoj Baresic, Isabelle Rojon, Colin Robertshaw [UMAS], Katherine Palmer, Shane Balani [LR]

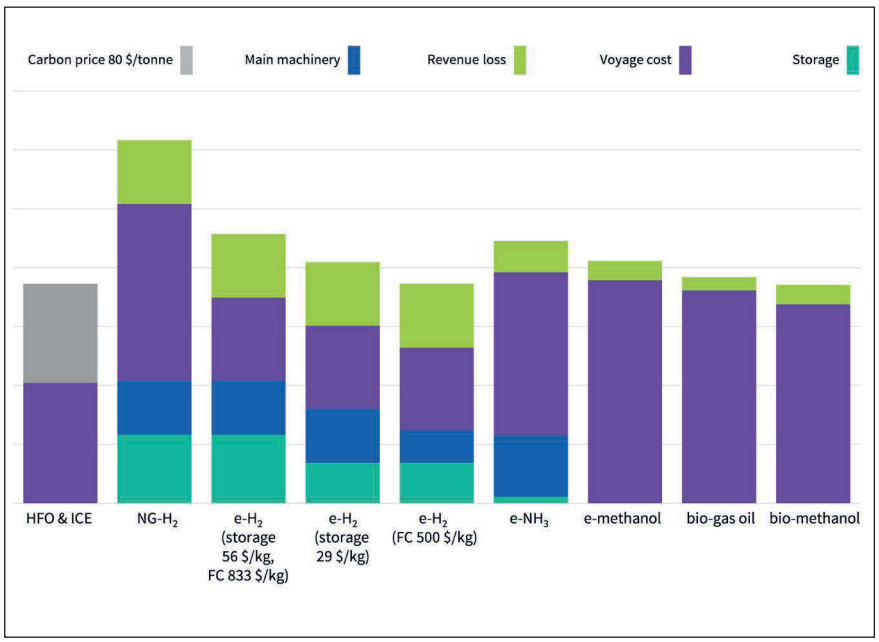


Figure 4: Relative competitiveness of ZEVs using electro-fuels for a small to medium sized containership in Pathway 1

The next level of autonomous navigation

A collaboration between Lloyd's Register, STEE and Mitsui plots new course for autonomous ships into deeper, more challenging waters with the first ocean-going system

In less than a decade, autonomous ships have developed from a visionary idea to a tangible reality.

One only needs to look at Rolls-Royce to see how quickly this technology has advanced. The company began investigating the potential of autonomous ships in 2013, remotely operated a retrofitted tugboat in 2017 and successfully demonstrated the world's first fully autonomous ferry last year.

As they're only too happy to tell you, many futurists believe maritime autonomy is a goldmine waiting to be plundered. The latest prospectors on this technological treasure hunt are Lloyd's Register (LR), ST Engineering Electronics Ltd. (STEE), a Singapore-headquartered engineering group, and Mitsui & Co., who have joined forces on a new collaborative project.

During Singapore Maritime Week in April, the companies announced a memorandum of understanding outlining their intention to develop the industry's first ocean-going autonomous navigation system.

The project aims to "develop and validate navigation intelligence for autonomous ocean-going vessel operations". This two-year development programme is funded by the Maritime and Port Authority of Singapore (MPA), which has invested S$7.2 million (US$5.3 million) into five autonomous shipping projects as part of its push to harness the use of remote technology.

Up to this point, most autonomous projects have focused on smaller vessels dedicated to coastal routes, making this partnership a significant step in expanding the application of autonomous systems across the industry.

"An ocean-going system will encounter increased environmental challenges compared to a coastal vessel, such as increased wave heights and operating in a variety of climates, from tropical waters to the North Atlantic," says Andrew Watt, manager at LR's Singapore-based SAMEA Naval Business Centre of Excellence.

LR, STEE and Mitsui partner up to develop the first ocean-going autonomous navigation system

"This will really provide new challenges to situational awareness technology, including the decision-making solution and sensors."

Watt adds: "An open-ocean system will also have to face a wider array of 'use-cases' for safe performance due to the range of scenarios encountered."

Ocean-going ships are likely to encounter a range of unfamiliar territories during operations, from dead calm waters to congested ports. Coastal vessels, on the other hand, typically face significant volumes of traffic within well-known local territory; therefore, they are subject to fewer use-cases.

Eventually, the autonomous system will be tested on a retrofitted ocean-going car carrier, *Themis*, operated by the Japanese conglomerate, Mitsui. Test routes will include busy waterways such as the Suez Canal, Panama Canal as well as the Straits of Malacca. The Singapore-flagged car carrier – capable of ferrying up to 8,000 cars – was recently re-classed by LR, which will provide its regulation expertise and system approval for the application of autonomous technology.

Besides pushing the boundaries of the technology and verifying its wider navigational competence, the joint project seeks to upscale STEE's technology for the commercial marine market. STEE has been highly involved in autonomous sector, having previously developed the technology for military purposes.

Although Watt admits predicting the timeline for the commercialisation of the technology is difficult, he anticipates that various forms of autonomous navigation systems on bridges, such as intelligent auto-pilot systems, may be fitted on numerous vessels as early as 2025.

"I believe the capability of these systems are already very close to being a commercial product," says Watt. "However, various additional factors remain such as legislation, public acceptance and established operating models for ship operators."

The process of composing new regulations to support the deployment of autonomous technology and demonstrating the system's safety remain the biggest hurdles in bringing autonomous ships to full fruition, particularly for ocean-going vessels.

"This project will aim to gather more experience of these systems in operation, now in an open ocean environment, to provide key learnings on safety of these systems and what the requirements of a regulatory framework could look like," says Watt. *NA*

Tackling solid bulk cargo liquefaction with safer ship design

While reducing the probability of liquefaction could be reduced by a range of measures, mitigating its catastrophic consequences through ship design could prove to be the most effective solution

On 27 October 2010, the bulk carrier *Jian Fu Star* reported a five-degree list while en route to China from Indonesia. Less than 20 minutes later, the vessel's port deck was level with the sea. Even though the abandon ship alarm was sounded, only 12 crew members of 25 were rescued.

Two weeks later, the Panama-flagged *Nasco Diamond* – a handymax bulker built the previous year – sank to the bottom of the Pacific without time to send out a distress signal. Of its 25 member crew, 22 died.

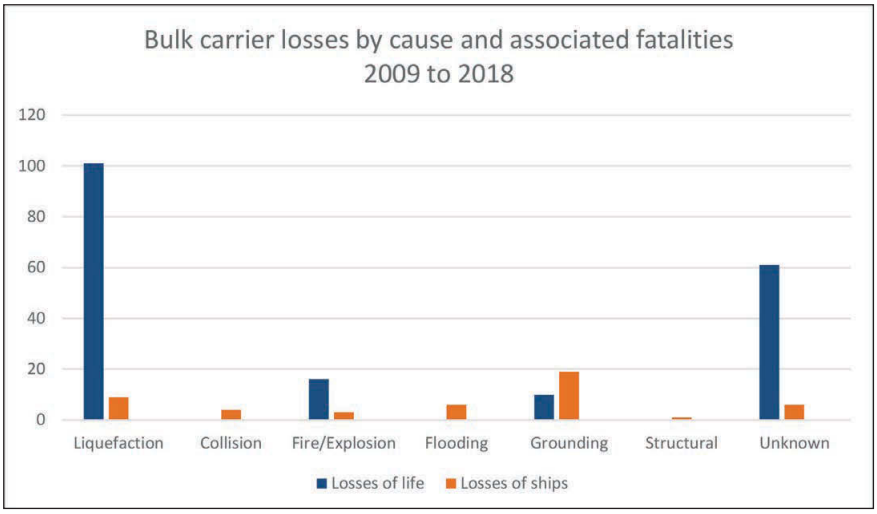
Then in December 2010, the *Hong Wei*, also a handymax, capsized off the southeast coast of China. Twelve crew members were rescued, but 13 others were presumed missing or dead.

Sadly, such fatal incidents are not unusual. Similar bulk carrier sinkings occurred in 2011 when the *Vinalines Queen* went missing, in 2013 when the *Harita Bauxite* capsized and in 2015 when the *Bulk Jupiter* sank off the coast of Vietnam.

All these vessels had been loaded with nickel ore in Indonesia – apart from the *Bulk Jupiter*, which was carrying bauxite from Malaysia – and were underway to China when they sank.

Investigations into each incident concluded the vessel loss was triggered by the same cargo failure: liquefaction. Granular cargoes like nickel ore, iron ore, and bauxite may not possess the combustible properties of coal or sulphur, but their propensity to liquefy during transit and critically undermine the stability of a vessel can pose a far greater risk.

Trade association Intercargo has described nickel ore as 'the world's deadliest cargo'. Its latest *Bulk Carrier Casualty Report*, which analysed all bulk carrier incidents from 2009 to 2018, found that the highest loss of life was due to liquefaction. Out of the 188 seafarers whose lives were claimed during the previous decade, 101 died in causalities related to cargo failure.



Liquefaction has accounted for 53.7% of total loss of life over the past decade (Data source: Intercargo)

Yet, of the 48 bulk carriers over 10,000dwt that were lost, only nine were due to suspected liquefaction. This means liquefaction has made up over 50% of bulk carrier fatalities over the past 10 years but just 20% of vessel losses.

Changing states

For a solid bulk cargo to liquefy, two key elements must be present: water and fine solid particles. In its stable state, the particles touch and the friction between them makes the material act like a solid, despite the presence of water.

However, when these materials are dropped into cargo holds off conveyor belts from great heights or exposed to the movements and vibrations of a ship while underway, the spaces between particles are reduced. This compaction increases the pore water pressure – the pressure of water held within a the inter-granular voids – and pushes the particles apart, decreasing the cargo's strength. Once the friction is reduced to zero, the cargo reaches a flow moisture point, giving it the ability to behave like a fluid.

Inside the wide cargo holds of standard bulk carriers, the liquefied cargo, which usually only occupies a small part of the hold, can move and shift around. This 'free surface effect', whereby the material freely sloshes about in an enclosed space, jeopardises the stability of the vessel. Sometimes the cargo may move to one side of the hold with a roll of the ship but will not completely flow back to its starting point with the following roll. Eventually, the cargo can build up on one side of the hold, increasing the vessel's heel or list.

"If your cargo liquefies, then the pressure on the vertical boundaries of your cargo hold becomes much larger than what it is designed for," says Håvard Helling, a principal engineer at DNV GL. "The pressure on the longitudinal bulkheads will increase typically by a factor of three."

Once the angle of list becomes great enough, the vessel may be unable to stabilise, leading it to suddenly capsize.

Yet despite our understanding of liquefaction and its potential consequences, there has been little diminution of incidents. So why is it still an issue and what can be done to mitigate the risks?

The loading of granular materials by large conveyor belts increases the risk of liquefaction during transport (Source: Vale)

International action

Awareness throughout the maritime industry about the risks of cargo liquefaction has increased over the past decade, heightened by China's demand for nickel ore.

IMO's International Maritime Solid Bulk Cargoes (IMSBC) Code was adopted in 2008 and made mandatory in January 2011, replacing the Code of Safe Practice for Solid Bulk Cargoes, which had been in effect since 1965. The IMSBC Code categorises cargoes by their basic characteristics – susceptible to liquefaction (Group A), chemically hazardous (Group B), or neither liable to liquefy nor possess chemical threat (Group C) – and provides instructions on how to transport different bulk cargoes.

The Code also governs how much moisture is acceptable in solid bulk cargo to avoid liquefaction. But while the IMSBC Code provides a foundation for the industry to build upon in attempts to increase safety, many experts feel it's too simplistic.

Transportable Moisture Limit (TML) tests, which are performed in a laboratory, may be carried out very differently in different parts of the world. Indonesia and the Philippines, where large exports of nickel ore originate, may not have the infrastructure or personnel needed to accurately complete the tests.

TML tests are not necessarily representative of the stockpiles either, as the cargo may have been rained on at the quayside while waiting to be loaded. Currently, the only way for masters to verify the moisture content of the cargo at the dockside is through a supplementary 'can test'. But the test, which involves tapping a can filled with the cargo on a table, has come under criticism as being inadequate.

More accurate testing methods, which could be carried out just before loading or onboard, could be developed with current technology. "Having a portable device that can make multiple in situ measurements of moisture content on the quayside would help increase confidence that the results from the laboratory testing are indicative of the cargo that is going to be loaded on the vessel," says Susan Gourvenec, a professor of offshore engineering at the University of Southampton.

New technologies, such as sensors and 3D scanning, also have the potential to mitigate the risks of liquefaction. Perhaps the simplest solution though, is one that is already well understood.

Time for a design change?

Designing a vessel so that it can safely carry liquefied bulk cargo could dramatically minimise the side effects of liquefaction.

"The free surface effect is very dependent on the width of the cargo holds, so you want to limit that to increase the stability of the vessel," says Helling.

The simplest and most effective way of doing this is by inserting centreline longitudinal bulkheads into the cargo holds, which currently extend from the port to starboard side of the ship. Dividing these large holds in two would give the cargo less room to slosh around, reducing the impact that any liquefaction may have on the stability of the vessel.

Such a solution has already proven successful for tankers with the (now-mandatory) double hull design.

The IMSBC Code includes provision for dangerous cargoes to be carried by 'Specially Constructed Cargo Vessels', with the approval of the flag state. Such vessels are certified to carry wet or liquefied cargo that exceeds the TML when loaded. However, the Code itself does not specify any definitions or requirements for such ships, other than that the vessels must have "permanent structural boundaries" and "specially designed portable divisions to confine any shift of cargo to an acceptable limit."

Instead, classification societies have set about providing more in-depth guidelines for shipowners. The first vessel to carry a Specially Constructed Cargo Ship (SCCS) notation was the Panama-flagged *Jules Garnier II*, certified by Japan's ClassNK in 2012. Built by Naikai Zosen Corporation and delivered to JX Shipping Co, the 27,200dwt vessel was specifically constructed for the carriage of nickel ore. ClassNK drew upon its own earlier research into the physical attributes of nickel ore to develop the hull structure and stability requirements for carrying the cargo in its liquefied state.

Typically, specially constructed vessels are designed with longitudinal bulkheads and built in a way that allows them to remain afloat in the event of liquefaction. The characteristics of the specific cargo the vessels will transport are also considered during the design process.

"You want to design your vessel so that it fits the density of the cargo," says Helling of DNV GL, which has developed its own BCLIQ notation. "For instance, nickel ore, which is not a very dense cargo, requires cargo holds as large as possible but with as small width as possible to reduce the free surface effect." But if you are dealing with a heavy cargo like iron ore fines, you can significantly reduce the width of the cargo holds while still being able to carry the deadweight capacity of your vessel.

Experts agree longitudinal bulkheads are an easy design solution for reducing the risk of liquefaction, though convincing shipowners of their benefits remains a challenge. Longitudinal bulkheads add extra weight to a ship and steal from the cargo hold volume, says Helling. "It's about finding a good balance between being able to carry liquefied cargo without losing cargo capacity and the flexibly of a normal bulk carrier." *NA*

The road from Hong Kong

A decade on from the adoption of IMO's historic ship recycling convention it has still not entered into force. A seminar of industry leaders met in London to discuss the progress made and the challenges ahead

The Hong Kong Convention (HKC) for the Safe and Environmentally Sound Recycling of Ships is 10 years old, but whether that's a matter for celebration or not is really a question of perspective. For its critics the HKC is the embodiment of the maritime industry's prevarication in taking a proactive role in environmental protection and corporate social responsibility. Even after a decade, only 11 countries have either ratified or acceded to the HKC, which requires signatories accounting for a minimum of 40% of the combined gross tonnage of the world merchant fleet to enter into force (the current total stands at around 23.2%) and 3% of gross tonnage when the ships are recycled.

Its advocates maintain that while progress has been slow meaningful changes have already been achieved. Statements of Compliance (SoCs) with the Convention have been issued by classification societies to more than 60 recycling facilities globally, many in the shipbreaking hubs of India and Turkey. Moreover, a range of initiatives are underway to help countries such as Bangladesh, another major recycling centre, achieve the desired standards.

However, since 31 December 2018 EU regulations require that vessels trading under the flags of its member states can only be recycled at facilities on the so-called European List, which includes just three shipyards outside of Europe (two in Turkey, the other in the United States). To compound matters, in December 2018 China announced new environmental protection measures which banned solid waste imports, meaning that only domestic-owned ships can now be recycled at its facilities.

In May, *The Naval Architect* was present for an international seminar on ship recycling hosted by Japan's Ministry of Land, Infrastructure, Transport and Tourism, held at IMO headquarters in London. Two months earlier, Japan became the 10th country to ratify the Convention and is now playing an active role in promoting its early entry. The seminar was geared as a forum for industry spokespersons to discuss their efforts towards compliance and the hurdles that remain.

Bangladesh is aiming to achieve Hong Kong Convention compliance within five years. Picture: IMO

Cradle to grave

IMO secretary general Kitack Lim opened proceedings with an address in which he emphasised the importance of the Convention as a 'cradle to grave' solution for ship recycling and its significance in supporting sustainable development. Importantly, Lim noted that while the current signatory states accounted for 23% of gross tonnage their combined recycling volume was just 1.6 million gt, or 0.56%.

He also highlighted the workshops, training and other projects IMO is using to raise awareness of the Convention, particularly with regard to the recycling countries themselves. One such project is the ongoing 'Safe and Environmentally Sound Ship Recycling in Bangladesh' (SENSREC), being funded in part by the Government of Norway as part of its international development programme.

SENSREC has conducted a number of studies and developed training materials aimed at boosting safety and environmental standards. The project, now in its implementation phase, led to the passing of the Bangladesh Ship Recycling Act 2018, which aims to achieve Convention compliance within five years. Bangladesh accounts for 20% of ships recycled but the working standards at facilities in Chittagong have been a particular focus for pressure groups such as the NGO Shipbreaking Platform (who were pointedly not among the speakers at the seminar).

In India, more than 80 yards have been issued SoCs and Dashrath Prasad, director of the Indian Ministry of Shipping, said that it has agreed in principle to ratify after a period of consultation with its coastal states. However, Nitin Kanakiya, secretary for the Ship Recycling Industries Association (India), observed that these facilities are often struggling to compete. Moreover, standards between yards vary according to which IACS member has audited them and there are questions over whether the same level of performance is being maintained after certification. Currently, 14 Indian yards have applied for inclusion on the EU's list of approved facilities, but there has been no indication when or if they will achieve this.

China has also signalled its intention to ratify despite, as mentioned above, the recent ban on the scrapping of foreign vessels in its territory. According to Chunchang Zhang, deputy director of the China Maritime Safety Administration, there are now more than 60 recycling companies in the country, but tightening environmental regulations saw the number of scrappings plummet from 148

vessels in 2015 to 37 in 2018. Liaising with other Chinese ministries to ensure national laws are consistent with the the Convention's requirements remains the main obstacle, said Zhang.

Lack of cooperation

Concerns that there is still no unified approach to implementing the Convention was a recurrent theme of the event. Kan Matsuzaki, director of international workers union IndustriALL, noted that while the Convention was realistic and achievable there was no cooperation between India, Bangladesh and Pakistan. Reinhold Pijpers of the International Ship Recycling Association said that there was not a level playing field and that competition with substandard practices was unfair.

Among shipowners there is, publicly at least, strong support for the Convention. Tim Wilkins of trade association Intertanko said his sector is under particular scrutiny with regard to its recycling strategies. One of the requirements of both the Convention and the EU is the Inventory of Hazardous Materials (IHM), but obtaining accurate materials declarations remains a challenge, a factor in some shipowners and cash buyers often seeking out less scrupulous yards.

It should be noted that classification societies are contributing strongly in this particular area, with platforms such as ClassNK's PrimeShip-GREEN/SRM, a cloud-based data system, making it possible to consolidate materials declarations from different suppliers during the construction phase, or even retrospectively. According the ClassNK's general manager, Junichi Hirata, the service now has around 3,000 users worldwide.

Guy Platten, secretary general of the International Chamber of Shipping, praised the remarkable development in ship recycling practices since 2009, while criticising the "significant difficulties" caused by the EU regulations, adding that the approved list was doing very little to encourage best practices. But there was truculent defence of the EU's stance from Peter Koller, policy officer for the European Commission's waste management and recycling department, who stressed that when the regulations were being drawn up in 2012-2013 there were serious concerns the Convention would not enter into force.

As always with IMO regulation, the question is whether the cart has been put before the horse and that the industry might have better coordinated its recycling efforts a decade ago and avoided the EU's overriding legislation. Even now, some are continuing to voice the concern that ratification of the Convention by some of the larger Member States could trigger it into effect before the key recycling nations have had sufficient time to implement its requirements. However, it would churlish to suggest there is not a great deal of well-intentioned work underway to make the Convention a reality. As one delegate observed: "In a global society we need to be international societies. That means treating the problem, not threats." *NA*

Observe, define, measure: demystifying maritime cyber risk

Defending against cyber-attack requires a deep but practical understanding of what contributes to risk onboard the vessel, writes Rick Scott, Technical Advisor, ABS

As the shipping industry navigates the 'smart' era of Operational Technology (OT), demand for remote access to onboard cyber-enabled systems is growing exponentially. This enhanced connectivity is making vessel operations more digitally visible to shipowners and operators while increasing dependability, limiting downtime and fulfilling the promise of condition-based maintenance.

But the benefits of enhanced digital connectivity have a downside. This connectivity means that more human and machine 'identities' from both the public and private sector will seek – and very possibly gain – remote access to sensors and control devices in critical OT systems.

Unless these identities are vetted and authorised, granting this access is equivalent to allowing strangers onboard the vessel, making it a major security issue. The task seems daunting, but our understanding of cyber risk for OT systems is constantly increasing and the solutions are within our grasp.

Every ship has an individual cyber risk profile depending on the number of cyber-enabled critical functions onboard, the connection points among those functions and the identities that access both. The risk profile also shifts somewhat throughout the mission. For example, the cyber risk profile of bulk carrier is more complex when connected to a port's loading system because of increased digital access during port activities.

The principles of risk management remain the same, but even so, shipowners and their technology consultants have struggled to measure the risk present in each ship and each port with which they share digital connections.

This lack of a quantitative system for measuring risk and risk mitigation efforts has made the verification of risk reduction challenging – until now. A maritime adaptation of a well-known risk model makes quantification of OT cyber risk possible.

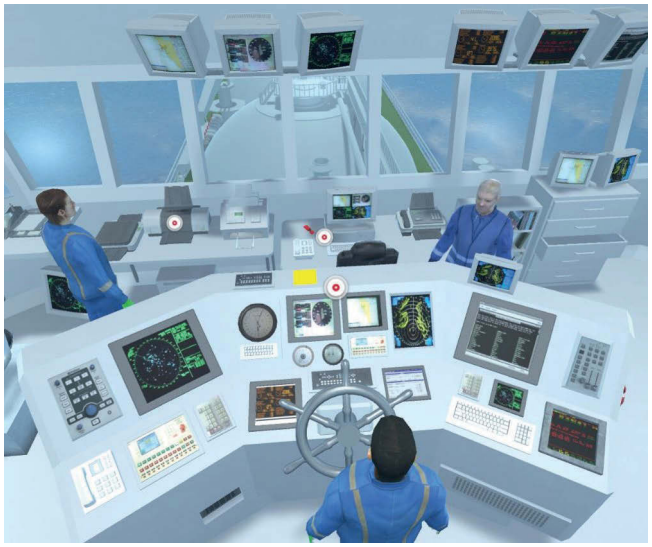
Rick Scott, ABS

The most common equation used to represent cyber risk has traditionally been "Risk = Threat x Vulnerability x Consequence". Also known as the 'FBI' risk equation, this concept has proved useful because it helps cyber security practitioners recognise that risk has three primary contributing elements and infers that reducing any one of those elements reduces risk in the observed cyber-enabled system.

However, the role of this model has been limited because it is not a true mathematical equation that has readily countable factors. Definitions of the elements of the traditional cyber risk model are abstract, difficult to observe and quantify – especially when trying to design a risk management solution. Such a shortcoming has reduced the typical cyber risk assessment to little more than informed guesswork.

With fleet owners and managers under increasing pressure to prove their ships' digital risk and resilience, cyber security and safety are better served by moving beyond abstract concepts such as 'consequence', 'vulnerability' and 'threat' to terms that can be easily defined, observed, and measured.

Calculation of OT cyber risks in a fleet requires the use of calculable elements in an equation using observable and countable terms. By contemplating OT risk as being



ABS's model takes a quantitative approach to cyber risk

ABS recently announced a partnership to incorporate its FCI Cyber Risk methodology into SecurityGate's Saas platform

determined by the specific contributions of 'functions', 'connections' and 'identities' (FCI), cyber security requirements onboard a vessel become quite clear.

This shift in the definition of OT risk is much more than a cosmetic substitution. It leads to measurable outcomes and clear risk management priorities and solutions.

In the ABS FCI Cyber Risk model, 'functions' represent a critical activity that a piece of equipment or system is designed to perform, whether it is vessel handling or completion of the vessel's intended mission.

'Connections' and their related endpoints describe how the 'functions' communicate to each other, to system providers, to the bridge, to shore, and to satellites – and in doing so create potential access points for intruders.

'Identities' represent the humans and digital devices through which corruptive software code is delivered to critical functions. These identities are the real threats to cyber security onboard a vessel. By replacing 'threat' with 'identity' in the equation, threats can be defined and counted, making the calculation of risk possible and logical.

Collaborative research with the Maritime Security Center, a division of the U.S. Department of Homeland Security, led by the Stevens Institute of Technology and further developed and refined by ABS in field applications, helped ABS develop the FCI Cyber Risk methodology. It is grounded in the NIST Cybersecurity Framework, a mature guidance familiar to the maritime cyber-risk practitioner.

By demystifying the nature of cyber risk, the aim is to help owners collaborate with their IT departments in a meaningful way to identify the specific risk contributors, target cyber security engineering decisions and prioritise company resources more effectively. *NA*

ClassNK keeps its foot on the gas

LNG is front and centre of the Japanese classification society's current plans, but it remains mindful of the rapid advances being made in emerging technologies

Demand for natural gas is booming; in China alone gas consumption is expected to reach in the region of 320billion m^3 this year, an increase of 18% on 2018. Moreover, with new production surfacing in the US, Russia and Australia, natural gas is available in abundance, lowering prices and adding to its allure.

This makes LNG carrier construction a rapidly evolving sector. "There are currently around 600 vessels in service or under construction," says Hayato Suga, director of ClassNK's Plan Approval and Technical Solution division. "But while previously construction of these ships was project driven, now it's more of a free market."

Like all the major classification societies, ClassNK is finding its expertise in demand for consultation on LNG carrier concepts and newbuildings. Last year, the society released its Guidelines for Liquified Gas Structures – Independent Prismatic Tanks, drawing upon its experience in certifying these structures and the need to ensure their particular requirements are better appreciated by newcomers to the sector. "Some of these areas are not regulated in detail, so we have established some of the processes and the key issues concerning design," says Suga. For example, the Guidelines include a dedicated section on fatigue strength assessment to prevent cracks caused by prolonged and repeated loads (e.g. LNG sloshing).

There are currently only three shipyards in Japan building LNG carriers: Mitsubishi Shipbuilding, Japan Marine United and Kawasaki Heavy Industries. All have newbuilds being delivered this year but are facing stiff competition from the resurgent South Korean shipyards. Meanwhile, China has made enormous strides with LNG carrier construction, albeit hitherto restricted to the CSSC-owned Hudong–Zhonghua shipyard.

ClassNK is also providing services for the development of new LNG-fuelled concepts, such as Kawasaki Heavy Industries' project to build a 207,000dwt bulk carrier, for which it granted Approval in Principle (AiP) earlier this year. Dry cargo remains the bread and butter of ClassNK's fleet, accounting for more than half its vessel numbers, and 37% of the dry cargo fleet among IACS members. Yet with Lloyd's Register similarly granting an AiP to a 250,000dwt LNG-fuelled VLOC to be built by Hyundai Heavy Industries (HHI), there is an obvious need to keep pace with evolving fuel trends.

Kawasaki Heavy Industries' LNG-fuelled bulker concept was granted AiP from ClassNK in January

Shipowners in Japan are conscious of the need to adapt, says Suga, pointing to a range of committees and initiatives taking place recently to discuss new technologies in the wake of IMO's 2050 decarbonisation targets. "The Japanese government has also recognised it's a very big issue to comply, but they are happy that the IMO has shown strong leadership. It also helps that the current MEPC chairman, Hideaki Saito, is Japanese."

Suga further acknowledges that LNG can only be an intermediary step towards emission-free solutions and is an advocate of hydrogen fuel cells. "The key point about hydrogen or ammonia fuel cells will be whether or not they are produced with a carbon free process. We believe that hydrogen has a high potential, but at the moment the cost [of production] is quite high and it comes from the reforming of gas. New technologies will use carbon capture systems and that's what's being discussed all over the world right now.

"I think hydrogen fuel cells are more reliable than engines or turbine systems, but it's very much dependent on the development. We are already involved in some projects with Kawasaki and Shell where hydrogen will be produced in remote areas where [renewable] energy is almost free, and then changed into hydrogen."

Hydrogen transportation is an area ClassNK has already prepared for, publishing its Guidelines for Liquified Hydrogen Carriers in 2017, based on provisional IMO recommendations. "There are no specific guidelines for hydrogen within the IGC Code, so we conducted an R&D project into the risks of hydrogen, its properties and how it compared with other cargoes. We then formed a national committee in Japan and relayed our findings to IMO via the government … We are still in an experience building phase before the [revised] Code will be finalised, but this has been an initiative taken by the Japanese government with ClassNK as the technical consultants."

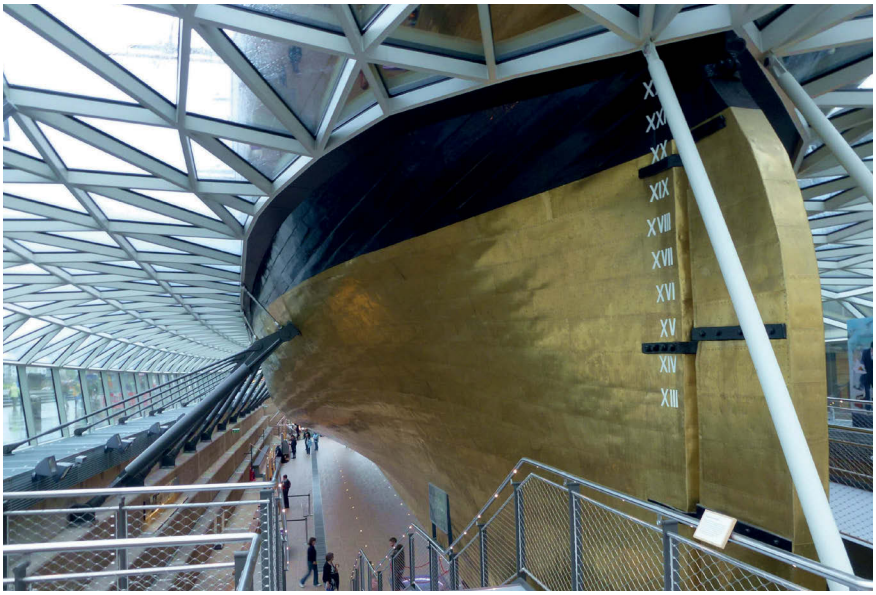
Additionally, the society is consulting upon a number of wind propulsion projects. "These are fixed sail and kite systems. We're hoping to establish guidelines shortly, but these will be very general and cover things from a safety perspective. Some of the big owners want to explore these technologies and they will dictate the direction, but new technologies are a very competitive area and we can't fall behind," says Suga. *NA*

Greener, smarter anti-fouling solutions on the horizon

Volker Bertram, of Stellenbosch University's Department of Mechanical & Mechatronic Engineering, paints a picture of the latest developments in coatings technologies

Fouling has been a headache for shipping since ancient times. An Aramaic scroll dated from around 400 BC stated: "the arsenic and sulphur have been well mixed with Chian oil … with the mixture evenly applied to the vessels sides so that she may speed through the blue waters freely and without impediment." Oh well, the ancient Egyptians tried. So did Columbus and Horatio Nelson while today's top operators continue to test the latest solutions. Each generation has come has come closer to the ultimate goal then the last, but none have been entirely successful or satisfied in their antifouling endeavours.

Marine growth can decrease ship performance drastically, resulting in a 30-50% increase of fuel consumption (and associated emissions) compared to a smooth hull. Hull fouling is also responsible for the spread of invasive species, even more so than ballast water. Anti-fouling, i.e. any measure to prevent or reduce fouling, is thus both an economic and ecological necessity.



Copper has played a key role as an antifoulant for centuries and is currently embedded in most antifouling paints. But has the time come to move to biocide-free solutions?

Biocide paints just a bridging technology

The era of modern anti-fouling paints began in the 1940s. When in contact with seawater, such paints release biocides which form a toxic boundary layer, preventing marine growth. As the ship moves through water, the toxins are washed off and the paint must re-build the protective boundary layer with new toxins. As the hosting paint itself dissolves in water, the surface of such 'self-polishing copolymers' (SPCs) remains fairly smooth. After five years, the paint and its embedded biocides have typically been used up and the ship is recoated in drydock.

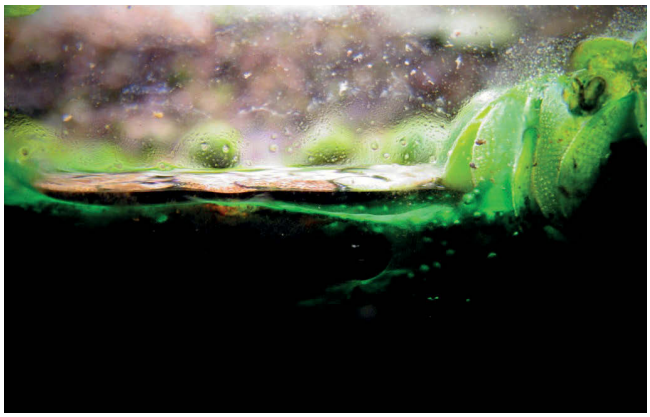
Since the 2008 ban on highly effective TBT biocides, copper compounds have become the predominant anti-fouling biocide. Various herbicides and fungicides are added to address plant fouling, which is not affected by copper compounds. These additional toxins are dubbed 'boosters'. Some of the boosters (including Irgarol 1051 and Diuron) have come under scrutiny, resulting in regional bans or legislation to curb their use. As such, copper- and biocide-based anti-fouling paints are now widely seen as a bridging technology. But what could be on the other side of the bridge?

We are moving slowly yet steadily towards sustainable shipping. Leaching copper and micro-plastics (the dissolved ingredients of today's standard SPC coatings) into the world oceans is not sustainable. The way forward is to phase out biocide-based paints and to adopt non-toxic alternatives. There is no shortage of ideas, but the road from concept to deployment is often a long one. This is especially true for antifouling, where a product's success and effectiveness are generally measured over five years, the standard docking interval.

The Teflon principle may not stick much longer

The surface energy is a measure of how easy or difficult it is to stick to a material. Low-surface energy coatings (LSE) – foul release or silicone coatings – use the same principle as Teflon pans: making adhesion (of fouling organisms) difficult. Even if fouling is not completely prevented, such 'non-stick' coatings are much easier to clean, e.g. by wiping or low-pressure rinsing. On speed boats the surface may be self-cleaning, however, cleaning is necessary on most other ships, especially in niche areas such as bow thruster tunnels and sea chests.

LSE coatings, like Teflon, are mechanically sensitive and fouling starts rapidly after the coating has been scratched. Even if the coating avoids surface damage the silicone film weathers



Researchers are inspired by floating fern (Salvinia) to develop air-trapping low-friction coatings for ships

over time, rendering it less effective. While the star of classical silicone coatings seems to be waning, with some new twists the idea lives on.

Silicone coatings are super-hydrophobic (i.e. water repellent). At the other extreme, super-hydrophilic (i.e. water attractive) surfaces also impede fouling. Such 'hydrogel' coatings are akin to soft contact lenses. Many fouling organisms mistake the surface of a hydrogel for water; in other words, the hull surface becomes invisible for them. Combined with a mechanism to trap biocides on the hull surface, this approach can reduce biocide leaching by a factor of 10-20 over conventional anti-fouling coatings with virtually constant performance between docking intervals. Hydrogel solutions are offered by at least two major coating manufacturers.

'Nano-coatings' use bio-inspired microscopic surface structures (e.g. shark skin, lotus effect, etc.). Several such products are already on the market but current research is continuing to present new ideas. The Fraunhofer institute in Hamburg, for example, is developing new coatings mimicking floating ferns, which trap a fine film of air.

Robots ahead

You have seen swimming pools cleaned by robots. You have seen lawns mowed by robots. Couldn't robots clean ships every time they are in port too? Yes, they could. But the coating should be adapted to it and current hull cleaning robots must learn a few more tricks, most notably team work.

Biocide-based antifouling paints release toxins under shear forces. Thus, any brushing or wiping will release more toxins, leading to premature degradation of the coating. Hard coatings, on the other hand, can endure frequent cleaning (e.g. every 1-2 weeks). While the coating technology is in place, more work is needed to develop cheap, fast and widely available cleaning. And robotics is the key to this.

Over the past few years, most leading industrial nations have developed robots for underwater hull cleaning, capable of cleaning upside down under ship bottoms, handling curved surfaces at bow and stern, and recessed areas such as bilge keels. Although the technology is available, it needs to be rolled out and made widely available at competitive prices. But time is on the side of robotics, and so is industry interest.

Robotic hull cleaning, akin to swimming pool cleaning, is progressing from research to commercial service

New ideas waiting in the wings

Ultrasonic vibrations cause very high accelerations, which destroy the cell structures of algae and weed. The technology has progressed from research to industrial applications. So far, ultrasonic antifouling requires oscillators ('transducers') every 6-8m. For a cargo-ship, this would mean hundreds of transducers, many in areas that are difficult to access. Reliable operation in double bottoms filled with water or fuel may need more research.

But already, transducers are a very attractive complementary technology to protect recessed areas, such as cooling-water pipes or sea chests. These areas are difficult both to paint and to clean, an issue that will become an even larger headache when currently regional biofouling management regulations (e.g. for Australia or California) are applied on a wider global scale. A strong point of this approach is that it offers biocide-free protection for ships even at zero speed. Feedback from pioneering operators is mainly positive.

The "young challengers" are maturing with a growing number of in-service reference applications preparing the ground for wider acceptance. Biocide-based coating will remain king for years and maybe decades to come, but vendors and buyers are getting smarter and "performance" is being monitored by both sides. The leading coating vendors have just begun to tap into their data treasures on how each coating performs where under which conditions, yet already we can see that this new approach is impacting the market dynamics. Performance monitoring insight allows better decisions on coatings and maintenance, ultimately fostering faster evolution to better hull management on a global scale. *NA*

Is ultrasound the future of biocide-free antifouling systems?

Ultrasound has been keeping biofouling at bay in land-based industries for decades. After nine years of successful marine R&D in smaller craft, the technology is now becoming a regular feature in larger commercial ships and offshore applications, writes NRG Marine's Dominic Findlow

Biofouling is estimated to add US$60-100 billion annually to commercial shipping costs. This includes increased fuel consumption, drydocking costs, coating application and downtime. Biofouling also accounts for about 30% of lifecycle corrosion.

The power increase required to maintain a certain speed is a good indicator of the effect that fouling has on fuel requirements and associated greenhouse gas emissions. Compared to a clean bare metal surface, a fresh coating of paint requires a 2% rise in power for a large commercial ship to maintain the same operating speed. Light slime over the entire hull will need an 11% power increase and calciferous fouling can require over 60% more power to maintain the same speed.

Figure 1: A typical engine room installation

The current regulatory situation

In the 1990s, the IMO's Marine Environment Protection Committee (MEPC) set out a framework to "reduce and eventually eliminate the use of antifouling systems which are harmful to the environment". Their work has been the driving-force behind the development of almost all antifouling systems ever since.

The Biocidal Products Regulation (BPR) was brought into law in 2012 and covers the approval of biocide products applied to vessels within the EU. The latest product approval window closed in 2016. With BPR approval, manufacturers are licensed to produce the approved biocide system (the formulations of which have yet to be published) for 10 years.

So, the current 'line in the sand' for biocides that rely on copper (or other poisonous metallic compounds) is 2026. At that point, systems containing biocides will have to be re-submitted for approval, which is a very long and expensive procedure.

Coatings industry insiders fully expect that many of the current biocides will be discontinued within the next seven years and that alternative biocide-free systems will become increasingly popular before the deadline. The increasing demand for future-proof anti-fouling solutions will, in turn, allow coating manufacturers the requisite investment to help create better biocide-free systems.

The future for biocide-free systems

While legally permitted, biocidal coatings (and systems) will still account for the vast majority of antifouling systems. However, there are various types of biocide-free systems that are available and gaining traction with operators looking for a less toxic way to protect their vessels.

Fouling Release Coatings (FRCs) – Coatings like poly-di-methyl-siloxane (PDMS) influence the mechanical properties of organism adhesion. They are expensive to develop and rarely effective when the regular hull speed (or internal flow speed) is under 20knots, like most commercial shipping operations. FRC's are also difficult to apply. They require meticulous surface preparation and dedicated paint lines. The finished surface is also not as resistant to physical damage as current alternatives.

Textured Surfaces – These coatings mimic naturally occurring surface textures that are resistant to bio settlement. Broad

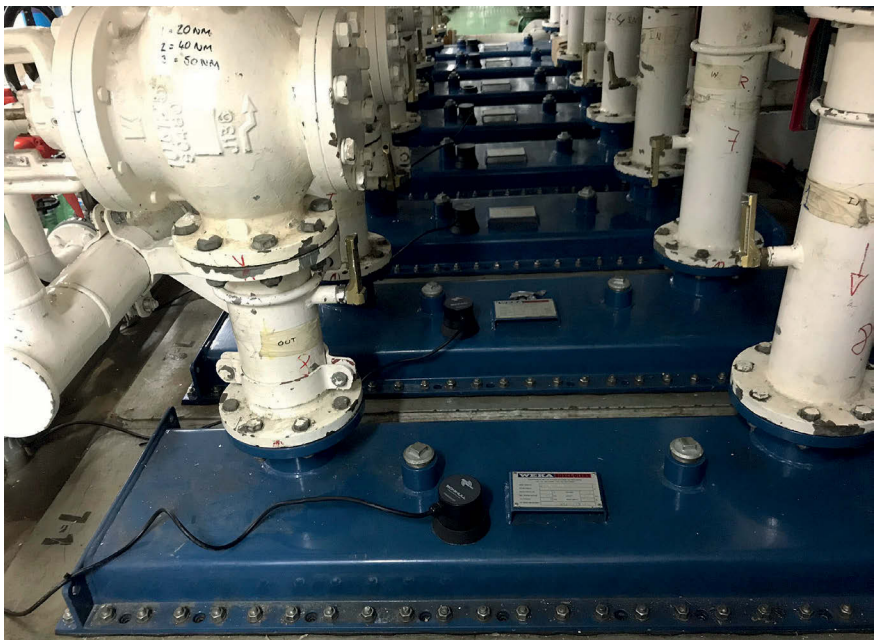


Figure 2: Bank of box-coolers with Sonihull ultrasound transducers bonded to the water covers

spectrum efficacy has been difficult to achieve for coatings using poly-methyl-meth-acrylate (PMMA).

Selektope – The marine antifouling variant of the drug Medetomidine has been shown to slow barnacle swimming response and is effective at keeping molluscs and barnacles at bay without long term harm. However, it is not effective for the control of slime, algae or weeds, so poisonous booster biocides are still needed to maintain efficacy.

Advanced Self-Polishing Co-polymers (SPC) – Nippon Paint's new Aquaterras SPC uses the science and materials used in medical anti-thrombogenic polymer technology that prevents clotting in vascular surgery. Hydrophilic and hydrophobic surface chemistry combines to naturally prevent biological adhesion.

Electrical fields – These have proved difficult to install and operate in large maritime applications.

UV-light fields – These solutions have shown to be effective against animal and plant-based fouling, but they have, so far, proved impractical to install on full-scale applications.

Figure 3: Typical Anode service items in an impressed current antifouling system

Ultrasound – Marine versions of systems already used in food, brewing and aquaculture industries to prevent biofouling are now being used successfully in many marine environments. They are a regular feature in commercial vessel cooling equipment and full-scale hull applications are also being trialled.

Ultrasound – penetrating the commercial sector

The adverse effects of bio-fouling are usually expressed in terms of water passing over the external hull, but the same issues impact the interior surfaces too. Areas like box coolers and their associated sea chests and raw seawater (RSW) pipe work are critical to the safe and efficient operation of main engines and auxiliary equipment.

The growth of ultrasound antifouling systems in the commercial sector has been driven by ship operators looking to reduce their operating costs and maintenance schedules. One key area is the protection of internal cooling systems where pressurised heat exchange pipework is surrounded by RSW.

Traditionally, sea chests and the box cooler pipework are protected from biofouling with impressed-current systems which require the box cooler to be drilled, welded and inspected after fitting. These systems bathe the cooling elements with poisonous metal ions which circulate round the sea chest making it an uninhabitable environment. The metal ions are released back into the ocean as the RSW is continually refreshed via the hull grates.

Impressed-current antifouling systems require the vessel to be drydocked with the box coolers drained and they need to have their anodes replaced regularly to maintain performance. This all adds to the installation and MRO costs.

With ultrasound systems, solid-state transducers are bonded to the box cooler covers and to the dry side of the sea chest by means of a mounting ring. In newbuilds, aluminium or steel mounting rings can be welded into place during manufacture. For retrofits, composite mounting rings can be bonded in place using epoxy resin. The systems can even be installed at sea while the vessel is operating. Standard OD pipe fittings can also be supplied to fit the outside of all kinds of pipework.

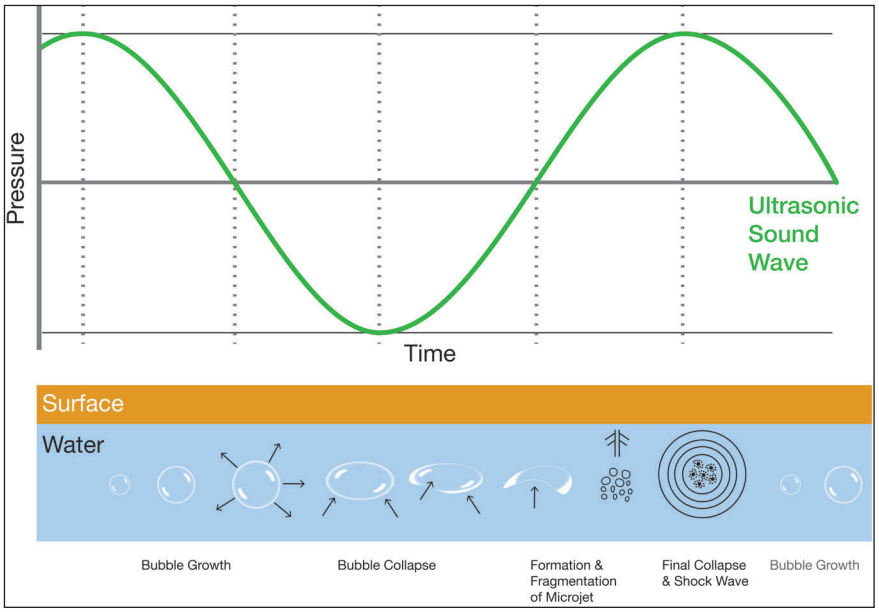


Figure 4: Graphical representation of the ultrasound-induced non-inertial cavitation process

Ultrasound can remove the poisonous environmental legacy of biocides, there are no expensive anodes to replace, no microplastic pollution and there is virtually no maintenance. The systems work with all types of metal and coatings, apart from silicone based antifouling paints which can absorb as much as 40% of an ultrasound signal.

How ultrasound antifouling systems work

Ultrasound systems, such as NRG Marine's Sonihull range, usually consist of a central control unit that is mounted somewhere in the engine room and wired to single or multiple ultrasound transducers, which are bonded to the dry side of the pipework or structure being protected.

In the Sonihull system, the transducers produce multiple bursts of ultrasound in a range of frequencies from 19.5kHz to 55kHz, well beyond the human and aquatic-mammal audible spectrum.

Pulses from the transducer are transmitted into the equipment being protected, producing a pattern of increasing and decreasing pressure on the wetted-surface. Microscopic bubbles are created through the process of non-inertial cavitation. Bubbles are created as the pressure drops and are imploded as the pressure increases.

As well as preventing the creation of a biofilm, the micro-jets created during bubble collapse prevent barnacle and mussel larvae from embedding on the surface.

Non-inertial cavitation is similar to 'inertial cavitation' – the process that can damage propellers or the insides of pumps. But the forces involved with non-inertial cavitation are much lower, so there is no chance of surface damage, erosion or pitting.

Typical results after 12 months service in a box cooler installation are shown in Figure 5. Photographed from the bottom of the sea chest looking upwards, the red surfaces visible are the sides and top of the sea chest with the seawater inlet grate visible to the right. All of these surfaces have been kept fouling-free by two Sonihull ultrasound transducers. A third transducer was mounted on the water cover of the right-hand box cooler, which also remains clear of any fouling. The left-hand box cooler was not fitted with a transducer and has fouled-up considerably.

Figure 5: Ultrasound antifouling results inside a box cooler after 12 months of service

Conclusion

Ultrasound antifouling systems demonstrate an unmatched combination of qualities. They provide effective bio-fouling without the poisonous environmental legacy of biocides, metal compounds or microplastics. They are also easy to install and can reduce lifetime costs by up to 90% compared to similar impressed-current anti-fouling systems. They will also reduce maintenance costs, extend maintenance intervals and can facilitate quick mothballing and re-activation without dry-docking.

There are also no penetrations while fitting and everything is bonded to the dry-side of the RSW handling equipment, pipework or hull, which removes the requirement for extra classification surveys, testing and documentation.

Currently there are around 94,000 ships in the world merchant fleet, with a total capacity of 1.9 billion DWT. This figure doesn't account for the vast array of other structures in the ocean, from wind turbines and offshore oil platforms to fish farms and floating solar arrays.

By adopting existing ultrasound technologies, marine industries can meet the economic and environmental challenges created by biofouling without restrictive capital costs, without unnecessary downtime and without a toxic environmental legacy. *NA*

About the author

Dominic Findlow is Technical Director for NRG Marine Ltd

Multipurpose vessel segment makes a cautious recovery

Heavy lift sector slowly regains its strength as MPVs benefit from surge in renewables and new infrastructure investments

After a prolonged downturn, the multipurpose (MPP) sector has finally found a hint of relief.

According to Drewry, the UK-based maritime research consultancy, the multipurpose vessel (MPV) and heavy lift sector will see an annual average growth of 1.2% to 2023. In the short term though, this looks even stronger, at 3.8% for 2019 and 1.4% in 2020.

"The recession in the wider shipping industry hit the MPP sector particularly hard and we are only now seeing green shoots of recovery – albeit slow," says John Pittalis, marketing and communications manager at AAL Shipping.

Despite the fact freight rates still sit below break-even levels while consolidation and further cost-cutting continues to loom, the trade wars, tariff threats and slowdown of emerging markets witnessed last year have finally ceased. Additionally, relations between the US and China have somewhat stabilised (though sudden combustion is possible) and global unemployment levels remain low.

"2018 was another tough year for MPP operators, with several players ceasing operations following massive losses, as well as many defaulting on their financing contracts and becoming financiers' distressed assets," says Pittalis. Last May, Zeamarine was formed as a joint venture between Zeaborn and Intermarine while German-based Hansa Heavy Lift filed for insolvency in December. "Although the market remains tough, there are some more positive signs emerging."

A growth in infrastructure and construction in expanding cities across the Middle East, Africa and South East Asia have enlightened the sector with a cautious optimism.

One of the segment's greatest supports though, is renewable energy. The international surge for renewables – wind energy in particular – has driven the need to move massive, heavy and irregularly shaped equipment like wind blades and towers. Such project cargo is ideal for large MPVs, which can both lift and stow the equipment.

The *AAL Kobe* arriving at the Port of Felixstowe

However, the MPP sector as a whole is not basking in this positive news.

Drewry has noted that MPVs with a heavy lift capacity of less than 100tonnes are in decline and expects this downward trend to continue for the "foreseeable future". It estimates these smaller vessels could see a drop of nearly 3% each year through to 2023.

In contrast, vessels with a lift capacity of over 100tonnes are increasing at a rate of around 2% per year. Most newbuild deliveries and orders are of this category.

The tendency over recent years has been to build ships with 250tonnes cranes and space for heavy equipment, while scraping smaller vessels with less than 100tonnes of lift capacity.

Popular mechanics

This uptake has benefitted heavy lift fleets such as AAL's second-generation 31,000dwt A-Class MPVs. With the ability to accommodate multiple cargo types on a single journey (breakbulk, project cargo and dry bulk commodities) and an intake of 40,000cbm, AAL's A-Class vessels offer shippers significant economies of scale, says Pittalis.

In April of this year, one of the Singapore-based company's A-Class vessels, the *AAL Kobe*, made its first call to the UK at Felixstowe – the country's busiest cargo port. Built in 2012, the 193.9m long MPV features a combined 700tonne max lift, five cargo holds with an intake of 40,000m^3, two tweendecks and a 2,700m^2 weather deck. Two supplementary cranes, situated at the fore and aft, have a lift capacity of 50 and 100tonnes respectively.

The vessel is an example the market's evolution towards ships that can transport oversized objects as well as various bulk and container products. Such an MPV also offers shippers the opportunity to call at smaller ports, which may lack landside cranes but are closer to the cargo's ultimate destination.

"The Kobe serves our global tramp chartering services, where her flexibility and mega-size are put to good use by a

broad mix of customers, representing multiple industry sectors like oil gas, mining, infrastructure, energy and leisure," says Pittalis.

Engineering challenge

While shipments unique in shape, size and weight have triggered a welcome rise within the sector, such market demands have subsequently heightened the challenges transport engineers face.

"The safe transport of such heavy, extremely large and expensive project cargo takes months of planning to properly consider, plan and prepare for each stage in the loading, sailing and discharge operation," says Nicola Pacifico, head of transport engineering at AAL.

During its call at Felixstowe, the *AAL Kobe* discharged four 32m, 200tonnne rubber tyred gantry (RTG) cranes that had been built and shipped from Shanghai. The task of loading, transporting and discharging such giant heavy lift project cargo is an extremely challenging engineering operation, says Pacifico, in which every detail must be exact.

Loading and unloading of very tall cargo requires considerable lift, lift height and outreach of the ship's cranes in order to ensure enough clearance of the hatch covers. The crew must work at great heights during rigging, derigging and lashing procedures as the lifting pad 'eyes' are located near the top of the RTGs, meaning third-part aerial man-lifts are required as well.

"Not only does this add an additional layer of complexity and oversight to the operation but using such equipment also costs money and limits the number of people able to work simultaneously and so ultimately increases time needed," explains Pacifico.

"Securing each RTG unit and understanding its structural integrity is another critical aspect of such a transport operation as RTGs tend to uplift and tip due to their high centre of gravity. Long lashings from the very top of each unit are required and enough clear deck space, to allow for their safe fastening to deck, must be calculated for."

Other aspects that need to be considered when shipping RTGs is the installation of carriage supports, which hold the RTGs off-deck for a more stable load-spread, and the ship's visibility.

Navigating through channel passages and high traffic areas can be difficult with large cargo, so to improve visibility, radar systems and special cameras may be fitted in certain cases.

The discharge of cargo is an equally delicate process as loading. After its arrival in Felixstowe, the *AAL Kobe* employed its anti-heeling system and both of its main cranes – drawing power from two of three 975kW Wärtsilä Auxpax gensets – to carefully unload the RTGs. *NA*

Making the case for green ammonia

A new study explores the feasibility of fueling ships with ammonia produced by onshore renewable energy and concludes that investment is the key

Published by Environment Defense Fund Europe, a division of the the US-based nonprofit environmental advocacy group, and in partnership with the engineering consultancy Ricardo, the 'Sailing on Solar' report drills down into the economics, logistics and technology required to make environmentally sustainable ammonia.

Because most industrial ammonia production (using the Haber-Bosch process) comes from hydrogen derived from the cracking of natural gas it still contributes to CO_2 production (see *The Naval Architect*, June 2018). However, IMO's target of cutting GHG emissions by 50% by 2050, fortified by a number of reports into the feasibility of various emission-free fuels, has seen ammonia emerge as one of the most promising candidates. Its potential has also been endorsed by future fuels studies by classification societies such as Lloyd's Register and DNV GL.

Unlike hydrogen, ammonia does not require cryogenic storage, has greater energy density (12,714 MJ/m^3 compared to liquid hydrogen's 8,791 MJ/m^3), can be processed using either internal combustion engines or fuel cells and a global storage infrastructure already exists through its use in the fertiliser industry. Another idea gaining traction is that of using ammonia as a means of chemically transporting surplus renewable energy generated by wind and solar power.

But unlocking this potential, the report suggests, will require investment in sustainable industrial infrastructure, including renewable electricity plants, to create a global energy supply chain. Given that some of the countries with the most abundant sources of renewable energy are themselves developing nations creates both a challenge and opportunity to reinvent the global energy supply chain.

As suppliers of green ammonia uch nations could be assured of a long-term revenue stream that could support their own economic development. But there exists something of a chicken and egg scenario: without the current demand there is no justification for the significant outlay when local energy demand is already being adequately met by fossil fuels.

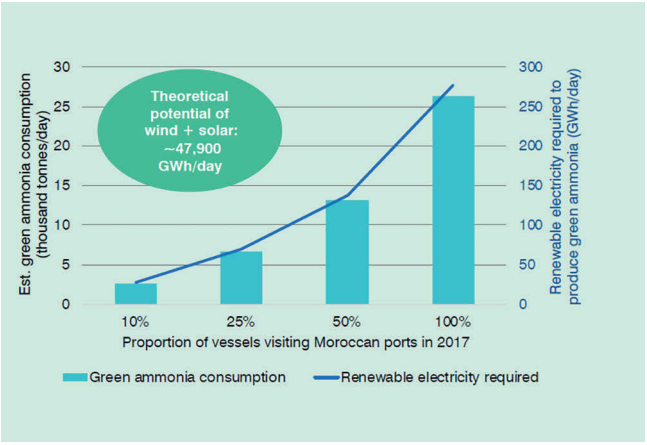


Figure 1: Annual amount of electricity needed for green ammonia production for bulkers and container ships passing through Moroccan ports. Source: Environment Defense Fund Europe

Morocco case study

With its location in the Straits of Gibraltar, large commercial ports (collectively ranked 33rd in the world for container throughput) and easy access to many key shipping routes, Morocco was selected as the ideal candidate for a case study. The country already has a long history in generating hydroelectricity, but this is now being bolstered further by the building of wind and solar plants.

The potential for offshore wind along the Moroccan coastline has been estimated at 250GW, 25 times the existing plant capacity in the country, enough to supply green ammonia to roughly a third of the global shipping fleet. Similarly, the Western Saharan region is identified as having great potential for scaling up solar production close to shore.

As home to around 75% of the world's phosphate reserves, Morocco has a mature inorganic chemistry sector, with ammonia already being imported to the Jorf Lasar port for a local chemical production facility. This is stored near the port in refrigerated tanks with a total capacity of 100,000 tonnes, equivalent to the theoretical daily ammonia fuel consumption of 500 post-Panamax vessels. The report suggests there is ample land in the area surrounding the port that might furnish sufficient solar energy to provide 700 tonnes of green ammonia per day, or the daily fuel consumption of four post-Panamax vessels, which would generate an annual revenue of US$194 million.

Around 280 gigawatt-hours (GWh) per day would be sufficient to produce green ammonia for all the ships passing through Morocco's ports, based on 2017 figures and assuming each vessel took on an average of 45 days worth of fuel. This figure presents just 0.6% of Morroco's theoretical 47,900 GWh/day wind and solar potential (see Figure 1). The drawback, inevitably, is the cost; at around US$100 billion to develop the green ammonia plants and renewable electricity facilities (70-80% of that cost comprising of the latter), it would clearly require significant commitment from multiple players.

Green ammonia consumption in 2050

To estimate the kind of green ammonia production that would be necessary on an international scale to meet shipping's requirements, the report took growth projections from the 2014-published *Third IMO Greenhouse Gas Study*. Drawing

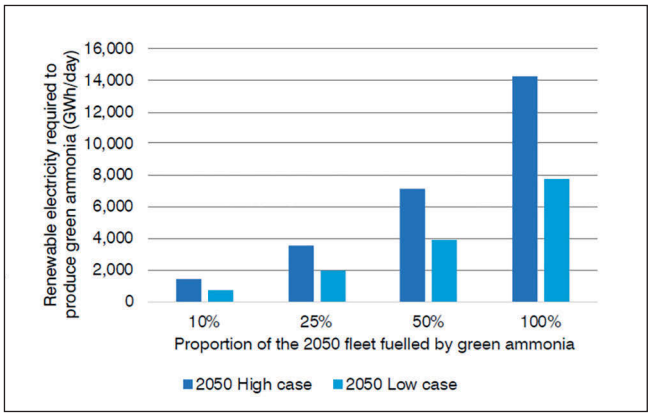


Figure 2: Renewable electricity required to produce green ammonia for the international shipping fleet in 2050

upon two of the 'shared socioeconomic pathways', it looked at two scenarios for the situation by 2050 – SSP1 'Sustainability' (High Case) and SSP3 'Fragmentation' (Low Case) – and considered whether 10%, 25%, 50% or 100% of the global fleet was using ammonia (see Figure 2). Under the 2050 High Case this would amount to approximately 1.35 million tonnes/day or 493 million tonnes/year, or around 2.8 times global ammonia production in 2017.

A typical post-Panamax vessel would require ammonia production requiring 1.9GWh of electricity per day, or equivalent to 117,000 EU citizens. In terms of solar energy to cover the combined global fleet of container ships and bulkers, under the High Case scenario, an area equivalent to 296km^2 would be needed.

The report emphasises that unlike traditional ammonia production, green ammonia production is still in its relative infancy. Moreover, the electrolysis for green ammonia requires high quantities of water; an ultra-large container vessel would need ammonia production of around 380kl/day and this might also require desalination depending on where the water was drawn from. Choosing the optimal choice of renewable electricity production will also be heavily dependent on where the ammonia plant is located.

Vessel propulsion

The report considers the four basic options by which ammonia might be used for ship propulsion:

- Combustion in an internal combustion engine
- Combustion in a gas turbine
- As a 'hydrogen carrier' in a hydrogen fuel cell system
- Chemical reaction of ammonia in a solid oxide fuel system

Research undertaken by Siemens as part of the Oxford, UK, based Green Ammonia project has already shown that a small off-the-shelf engine can run off ammonia without modifications. MAN Energy Solutions is also heavily engaged in this area. In February, the engine manufacturer reported it was working with Kyushu University in Japan on ammonia combustion tests for its MAN ME-LGIP engine, with the hope of having an ammonia-combustible engine fully tested within two and a half years. By contrast, gas turbines, although widely used in naval vessels, require higher fuel consumption which has deterred uptake for merchant shipping and makes it unlikely ammonia will be heavily researched.

Given the ubiquity of large diesel engines, these are anticipated as being the entry point, but in order to achieve IMO's 2050 targets uptake will need to begin during the 2020's (see Figure 3). One of the drawbacks with ammonia combustion is that it has both a limited flammability range (15-25%) and low propagation. This impacts its effectiveness at the extreme ends of the speed range and means ammonia may need to be supplemented by a secondary fuel, whether that is a fossil fuel, biofuel or hydrogen. It could be that the growing popularity of LPG, for which storage tanks are often situated above deck, might allow for the additional storage space for ammonia tanks below deck.

The report suggests that rollout of fuel cells may be a more protracted process that doesn't get fully underway until the 2030's, with proton exchange membrane (PEM) being favoured until solid oxide-based technologies reach maturity. The advantage of solid oxide systems is that they can receive the ammonia directly, without hydrogen cracking.

Conclusions

Ammonia, the report summarises, is the most technically feasible carbon-free solution for maritime in the immediate future, but that in order to compete with fossil fuels the "externalities" of these fuels need to be taken into account. Moreover, policies will be needed to incentivise its deployment, and it implores the IMO to discuss "as a matter of urgency" options to bring forward investment.

"The immediate focus should be on establishing policy that will drive the uptake of fuels that have zero climate impact on a lifecycle basis, taking into account consequences for direct and indirect emissions. Green ammonia should be considered in that fuel mix. Such policies should include regulatory requirements for the safety and environmental effectiveness of these fuels," it states. *NA*

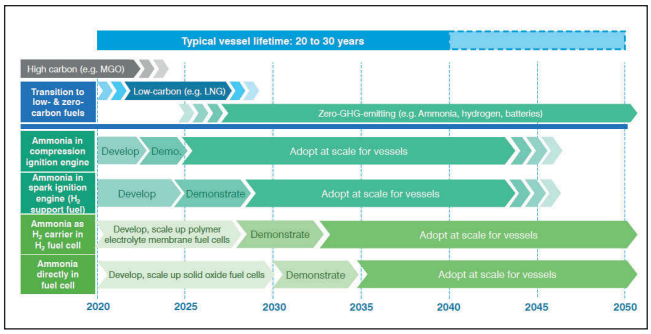


Figure 3: Technology roadmap for ammonia propulsion technologies

Measuring vessel speed with radar

A new radar-based method of accurate speed through water measurement, which could negate the need for acoustic Doppler current profiling, has been developed by Norwegian company Miros AS

Accurate measurement of speed through water (STW) and ocean surface currents plays an important role in vessel fuel optimisation. An increase of just a couple of knots can increase the daily fuel consumption of a ship by several hundred tonnes, significantly impacting profit. Beyond that, STW measurement also plays a key role in hull performance estimation, navigating in restricted waters and estimating the drift of, e.g. oil spills or floating objects.

However, using underwater instrumentation on moving vessels involves a number of uncertainty factors, not to mention the installation and maintenance of expensive equipment. Sensors, such as acoustic Doppler profilers, are vulnerable to disturbances to vessel motion caused by air bubbles, turbulence or, in some cases, they may not have been correctly calibrated. Fouling of the equipment while immersed in water can also compromise readings.

But with improvements in hardware and algorithms, it's now possible to read STW and ocean surface currents using X-band radar images, removing the need for underwater equipment. Developed by Norwegian technology company Miros AS, the Wavex Virtual Sensor (Wavex) system instead measures the current using radar images covering local areas that remained undisturbed by structures such as the vessel hull. The relationship between the current and STW, as well as the GPS-provided speed over ground (SOG) is represented by:

$$\vec{v}_{STW} = \vec{v}_{SOG} - \vec{U}, \qquad \text{(eq 1)}$$

where $\vec{U}$ is the current vector.

Wavex takes images from a marine navigation X-band radar, which can be either the existing radar system or a dedicated one, that are then digitised by Miros hardware developed specifically for this application (although if an Internet Protocol (IP) radar has been used it's possible to take this digital feed directly). For the best results the radar should be operating in short pulse mode and with a wind speed of 2-3m/s so that there is electromagnetic backscatter from the ocean surface.

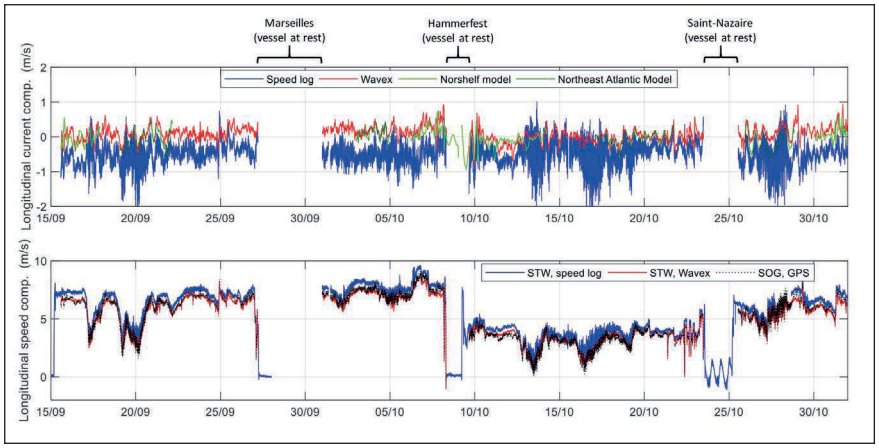


Figure 1: Overview of longitudinal current components and STW during six weeks of operations

The digitised radar feed is then processed by algorithms to generate the STW, wave and current data. During configuration (and whenever they should wish to reconfigure) the user is able to define a number of Cartesian image sections for which measurements are performed. 3D Fast Fourier transforms (FFT) are applied to subsequent Cartesian images in time, and these spectra provide information about the power present at various wavenumbers and frequencies.

The novel approach developed by Miros uses established methods based on the dispersion relation between wave frequencies of ocean gravity waves for zero current:

$$\omega_0^2 = g|\vec{k}|\tanh(|\vec{k}|d), \qquad \text{(eq 2)}$$

where ω_0 is the wave frequency, $\vec{k}$ is the wavenumber vector, is d the water depth and g is the gravitational acceleration. If there is a surface current relative to the radar, a Doppler frequency radar is introduced in the wave frequency:

$$\omega = \omega_0 + \vec{k} \cdot \vec{U}. \qquad \text{(eq 3)}$$

This causes the energy in the 3D spectra to be located on ellipses rather than circles. The STW and current vector estimates

Table 1: Deviations between longitudinal current components from Radar-based (Wave) system, speed logs and models

	Radar-based vs.		Speed log vs.		
	Norshelf model	Northeast Atlantic model	Norshelf model	Northeast Atlantic model	Radar-based vs. speed log
Offset (m/s)	-0.08	-0.11	0.49	0.46	-0.56
RMS dev. (m/s)	0.24	0.20	0.55	0.49	0.59

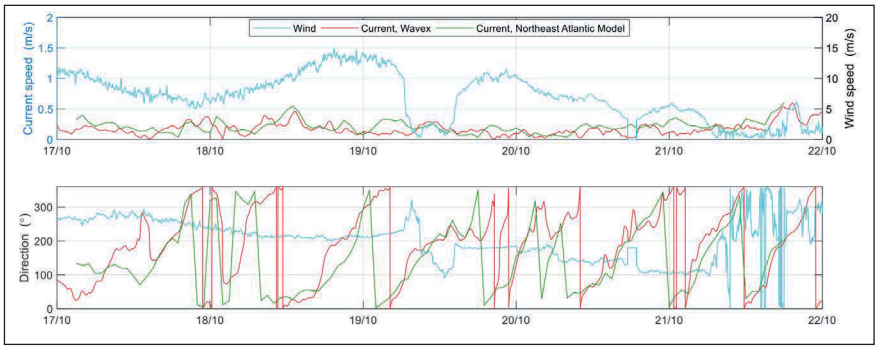


Figure 2: Time series of current and wind data for Arctic Lady over a five-day period covered by the Northweast Atlantic Model

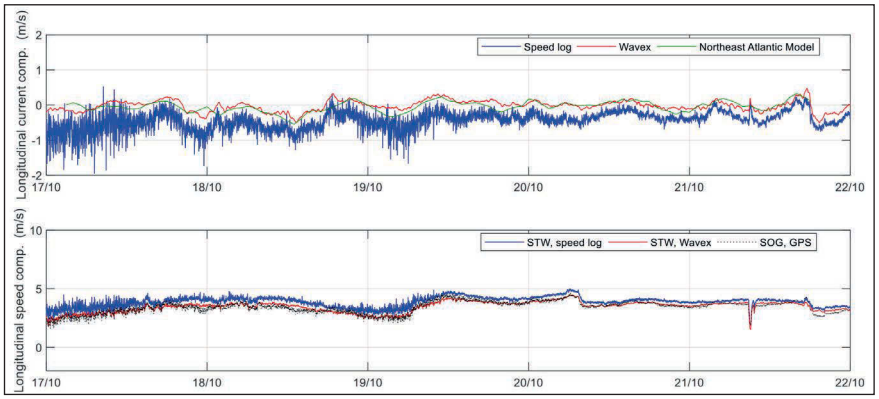


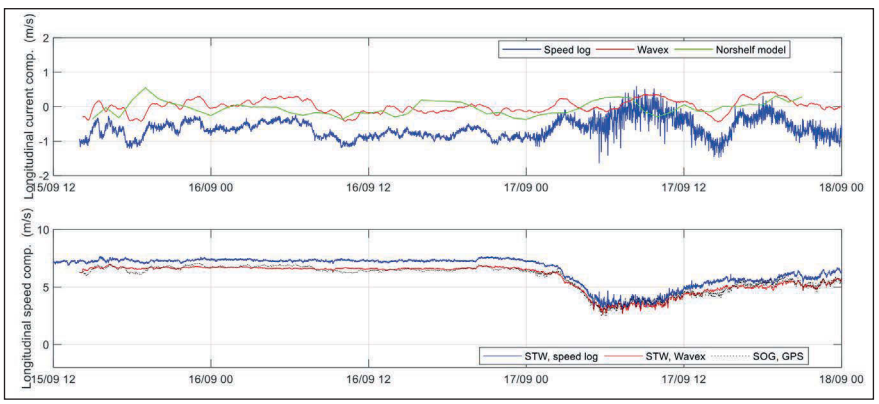
Figure 3: A comparison of the STW for the acoustic speed log, Wavex and GPS for the same five-day period as Figure 2

are based on the power distribution in the wavenumber-frequency spectra.

Miros is continuing to refine these estimate processes, with new innovations including a method for utilising full power distribution properties and improved motion compensation. It also hopes to improve performance in conditions where there are high-speed currents and a low signal-to-noise ratio.

Wavex pilot systems have been installed on vessels using X-band radar and compared against theoretical models. Among these is the Höegh LNG tanker *Arctic Lady*, which regularly travels between Hammerfest, Norway, and Marseille and Saint Nazaire in France. In addition, *Arctic Lady* is equipped with the widely used JLN-550 Doppler Sonar acoustic speed log. It also receives current data from both the Norwegian Meteorological Institute's Norshelf model and the Irish Marine Institute Northeast Atlantic Model. Measurements were taken over a six-week period between September and October 2018.

Figure 4: Comparison of the STW for the acoustic speed log, Wavex and GPS for a five-day period covered by the Norshelf model



For convenience, and because STW is closely linked to current measurements, it was decided to make current measurements the basis for statistical comparison. To compensate for different averaging strategies, and smooth out any temporal offsets between the various data sources, a 40-minute centred average filter was applied to the time series (see Table 1).

Figure 1 gives an overview of the longitudinal current components and STW during the six-week duration of the measurements (there are three gaps when the systems were switched off while at port). Figure 2 focuses upon a five-day period of current and wind data covered by the Northeast Atlantic Model, during which wind speed varied from 0-15m/s. Currents in this region are relatively homogenous, making comparison easier.

The longitudinal current component and STW during the same five days, without any additional averaging (Figure 3), indicates that the radar-based system produces smoother data than the acoustic speed log, something also reflected in Table 1. While the reasons for the additional noise in the speed log data aren't entirely clear, this disparity in speed log data would translate into a significant difference in fuel consumption.

By way of comparison, there is greater variation for the longitudinal current component and STW during a period covered by the Norshelf model data (Figure 4), where wind speeds range from 0-19m/s and there are both more local eddies and less homogenous currents. However, it still shows smoother data than the speed log.

Miros is confident that the tests have proved X-band radar images can provide reliable and accurate STW data, and that Wavex installations produce less noisy measurements than underwater speed logs, away from the chaotic conditions of the vessel hull. *NA*

The article is based on a whitepaper published by Dr Rune Gangeskar, Senior Development Manager, Sensors, at Miros. For the full document please visit: *www.miros-group.com/resources/speed-through-water*

COMPIT comes of age

Nick Danese reports on proceedings at this year's Conference on Computer Applications and Information Technology in the Maritime Industries conference, and notes a growing maturity in attitudes towards the role of computing in ship design

The 18th iteration of COMPIT marked a coming of age for this unique, research-focused conference, tirelessly orchestrated by the timeless Volker Bertram. The discretely plush Tullamore's Bridge House Hotel was the perfect set for the occasion, which was well celebrated by the variety of papers coming from four continents.

Perhaps, an in-step coming-of-age in the industry may have taken place, too: quasi-absent triple integrals and partial derivatives with imaginary numbers were replaced by a somewhat sobering recurrence of the notion that Artificial Intelligence (AI) and Autonomous Ships are still products of human programming and, hence, not human-error free by definition. One may wonder whether the current AI paradigm used in word processors to auto-complete, auto-correct and translate by affinity is to be considered a representative preview of coming events. Lean, Agile, Gartner Hype Cycle and progressive PLM implementation based on a solid Business Process Assessment were finally discussed beyond the confines of SSI's Denis Morais' precursor presentations in previous years. Even neural networks and the Pareto Frontier – applied to PLM implementation, of all things – have been polished up on the background of the widening, and luckily now finally seen by many, generation gap.

The very commercial and long-term notion of total cost of ownership of complete processes – as opposed to that of just products – was discussed, if not the focus of more than one paper, and the Generative Design to real structure example presented might have very well have been the first theory-to-practice effort of its kind in this industry. Also, from an applied research angle, discussion on how to palliate the absence of legislative and regulatory guidelines and rules when it comes to designing and operating autonomous vessels – autonomous being a definition presented as unclear at best – highlighted the issue of the huge and growing technological progress/law gap to the commercial world, opening a whole new branch of marine, non-engineering research.

Hans van der Tas of DEKC Maritime presented on Communicating Ship Designs via Virtual Reality

In a quasi-first principles approach, freely available AIS data is being used in new ways to enhance both the forensic and the predictive digital twin and applied to the analysis of ship navigation patterns and to collision prevention.

On the other hand, the question is raised of whether some may be missing the very forward-looking COMPIT mission statement. For example, results of research in the multi-author, distributed, collaborative, multi-platform, etc. environments – an established reality in so many other industries – questions the long-term added value of work carried out by the 'major' software houses to incorporate modern technology, including but not limited to AI, into their arguably monolithic legacy programs.

One may also argue the relative short vs long term value of efforts aimed at composing a diversified, collaborative environment made up of legacy software produced by a geographically compact group of companies, an approach which does not exorcise the lamented multiple file conversion, one of several plagues, and exploits state-of-the-art technology in a rather limited fashion. It was pointed out (again) that we are "several years behind", and a little web searching confirms that breakthrough technologies and practices announced in our industry are often well established in other sectors. In parallel, at least one author proposed a truly agnostic self-explanatory format already used by many and available to all to create a truly open data environment with intrinsic connectivity to ERP and PLM databases of all kinds.

Going on a start-up buying spree à la GAFAM (Google, Amazon, Facebook, Apple and Microsoft) may not be advisable, but one cannot ignore the growing influence of technologically advanced mainstream companies well present in our industry, either.

Irrespective of opinion, throughout three days of assorted sessions all papers were undeniably interesting, informative and in more than one case, instructive.

ZEN and the art of CASD

Gaspar's 'A perspective on the present, past and future of computer aided ship design' describes how advances in Computer Aided Ship Design (CASD) solved many practical

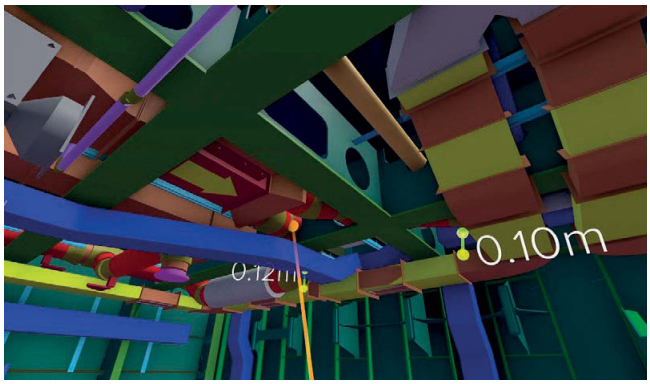
issues but also how these solutions are not implemented at the enterprise level or made to share common data sets. Rather, they remain a disparate collection of niches of ever more specialised software applications sporting limited data exchange capabilities. Moreover, Gaspar notes how the complexity of setting up and implementing a PLM system is compounded by a fragmented IT scenario, cultural resistance to change and a widening generation gap. The effort spent to make it all work causes resources to be wasted in data conversion, and therefore, not available to critical design work components.

Siemen's *Sears et al.* discussed the use of Model Based Enterprise strategy with Product Breakdown Structure logic to support engineering-to-order, similarly to industry standard products like ShipWeight (weight/CG estimation) and CostFact (cost estimation).

Bole introduced hull design as an Agile design tool and Hollister presented 'OpenCalc – an Open Source Programming Framework for Engineering', a remarkably agnostic, pragmatic and ubiquitous approach to the free-for-all exploitation of distributed and collaborative environments. Using XML files, author-specific data of any kind is intrinsically documented via the embedded and human-readable schema, making it directly available to any consumer, be this a person, a program, a machine, a dashboard or a process. Also fundamental in a non-proprietary, distributed scenario, by definition this approach makes available weakly redundant data sets. For example, same-type data produced by different authoring tools can be chosen by individual consumers as a function of the use to be made of the data itself.

Optimisers do it better

Sobey et al. compared legacy and modern genetic algorithms of specialised and generalised types on structural optimisation and internal layout problems, the clear winner overall being the cMLSGA of 2018. *Van Dijk et al.* reported how 'Automatic Selection of an Optimal Power Plant Configuration' now involves not only overall propulsion efficiency but also alternative fuels and clients' preferences. The algorithm indicates fuel cells are the preferred but still a higher cost option.



Knud Hansen's ShipSpace solution was among the VR tools discussed

Harries et al. detailed progress in the 40-plus team working on the Holiship initiative to build a CAESES-based flexible design platform aimed at creating a "synthesis model in a bottom-up approach".

All simulations great and small

Goodwin et al. illustrated the practical application of generative design to a real structural component taking into account changing constraints. Similarly, Donohue et al. approached a General Arrangement design by the probabilistic mapping of dependencies between layout and system configurations. This approach matches very well with the still very ignored functional design requirements of nowaday's heavily system-laden ships. In 'Discrete Event Simulation for Strategic Shipyard Planning' Min et al. approach the overall shipyard problem via a process-centric simulation, improving productivity by facility expansion and layout changes.

VR-Tigo

Gaming technology (finally) enters the industry: Spencer et al. depart from commonly used, high cost mainstream VR strategies to build ShipSpace, a significiantly lower cost yet high performance and realistic VR environment via Head Mounted Displays employing VR collaboration tools, the use of which in an up to 64 participant environment is illustrated by *Goh*, who also lists a number of ensuing tangible benefits. *Van der Tas et al.* examined CFD analysis results in full-immersion VR, while *Cassar et al.* use VR to support Human Factor Engineering by identifying and accounting for crew requirements, constraints and limitations, be they objective or subjective.

Come Together (,technologies)

Ommani et al. present an iterative ship-digital twin model strategy allowing for what-if studies and operational changes in the context of a simulation-based decision support system aimed at an offshore platform's station keeping. They also highlight a core issue of simulation, that is how to replace simulation components with newer ones, or add more, while preserving the reliability of the process overall. *Sieranski et al.* discussed the relative merit of implementing a 'Best of Breed' approach that makes use of distinct, specialised tools but might result in a discontinuous design process vs a monolithic, all-in-one, less discipline specialised systems delivering a lesser quality overall result, the preference going to the fomer. *Seppäla* revisited a paperless scenario in 'Drawingless Production in Digital Data-Driven Shipbuilding', reporting significant reduction in the paper documents required by the shipyard after adopting electronic viewers and highlighting that: "CAD . . . is an example of how a small innovation became the backbone of the regime . . . it can become the cradle for all IT systems . . .", a platform-centric view (CAD in this case) different from Hollister's.

Digital Twin

Huikkonen et al. combine AIS and other public weather data coupled with structural models to estimate remaining ship structure fatigue cycles using 3D panel methods and FE analysis, while *Drazen et al.* compose a 'System of Systems' digital model to increase situational awareness and predict future ship condition and performance. From an Industrial Internet

DNV GL presented on pitfalls of e-learning, including VR based surveyor training

of Things (IIoT) perspective, *Nowak et al.* use on-shore digital models to improve and design new, on-board edge analytics in an iterative process. Poignantly, they point out that sensors and gauges must be located appropriately and of the highest reliability.

Tutti Frutti

Colling et al. documented constraints and costs of applying platooning to river trains, and another look at crew reduction (in easyJet style) by automating navigation tasks was taken by *Kooji et al. Deul et al.* proposed an expert system to depart from the by-weight paradigm and assist in capturing the rationale, reasoning and decision-making process in estimating the cost of ship structure. *Herrero et al.* reviewed various main stream AI initiatives in detail, with special attention paid to Autodesk's Dreamcatcher and the IBM/Foran-cognitive engine.

Seeing eye-to-eye with AI

Stensrud et al. described constraints in applying machine learning to drone inspections in low-light, GPS-denied environments with the sobering insight that more data may lead to worse results. *Weymouth* improves 'Roll Damping Prediction Using Physics-Based Machine Learning' by up to 200% using a very scarce training set, a notable development in solving a very computational-intensive problem. In a first, *Chatzikokolakis, et al.* propose to generate alerts by using AIS data to statistically detect anomalous navigational behaviour of ships.

Digital Training

Bertram et al. provided a comprehensive overview of the many digital training options available and conclude that classroom training remains a valid option, too, as many digital options are made either unfeasible by cost or ineffective by the very human nature of those undergoing training. *Kil et al.* developed virtual training scenarios based on the ISM Code using a VR gaming multiplayer supporting platform, to which *Schmidt et al.* add student/instructor roles, allowing for scenario changes on the fly, reminiscent of sci-fi movies.

Smooth Operator

Like *Hollister*, *Cady* proposes an agnostic and autonomous microservice architecture based on asynchronous communications via message queues, advocating the use of hi-tech commonplace Chaos Engineering for troubleshooting. This approach might well evolve into a condition or prediction-based adaptive service environment and fits very well with Hollister's data model's architecture. Combining AIS and hindcast weather data with parametric resistance estimation, *Son et al.* estimated the fuel consumption of a meaningful set of ships and documented the waste of fuel due to the navigational rush-to-wait. Erikstad proposed continuous onboard motions and slamming monitoring to support operational decisions, while *Uzun et al.* computed the Total Cost of Ownership, down to the factory's carbon production, of using antifouling paints. Uncommonly and equally realistically, *Porathe* proposes that AI and machine learning should be a time-unlimited, andromorphic process, one of the goals being computers learning awareness. *Wahlström et al.* follow with a discussion on whether machine learning and AI can actually become capable of "taking perspective" and "feeling" a situation, a basic feature of social cognition present in human decision-making. *Berge et al.* as well as *Steidel et al.* proposed collision avoidance strategies combining anticipation of the other ship's action and data exchange between ships leading to negotiation-capable, safer autonomous ships.

Unmanned Ships on the Horizon

Eriksen's very interesting and somewhat metaphysical discussion of 'what is autonomy, really', and by corollary an autonomous ship highlighted that humans remain in the loop from programming of AI algorithms to remote control. In this respect, *Walther et al.* studied the requirements of supporting increased situational awareness in tug operation eventually leading to effective remote control. Similarly, *Yan et al.* discussed applying AI to steer unmanned passenger ferries across the very densely busy Yangtze river.

The AI operator is supported by combined onshore and onboard navigational data that provides extended situational awareness. This already in-use AI system is of particular interest because it creates an immersive, augmented awareness scenario, used by the AI operator and AR-monitored from onshore, achieved by synchronising and streaming field data collected from geographically distinct sources using a variety of technologies, very possibly a first of its kind. Might this be not that far a cry from the on-call, physical weight-supporting holograms seen in last year's blockbuster film *Black Panther*? *NA*

About the author

Nick Danese is the founder of Nick Danese Applied Research (NDAR), a consultancy specialising in Business Process Assessments, Implementation Consulting and engineering system integration of software such as ShipConstructor, MAESTRO, ShipWeight, Express Marine GHS and Navisworks in distributed, collaborative environments. He regularly presents at events on of ship design and construction.

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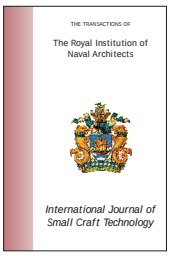

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londoninternationalshippingweek.com

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www.transtec-neva.com

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www.rina.org.uk/ICCAS_2019

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www.inmex-smm-india.com

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www.pacific2019.com.au/index.asp

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www.gem-exchanges.com/smartship

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www.kormarine.net

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The Royal Institution of Naval Architects

International Conference: Wind Propulsion

15-16 October 2019, London, UK

In Association with:

International Windship Association

Call for Papers

The current use of alternative fuels and renewable energy sources within the shipping industry is still relatively scarce. Growing environmental legislation and concerns are driving the need to develop and apply innovative alternative power and propulsion technology for ships. Now, industry players are increasingly putting a modern spin on one of the oldest concepts in shipping: harnessing the power of wind for ship propulsion. RINA and International Windship Association (IWSA) invites papers from designers, class societies, operators, researchers, and builders on all related topics, including:

Market level assessment

- Wind propulsion market future trends – effects of policy, regulation, price…
- Developing world markets – challenges, opportunities and designs for wind propulsion solutions.
- How does wind propulsion perform in the small vessel market, inter-island ferry, workboats…

Concept level assessment

- The challenge of technical barriers to deploying wind propulsion rigs - stability, navigation, etc.
- Optimization and integration of retrofit installation on existing vessels.
- Wind propulsion and classification – pathways to a standardised approach.

Technology level assessment

- How maximising wind propulsion benefits impacts the way we operate ships.
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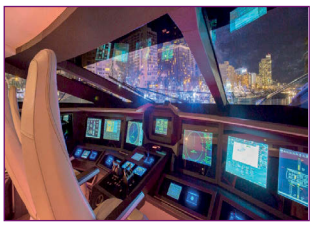

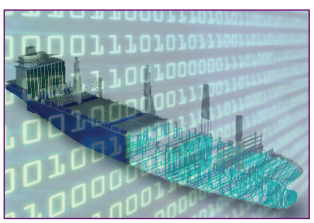

Call for Papers

Industry 4.0, otherwise known as the fourth industrial revolution, is coming to the marine industry. While there are still some technical challenges to overcome, much of the technology is already available and is starting to be applied to real world design, construction and operation problems. However, there are still regulatory, class and public perception challenges to overcome before all of these advances can become a reality. This conference seeks to explore relevant technologies and their application to the maritime industry, including:

- Smart sensors
- Networked technology (IT/IoT/Comms)
- Intelligent data analysis
- Artificial Intelligence (AI)
- Advanced robotics
- Additive manufacturing (AM)
- Augmented and mixed reality
- Constrained and fully autonomous operations

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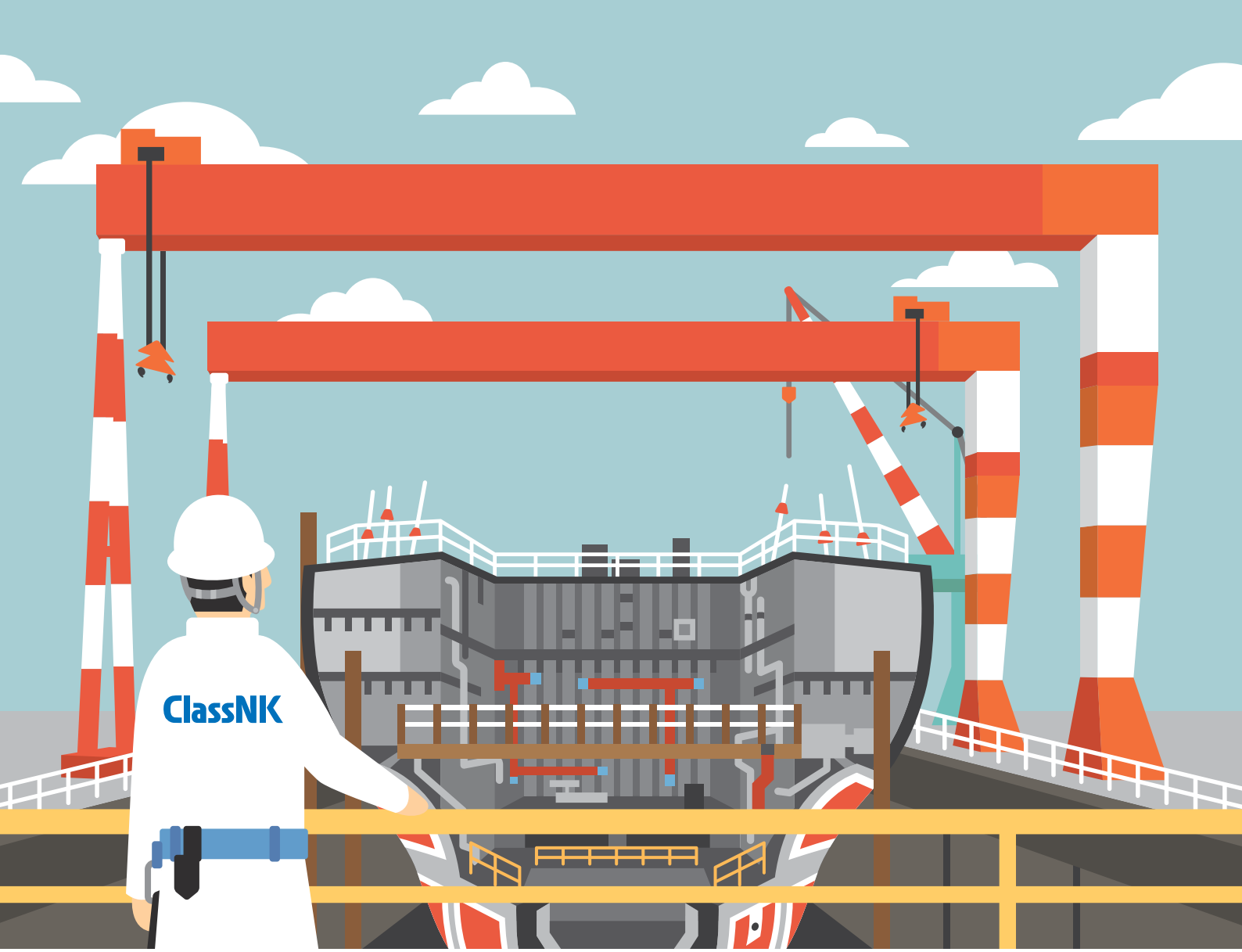

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