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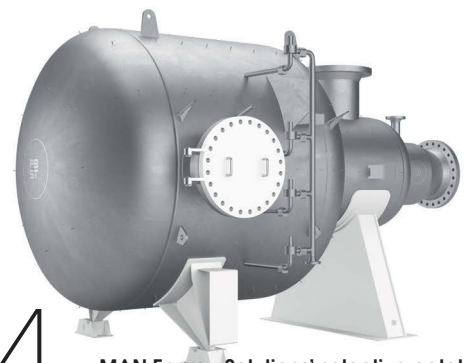

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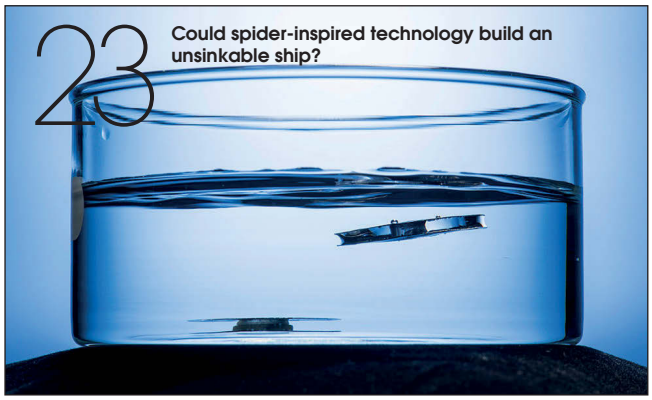

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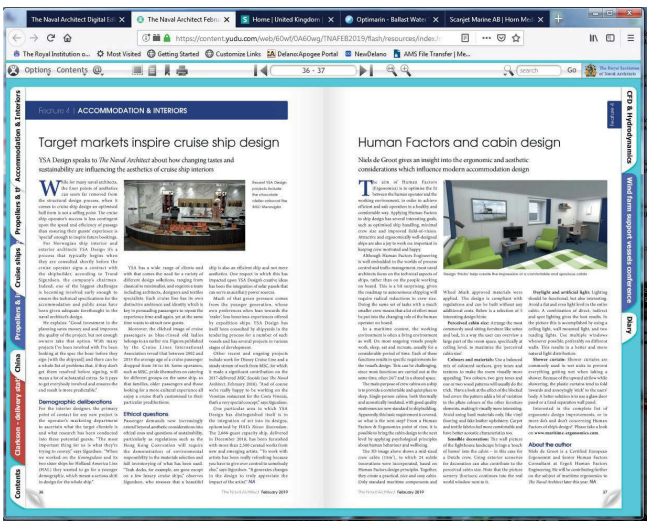

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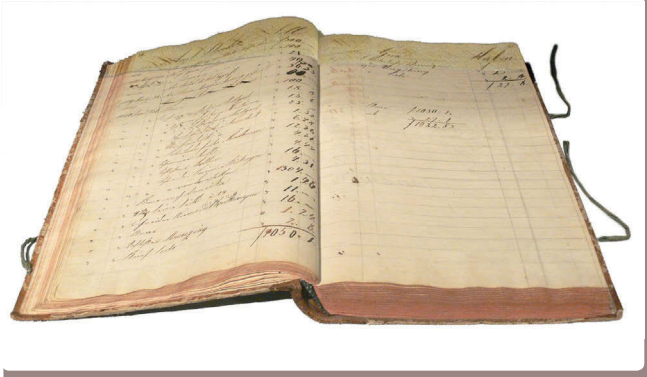

Don't let shipping's carbon accounting become a Fiddler's Green

Can we believe the numbers in the carbon ledger books?

The cult author B.S. Johnson wrote a satirical novel, *Christie Malry's Own Double-Entry*, in which the title character, a young man disaffected by society, decides to start applying the standards of double-entry bookkeeping to his own life. For each wrong he perceives the world has done him he calculates the 'cost' to himself and exacts a commensurate recompense in kind, noting down the corresponding figures. By the end of the story these perceived injustices have become the justification for mass poisoning and an attempt to blow up Parliament.

In the real world such dubious accountancy would seem ludicrous. After all, parenting a given number of children doesn't put you in credit to commit an equivalent number of murders (to borrow from something I saw tweeted recently). Yet a not dissimilar mindset appears to have been legitimised with regard to the offsetting of carbon emissions and shipping is becoming as guilty of it as any other sector of business or society.

On p20-21, as part of our Eco Ship Technology feature, you'll find a report on decarbonICE, an extraordinary Danish initiative which proposes that vessels cryogenically freeze their CO_2 emissions during transit and deposit them overboard as large capsules of dry ice. These capsules will then descend to the ocean floor and become embedded in the soft sediment, where it will be permanently stored as CO_2 hydrate.

Ships currently running on fossil fuels could continue to do so, secure in the knowledge there was no contribution to global warming. Meanwhile, those smaller and coastal vessels for which a switch to synthetic and biofuels was viable would mean that shipping's net contribution to emissions was carbon negative.

That's the theory, and the decarbonICE team will readily point to scientific evidence they've amassed to support it. The trouble is at present there's no prototype, no trial project and no proof of concept. I've no doubt of the sincerity of ex DNV GL CEO Henrik O. Madsen and the various project partners involved, but at the moment all we have is the curious ideas of ships being equipped with a dry ice-pooping Heath Robinson (or Rube Goldberg, if you're American) contraption.

Several months ago (*TNA*, November 2019) I used this column to discuss green technologies and some of the more dubious claims made for their benefits. The same reservations apply, with interest, to Carbon Capture and Storage (CCS), both for maritime and other industries. There's no shortage of proposed CCS solutions, from storing CO_2 within the porous structures of basalt rock or limestone to depositing it in disused North Sea oilfields.

Last October, parties to the London Protocol provisionally agreed an IMO resolution allowing the transportation of CO_2 across national boundaries for sequestration purposes. Again, it's purely theoretical, given that no CCS technology has been granted approval for this purpose nor is likely to for several years. Moreover, in many cases there remains questions whether these really are permanent storage solutions (i.e. the CO_2 won't leak back into the atmosphere at some later point) or if the processes are too energy consumptive to create an overall benefit. Similar concerns abound regarding carbon offset projects, which are largely unregulated and in many cases make wildly exaggerated claims for their effectiveness.

Let's be clear, there's a growing acceptance that it may be necessary to address the symptoms before it's possible to find the cure. Attending a DNV GL press briefing in February (see p.8) there was something refreshing about the pragmatism with which it was suggested gas-based fuel solutions may be the best on offer for the foreseeable future, that maritime needs to reconcile itself to short-term pain for long-term gain. In the wider world, even the environmental left is coming around to the idea that stop-gap solutions may be necessary, while cautioning that we cannot allow them to be a final solution.

The pressure on shipping to show its commitment to tackling GHG emissions is only likely to build over the next few years, but the temptation for recourse to fallacious claims and misleading terminology risks doing further damage to its reputation.

'Carbon neutral', 'carbon negative', 'net zero'... no doubt these will be joined by further buzzwords and expressions on the road to 2050, bandied around with alacrity by shipowners and marine technology providers seeking to promote their virtues. But to gauge progress, the bottom line needs to be unambiguous, effective measurement of energy consumption, and the resulting emissions, from well to wake.

However promising CCS technologies and offsetting projects may appear, and the desire to shout about them, they need to be kept firmly away from the carbon bookkeeping until they can be independently verified and quantified. We need less carbon accounting and more accountability. *NA*

Wind propulsion

Wind-assisted propulsion project sets sail

The EU-backed WASP (Wind Assisted Ship Propulsion) project has overseen its first commercial installation of a wind-assisted propulsion system, using eConowind Ventifoil technology.

The 3,600dwt cargo vessel, MV *Ankie*, built by Jan van Dam Shipping, was docked at the Royal Niestern Sander shipyard in January 2020 for the first retrofit eConowind Ventifoil wind-assist system. The installation comes six months after the fitting contract was signed between Van Dam Shipping and eConowind. The companies believe that the Ventifoil technology will offer ships a considerable saving and could be an influential solution for IMO 2030 and 2050 decarbonisation goals.

The modular Ventifoil units (wings featuring vents and an internal fan which use boundary layer suction) will generate force and allow the ship to reduce its motor power and save energy. Initially the two installed wings will be 10m, but in its second stage the units will be extended by another 6m.

eConowind BV has developed its wind-assist system over three years, using support from the European Union backed grant, WASP. Design approval, foil production and construction supervision, and the commissioning protocol preparation for the product has been carried out by RINA.

MV *Ankie* has already sailed its maiden voyage featuring the newly installed wings for Netherlands ship operator Wagenborg, travelling from Delfzijl to Hamburg and onwards to Norway, then finishing back to Rotterdam. This first journey is a significant breakthrough in Jan van Dam Shipping's aim to combine wind propulsion and modern shipping, which the company has spent nearly 40 years pursuing. "We expect to show in the WASP research project this first step will be economically feasible. We are hoping to set the next steps as well in a new-to-build ship in the coming years, getting step-by-step into low and even zero emission shipping," the shipping company states.

Key wind-assist propulsion installation on the MV *Ankie*

Classification society

Shipping must capitalise on gas, warns DNV GL

DNV GL's maritime CEO, Knut Orbeck-Nilssen, says the class society believes that gas will have a crucial role to play as a bridging technology for achieving IMO's carbon targets.

Speaking to journalists at a press briefing in London on 18 February, Orbeck-Nilssen warned that with measurable GHG savings in the region of 15-20%, shipping needs to capitalise on the gas infrastructure that is readily available, adding that it could be the best fuel choice for the next two generations of vessels.

"I know a lot of people talk about gas as a bridging fuel, but it's a pretty long bridge and I think that it's likely to be at least relevant for maybe 20 or 40 years into the future," he observed. "Should we all just wait and hope that in 10, 15 or 20 years' time there will be a better alternative? I can guarantee that will not help us reach the IMO targets."

Addressing the issue of methane slip from gas-burning engines, Orbeck-Nilssen added that the problem has been drastically reduced with modern systems and further reductions can be expected. Noting the findings of a recent report by the International Council on Clean Transportation (ICCT) concerning the climate implications of using LNG as a marine fuel, he criticised its focus on four-stroke engines over two-stroke, which are expected to comprise two thirds of LNG fuel consumption in the future and have higher GHG savings potential.

Moreover, while the ICCT report had taken a 20-year perspective on global warming, DNV GL favours the United Nations Framework Convention on Climate Change (UNFCCC) 100-year outlook. Over this longer timeframe methane's potency as a GHG declines considerably.

However, Orbeck-Nilssen also stressed that LNG and LPG alone and will not be sufficient by themselves to solve global climate change. "I think it's important to have an open mind about what these other alternatives can be, and which we are investigating, researching, piloting and testing. But there is the possibility of phasing in those better options for the future for on the back of gas."

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Orbeck-Nilssen highlighted DNV GL's support of the International Chamber of Shipping's (ICS) initiative to establish a carbon levy fund, based on a US$2 surcharge on every tonne of fuel consumed by ships. Although such a fund would only raise around US$500 million per year, the class society believes it is a preferable option to an emission trading scheme.

Hydrogen

Liquid hydrogen to power Norwegian coastline cruises

The FreeCO2st project, a collaboration between Norwegian companies, has announced its plans to install a 3.2MW hydrogen fuel cell and battery system onboard a Havila-owned coastal cruise ship. In accordance with impending Norwegian regulations, the project aims to achieve zero emission operations throughout the World Heritage Fjords and sections of the country's coastal route.

Designed in Norway by Havyard Design for Havila Kystruten AS, four 122.7m long coastal cruise ships are under construction at the Tersen Shipyard in Turkey, one of which will be fitted with the hydrogen fuel cell system.

All four vessels will initially be fitted with an integrated LNG and battery power system and are due to begin voyages along the Norwegian northern coastline, between Bergen and Kirkenes, from January 2021. To begin with, this battery will allow for zero emission cruising for approximately 10 hours, supported by LNG. Once the liquid hydrogen fuel cell is installed, it will not replace the LNG system, but extend the hours possible for emission free cruising.

In order to obtain an Approval in Principle for the hydrogen system, the FreeCO2st project is working on design and power requirements with both fuel cell supplier PowerCell and tank supplier, Linde. Norwegian Electric Systems (NES), another member of the FreeCO2st project, will oversee the integration of the combined hydrogen-fed fuel cell and battery system.

"For larger vessels and longer routes batteries will not have enough power or capacity. Here, we need to look at other solutions, and fuel cells are part of this solution. However, we cannot use fuel cells powered by hydrocarbons, so, with the growing acceptance and production of hydrogen, we looked at integration of a liquid hydrogen tank and the required fuel delivery system," says Stein Ruben Larsen, Senior Vice President of Sales, NES. The company adds that it is excited to lead integration efforts on what is claimed will become the world's most advanced clean coastal cruise ship when the planned retrofit is completed in 2023.

CAD/CAM

Aveva launches marine design software update

UK-based industrial software company Aveva has announced a marine sector-specific update to its AVEVA E3D design software, offering an increased efficiency for ship engineering and design.

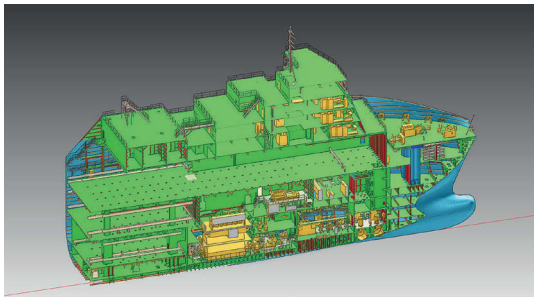
The Aveva E3D design software uses user interface technologies and 3D graphics in combination with advanced data management. The software is designed to reduce emissions by increasing shipping vessel design and accelerating ship retrofits. According to Aveva, the new technology offers improved efficiency and new tools in anticipation of market needs following IMO 2020 emission targets.

The company says that the updated software can help with effective resource management and achieving an error-free production process. It also includes the Aveva Hull Basic Design Module that can be used in the preliminary stage of hull structure design. The module is intended to assist with decision-making in naval architecture characteristics, space management, outfitting design and drawings.

According to Ravi Gopinath, COO, Aveva, the new software will generate up to 40% gains in engineering efficiency for marine operators, as well as guiding them to operating models which will help protect the environment.

"With this latest software release, Aveva is responding to the ever-growing and changing needs of ship owners and shipyards the world over. Meeting sustainability goals, maximising business agility and improving operational performance calls for integrated design and engineering tools that can streamline the process, improve speed and remove cost and complexity to rapidly address these market imperatives," Gopinath states. *NA*

A multi-discipline outfitting design based on the real hull data



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Shipping hit by virus and slow progress at PPR7

February was expected to bring more information on the availability and characteristics of 2020 compliant fuels and see shipowners preparing for the impending ban of HFO carriage on non-scrubber equipped ships, writes Malcolm Latarche

As it transpired, it was an unexpected problem of a very different sort that has dominated the headlines – Coronavirus. Although the death rate of this new threat has not reached the level of the SARS outbreak of 2002, the death toll is much higher as evidence suggests it's far more contagious. The most publicly visible impact on shipping has been the case of the cruise ship *Diamond Princess* moored in Japan with a full complement of passengers and crew in effective lock down for several weeks. There have been other cruise ships affected too, with one apparently having been refused entry to several ports before finding an available berth.

But cruising is just a small part of shipping and the effect on other areas, if less public, has likely been more of a problem. The actions taken by the Chinese authorities to extend the New Year holiday and to isolate affected areas has meant that trade volumes have been significantly reduced, leading to falls in freight rates. Fortunately, the price of oil has also dropped meaning cheaper fuelling costs which has offset some of the freight revenue loss.

Shipbuilding and repair is also suffering. Some delays in newbuilding delivery may not be a bad thing given the drop in trade but disruption to drydocking schedules looks to be leaving some vessels unable to install scrubbers and ballast water treatment systems, as well as having to make arrangements to extend certificates until space becomes available.

There are some anecdotal reports of ships not being able to obtain spare parts or stores, which has implications for maintenance and safety. In addition, routine port calls are beginning to be affected as some states and port authorities introduce restrictions on crew being allowed ashore and shipowners suffer consequent difficulties in making crew changes.

It may be sometime before the epidemic subsides and things return to near normal again but then will be the time to count up the cost to shipping. Some analysts have already predicted it will run into billions of dollars in lost time and reduced freights and that will come on top of the expenses in meeting the 2020 sulphur cap and installing ballast treatment systems.

The end of January and early February saw an exchange of open letters between environmental groups and industry bodies in advance of the IMO PPR7 sub-committee meeting on the question of black carbon (briefly alluded to in last month's News Analysis). That was followed by calls for rapid action banning HFO in the Arctic due to the risk of pollution from a fuel spillage incident.

The argument that the new VLSFOs are more aromatic and contribute to higher black carbon levels was refuted as being unlikely since evidence suggests that they are more likely to be paraffinic. As it transpired, PPR7 decided that further experience in building and research was needed on both fuels and engine operating parameters and setting limits on aromatic content of fuels would be premature.

The demands for a quick block on HFO were also refused by the meeting although there was some move towards an eventual ban. A draft regulation was drawn up for further discussion at MEPC 76 in October. The draft proposes that there will be no change in the use and carriage of HFO in the Arctic before the middle of 2024 when the regulation takes effect. The ban would also be phased in over a five-year period leading up to July 2029. IMO member states with Arctic territorial waters will be allowed to set their own rules for domestic vessels.

There were other contentious matters discussed at the meeting including how to deal with cybutryne, a component of some antifoulings for which there has been a movement to ban for some time now. The meeting recommended that new systems should be avoided and existing ones sealed but a final decision is to be considered by MEPC 75 meeting in March.

Further debate on biofouling centred upon updating the IMO guidelines on the subject. Controlling biofouling looks set to be the next environmental battleground for shipping but there is a feeling that the current guidelines lack clarity in some areas and are impractical due to a lack of facilities. It was agreed that more research was necessary.

The issue of washwater from exhaust gas cleaning systems was left open for a further year with the only agreement being reached on the scope of work and a need for further research. Other matters discussed included methods for testing ballast water discharges but there was no time for debate on how engine multi-mapping might be permitted under the NOx Code. *NA*


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Communications

Wärtsilä and Carnival implement just-in-time sailing solution

Technology group Wärtsilä, along with its project partners Carnival Maritime and the Hamburg Vessel Coordination Centre (HVCC) have announced the first successful implementation of Wärtsilä's Navi-Port solution.

Described as the first commercially available ship-to-port communication platform, Navi-Port is a bridging software (or middleware) product that works in conjunction with Wärtsilä's Fleet Operations Solution (FOS) system, a online platform for ship-to-shore reporting and fleet performance management. Navi-Port facilitates exchange data between ports and ships, so that the ship's speed automatically adjusts to achieve just-in-time arrival and more cost-effective planning of port operations.

Wärtsilä Navi-Port is the first commercial product to apply the port call message standard as defined by the Sea Traffic Management (STM) Validation Project which was completed in 2019.

HVCC, which is responsible for traffic coordination into and out of the Port of Hamburg, has in recent years been a forerunner in terminal-carrier communication. In 2019 alone, it distributed more than 3,800 passage plans to its customers.

Navi-Port was tested onboard two Carnival cruise ships, *AidaSol* and *AidaPerla*, with the two vessels' Wärtsilä NACOS Platinum navigation systems connecting directly with HVCC, allowing continuous communications between the ship and port. The applied solution has been granted Approval in Principle from Bureau Veritas in meeting the class society's cyber security requirements.

Navi-Port aims to synchronise the Estimated Time of Arrival (ETA) with the Requested Time of Arrival (RTA)

"Wärtsilä's Smart Marine Ecosystem approach is aimed at eliminating wasteful practices in shipping operations, and the Navi-Port solution does just that. Collaboration between industry stakeholders is a key enabler to our approach," says Torsten Büssow, Director, Voyage, Wärtsilä.

Batteries

Corvus to supply batteries for zero-emission ferries

Corvus Energy has been selected to supply the energy storage systems (ESS) for three new battery hybrid ferries being built for Finnlines. The battery solution will form part of a Hybrid Power Conversion system being developed by Wärtsilä for the project and will allow zero-emission operations in port.

First announced in 2018, the Knud E Hansen-designed ferries, described as the most modern and environmentally friendly ro-ro's ever built, are currently under construction at Nanjing shipyard in China. A variety of other efficiency technologies are planned for the 238m (5,800 lane-metres) vessels, including energy efficient engines, scrubbers and a Silverstream air lubrication system. The first vessel is expected to arrive in 2021.

"There is significant potential for fuel and emissions reduction in ro-ro ships as they are normally on fixed routes," believes Roger Rosvold, Corvus Energy's SVP for sales. "Finnlines [has] invested heavily in technology for all their vessels to reduce emissions. Combined with a series of operational measures such as timetable planning and route optimisation, as well as optimising speed, load, and trim."

Ballast water management

Panasia BWTS approval cancelled by Korean court

Ballast water treatment system (BWTS) manufacturer Panasia could be facing costs of up to KRW100 billion (US$84.5 million) after a South Korean court cancelled the type approval status of its systems.

The Seoul Administrative Court declared that 48 units supplied as part of Panasia's GloEn-Patrol range had been invalidated because the number of UV lamps in the systems sold to shipowners differed from that indicated in the plans submitted to Korea's Ministry of Oceans and Fisheries, according to local reports. A lower number of lamps would influence the disinfection rate of the system.

Panasia is appealing the ruling, which has been suspended until 20 March. However, if upheld the manufacturer faces replacing the BWTS for all affected vessels. No information was available on which 48

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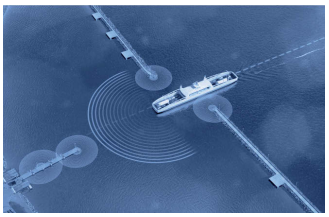

Remote and autonomous ships have the potential to redefine the maritime industry and the roles of the players in it with implications for shipping companies, shipbuilders and maritime systems providers, as well as technology companies from other (especially the automotive) sectors.

The operation of remote and autonomous ships will need to be at least as safe as existing vessels if they are to secure regulatory approval, the support of ship owners, operators, seafarers and wider public acceptance.

RINA invites papers from ship designers, builders, operators, classification societies, legislative government bodies and organisations/companies with experience in other related autonomous domains, on topics including:

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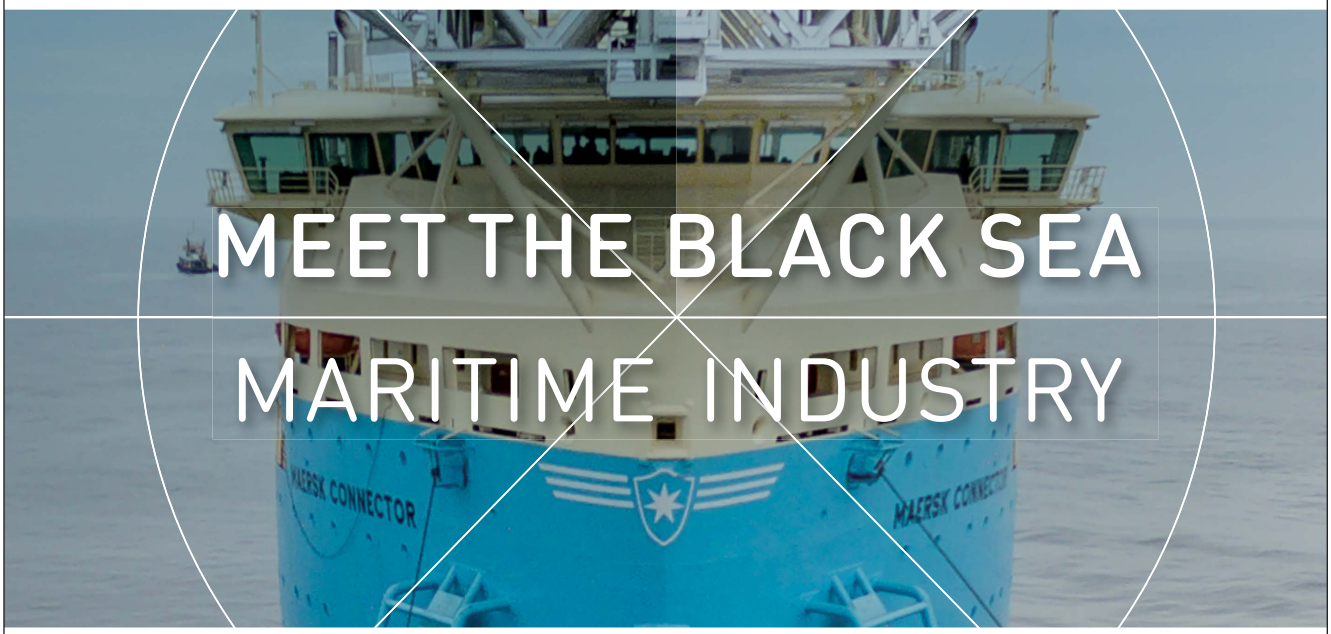

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vessels are affected but around 1,100 vessels worldwide have GloEn systems installed.

Hybrid propulsion

Kongsberg seal Mystic deal

Kongsberg Maritime has secured a contract to supply its hybrid propulsion system to three adventure cruise ships currently under construction for Portuguese operator Mystic Cruises, as well as a fourth vessel due to follow.

The Norway-based company will provide main engines, auxiliary engines, motion control, propulsion, power electric systems, automation and control systems for the 126m, 9,300tonne luxury vessels, which are being built at WestSea Viana Shipyard. The hybrid technology allows the engines to run at variable speeds to minimise fuel consumption and emissions. As part of the package, Kongsberg will also provide dynamic positioning technology to negate the need for anchors and protect ecosystems on the seabed.

Delivery of the equipment is due to take place across 2020 and 2021 on a per-vessel basis. Mystic Cruises, which commenced operations last year with the delivery of *World Explorer*, currently has three vessels in service catering for the growing market for expedition vessels. Designed by Italian naval architect Giuseppe Tringali, the Ice Class ships are able to reach destinations inaccessible to larger cruise ships.

Emissions control

First high-pressure SCR gets class endorsement

MAN Energy Solutions and its licensee, low-speed engine manufacturer Makita Corp, have jointly announced that they have received ClassNK's approval for a cluster-3 high-pressure selective catalytic reduction (SCR-HP) system after testing at Makita's works in Japan.

Produced under MAN's PBST brand, the SCR-HP system, which is said to be the most compact on the market, was developed for four vessels originally ordered in 2018 and 2019, each of which is equipped with a MAN B&W 6S46ME-B8.5 engine. The first such engine was ordered by Kanax Corp, for a 39,000dwt bulker built by Shin Kurushima Toyohashi Shipbuilding.

The SCR-HP system at Makita Corp's testbed

MAN first introduced the SCR-HP concept in 2017 based on its experience with four-stroke engines. Its internal catalytic reduction process, which uses specially developed honeycomb materials and an integrated mixing unit, is achieved with a significantly smaller reactor by comparison with typical designs.

"The results from the engine shop test were quite spectacular, with the PBST SCR-HP system able to undercut the currently valid IMO III NOx values of 3.4g/kWh by more than 1g/kWh," says Ralph Klaunig, PBST's VP of sales and license turbochargers & exhaust gas.

Low-sulphur fuels

Infineum fuel additive combats IMO 2020 challenge

Chemical company Infineum has launched its fuels additive package, Infineum B201, which addresses fuel stability and compatibility issues that occur when blending IMO 2020 compliant fuels.

The company has conducted laboratory tests on Infineum B201 as well as field trials, which were in partnership with an undisclosed international oil company. The field trials confirmed that the additive package is able to stabilise total sediment potential (TSP), prevent instability of VLSFO fuel blends onboard ships, and extend the fuel blending window.

Infineum believes that the properties of Infineum B201 demonstrated during these tests could solve problems that the shipping industry faces with the introduction of very low sulphur products. Steve Benwell, Global Fuels Venture Manager at Infineum, comments that one of the major routes for VLSFO production to meet IMO 2020 legislation is the blending of high sulphur residual streams (aromatic) with low sulphur distillate streams (paraffinic) to produce compliant fuels. But the challenges that occur when blending fuels can be critical.

"This comes with risk as asphaltene-containing aromatic streams tend to be incompatible with paraffinic components and can result in asphaltene drop out which can significantly hinder ship operating conditions, or in severe cases cause engine failure," Benwell adds. *NA*

Digital Transition 4.0

Volker Bertram, Dept. Mechanical and Mechatronic Engineering, University of Stellenbosch, looks forward to some of the digital trends and developments to be discussed at COMPIT 2020

Have you been warned about the digital disruption today? We all seem to get daily messages about how our industry is going to be disrupted, how empires will fall, and new ones will rise, if only we... But maybe we should say goodbye to the concept of disruption. The digital transformation of our industry is a fluid process. We can't even pinpoint when it started. Was it when we introduced computers on shipyards, or PCs, or the internet, or 3D models, or simulation-based design, or…? You get the point. Progress in information technology (IT) has been incremental and continuous.

With such ongoing processes, like watching our children grow up, it is often helpful to take a step back and look at the larger trends. What are the predictions of where we will be in 10 or 20 years? Or what has fundamentally changed in the last 10 or 20 years? It is thus a convenient coincidence that the first Conference on Computer and IT Applications in the Maritime Industries (COMPIT) was held in the year 2000. Back then, there were already some visionary predictions, such as using virtual reality in design, operation and training; or 3D design, simulations and optimisation; or unmanned ships. Sound familiar? While we have not turned all these visions into living reality yet, we have come a long way towards them. And the predictions have been fairly accurate in how we have employed the technology and where we have encountered stumbling blocks.

MAN CEON's augmented reality maintenance program, Hololens

Digital Twins

Digital Twins are an area where the industry has come a long way from the 2D computer-aided design (CAD) world of the year 2000. From essentially using the computer as a digital drawing board, we have graduated to modelling ships as 3D objects which change over time e.g. due to retrofits. Enter the geometrical digital twin. The information must be managed throughout the whole lifecycle of the ship, starting from the beginning of the initial design, explain *Perez* and *Munoz* (SENER). Classification societies have mimicked the development in plan approval, where 3D models replace the traditional large size 2D drawings, making the exchange between shipyard and classification society more efficient. *Kil et al.* (Korean Register) describe the 'Development of a 3D model-based design approval system'.

The 2020 Global Sulphur Cap has led to many retrofit projects for the existing fleet in service, where often no up-to-date geometrical models are available. "For older ships without appropriate digital representation of the as-built status, this can be a major headache. 3D laser scanning has been found to be a viable solution for such cases. Initially motivated by retrofits, the geometrical digital twin created by advanced 3D laser scanning has turned out to be very versatile, being used e.g. also for preventive maintenance or further redesign of engine rooms," explains Marius Blom, CEO of Blom Maritime. More than an interesting side note, Blom quotes up to 30% savings on material cost and up to 35% on manhours in retrofit projects.

Predictions are difficult, especially for the future. The only constant seems to be change. The (computer-aided) design world starts to accept this and supports a design philosophy of 'adapt, adapt, adapt', where simulation and machine learning often work hand in hand. Considering widely differing technological concepts (for fuels and associated machinery systems) is not easy, but largely influences the ship life cycle performance. *De Vos et al.* (TU Delft, Damen) describe a novel design tool to assess the impact different carbon-neutral fuels will have on cruise vessel design. The tool allows rapid reconfiguration of machinery and tank arrangements depending on fuel type, supporting rapid design exploration and assessment. Similar work from Norwegian University of Science and Technology (NTNU) is applied to a Ro-Ro ferry design, comparing a conventional design with an alternative 'ammonia-ready' design.

Virtual and augmented reality

We not only design in 3D now, or capture with 3D laser scans, but we also view the world in 3D in Virtual Reality (VR) and

Cadmatic software supports innovation in shipbuilding

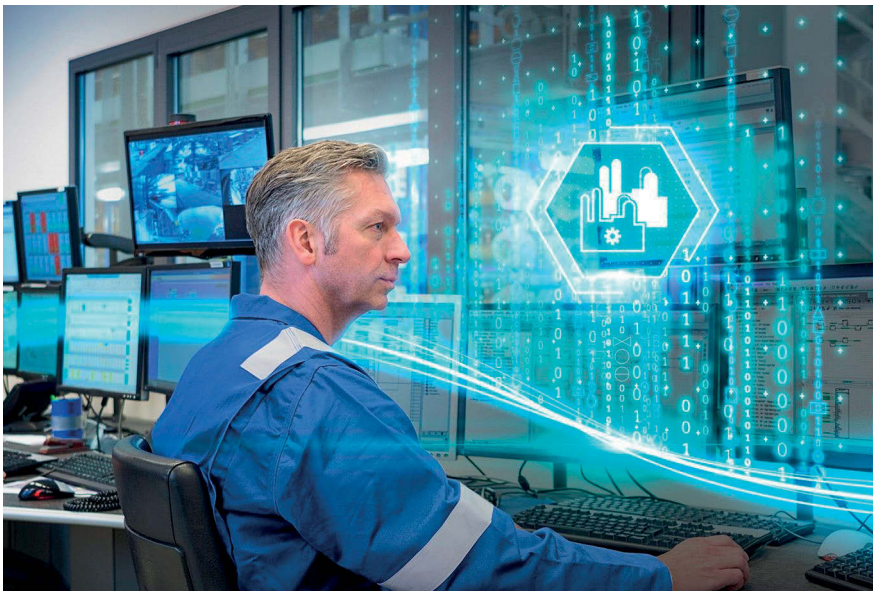
Augmented Reality (AR). The technology is advancing in design, production, and training. *Friedewald et al.* (TU Hamburg) describe an augmented reality system for installation of equipment, including the display of maintenance instructions, the feedback on setting values and the documentation of the work including storage in a digital twin. Industry users estimate time savings of up to 75% per maintenance case. Whether for more intuitive maintenance manuals (MAN) or potentially dangerous training environments (DNV GL), virtual reality and augmented reality are becoming common industry practice.

Open software

Another vision from the year 2000 that is at least getting closer to reality is the concept of open software. "Openness and collaboration are words that are rarely associated with the maritime area, especially in the narrow, competitive, traditional and change-averse world of ship design. It is the understandable (even though unfounded) fear that, by making knowledge available, one can lose one's position in the market," describes *Gaspar* (NTNU) as one of the key obstacles. He argues strongly and convincingly in favour of a change of mindset and software approaches towards "open and collaborative ship design", adding a stepwise tutorial on how to be open and collaborative from day one in future projects.

An 'open' philosophy is a prerequisite for a best-of-breed approach in the maritime industry with its many stakeholders, where interface problems have traditionally been a plague. "Transferring and harmonising information between (various) applications robustly and conveniently is challenging but offers long-term efficiency and data integrity benefits," says *Gresens and Zerbst* (Prostep). They describe a unified data model to implement lean interfaces between NAPA Steel, SSI ShipConstructor and Siemens Teamcenter. This enables yards to spin their digital thread from initial design to manufacturing preparation, and thus to work more efficiently without data disruptions.

Various Norwegian players are working together in a joint industry project to create the Open Simulation Platform for collaborative digital twin simulations. "The project will deliver an open-source co-simulation code to the industry, accompanied by sample applications and simulation tools, as well as a new standard for models and simulations in the maritime industry," explains *Smogeli* (DNV GL).



Seimens explore digital twin technology with its integrated COMOS software solution

Continuous transition

The digital transition is exactly that – a transition. There is no single point in time where we can pinpoint that we turned digital. It is a lengthy and continuous process. We have come a long way and we still have a long way to go. But we are getting there. The visions are there, and the stakeholders are working together to turn them into reality. *NA*

The names referenced here point to papers in COMPIT 2020, which will take place in Pontignano, Italy on 11-13 May. If you unable to attend the event, after May 2020 you can download the proceedings for free from: www.compit.info

Cryogenic technology project keeps its cool over carbon emission targets

Could decarbonICE, a carbon capture and storage technology, be a key player in the future of carbon neutral shipping?

The shipping industry is in a period of the unknown. Shipowners are prevaricating as they wait to see which future fuel or technology will win out in the race towards carbon neutral shipping. But as the clock ticks down, potentially radical projects are emerging from the leftfield.

One such player is Denmark-based decarbonICE with its carbon capture and storage solution. Initiated by the Maritime Development Center (MDC) in Copenhagen, Denmark, the project is already backed by shipping companies including DSME, BV and scrubber manufacturers, CleanWater.

The proposed technology would transform carbon emissions from ship exhaust fumes into dry ice powder using a cryogenic process, which is then cast into capsules and deposited in the soft sediment of the seabed. DecarbonICE envisions the technology could be seamlessly integrated into normal shipboard operations on both newbuilds and existing vessels. The only change would be that ships fitted with the technology would be required to periodically drop torpedo-shaped capsules of dry ice from the back of the vessel down into the seabed.

The process, based on a now-expired patent filed by French cryogenicist Denis Clodic, would be constantly running while the ship is travelling through waters of 500m depth or above. As each 'Carbon Descent Vehicle' (CDV) is discharged then formation of the next CDV would begin.

Because the CO_2 dry ice has a density of 1.6t/m^3, 60% heavier than that of water, the CDV will drop towards the bottom of the ocean at a rate of 20-25m/s. As the -80°C CDV becomes embedded in the soft sediment of the seafloor it undergoes a series of reactions with the warmer 2-3°C water.

Carbon begins to melt from the vehicle's surface and reacts with water to create a carbon hydrate. This hydrate will bond with the sand, silt, clay and water in the sediment to create a 'CO_2 concrete' around the inner body of still solid, dry ice. The CDV will continue to expand as it melts from the heat of the water, which causes cracks to the external concrete shell. This allows more melted carbon to run between these cracks, generating more hydrate cement until the CDV reaches a final state (see Fig. 2).

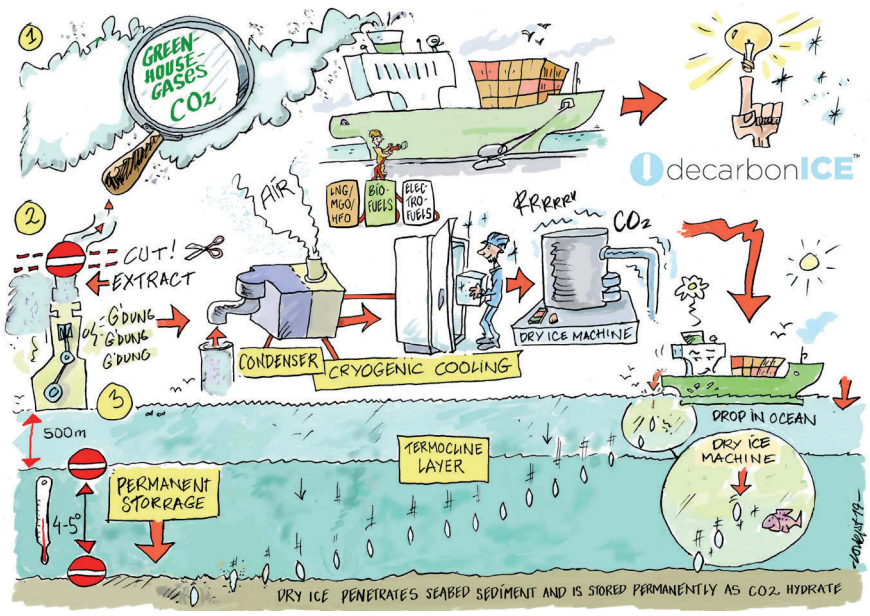


Figure 1: A cartoon lifecycle illustrating decarbonICE's carbon capture and storage concept

Permanent storage

Creating an environmentally neutral solution is at the centre of decarbonICE's concept. "We refer to CO_2 emissions as discharge, but we realise that others may use other words. Instead of discharging CO_2 to the atmosphere and creating climate change and damage to the upper ocean water, we discharge the CO_2 to the seabed sediments, where it becomes permanently stored, primarily as CO_2 hydrate," says Henrik O Madsen, the former CEO of DNV GL who chairs decarbonICE's steering committee.

Madsen compares decarbonICE technology to scrubbers, as CDVs are a post combustion solution to carbon emissions. Moreover, like scrubbers, CDV technology can be used on existing propulsion systems that run on current fuels such as HFO, MGO and LNG. He believes that the technology could ultimately be combined with future carbon neutral fuels, whether it be synthetic, bio or otherwise, to make shipping 'carbon negative'. "If shipping is to be totally zero carbon in 2050, I think we need to have a ship that can be carbon negative, because we will have lots of shipping that we cannot really change."

Carbon negative, in this iteration, accounts for the production and usage of future fuels in vessels alongside sectors of shipping that will still run on carbon emitting fuel. "As CO_2 is taken from the atmosphere by the plants used to produce biofuels or in the e-fuels production process," adds Madsen. From this viewpoint, ships capable of running on biofuel are carbon negative and ships still

operating with carbon emitting fuel with CDVs will become neutral – overall, net shipping is carbon negative.

"As is common practice in the public debate, we denote bio-fuels and synthetic fuels (e-fuels) as carbon neutral. The reality is, of course, a little more complex as scientific lifecycle analyses shows," he admits.

Journey to the soft sediment

Carbon reacts with water depending upon its state and decarbonICE plans to prevent CDVs from sublimation as they descend and once stored. The project has determined that according to carbon's phase diagram, CDVs will not return to a gaseous state once they reach a depth over 500m where the pressure surpasses 50Par.

Around 85% of the ocean's surface is deeper than 500m and areas where there are oceanic ridges, volcanic activity, continental slopes, points at which continental slopes meet abyssal plains, and areas with pipelines and cables, are all excluded as discharge areas. "We are in the process of categorising the seabed along major shipping lanes and identifying where the seabed is soft enough we are guaranteed the CDV to fully penetrate," says Madsen.

He stresses that decarbonICE is working closely with geologists and marine experts to identify areas of the seabed that are suitable for carbon storage and to advise on the ecological impact. "When considering storage in the sediments of the abyssal plains, we have not had anyone believing this to be a problem from a biodiversity or environmental perspective. The impact of the CO_2 storage will be much less than what is currently proposed as acceptable for deep sea mineral mining."

Henrik O Madsen, former CEO of DNV GL, decarbonICE steering committee chair

The project also plans to cover its CDVs with a 'spray paint like' coating, of around 5mm thickness, to avoid carbon escaping as gas while it travels through the water, though it has yet to determine what material the coating will be made from. "We do, however, wish to avoid any material that is not natural to the environment. Water or CO_2 hydrate seem like the two most promising cladding materials at the moment. The purpose is to completely avoid any loss of CO_2 from sublimation during the descent," says Madsen.

The project is performing strength tests on dry ice that considers the stability of its CDV's upon impact with the ocean surface and the seabed, which will affect the vehicle's shape. "It may be necessary to counter the forward speed of the ship in the CDV launch method. We are also making sure that the CDV does not get crushed upon impact and all calculations so far show that not be a problem at the relevant storage site."

United Nations Convention for the Law of the Sea (UNCLOS) requirements specify that CO_2 cannot be discharged on the seabed, but decarbonICE is currently unable to evaluate each specific landing site for its CDVs. The project is considering additional technology might be utilised prior to CDV launch, including seabed charts and advanced echo sound systems capable of recognising volcanos and continuously monitoring the density of seafloor sediments. Madsen even suggests that deployment would be halted in the presence of large sea mammals. "We avoid all kinds of harm to sea life and want to make a rounded solution," he stresses.

The next stage

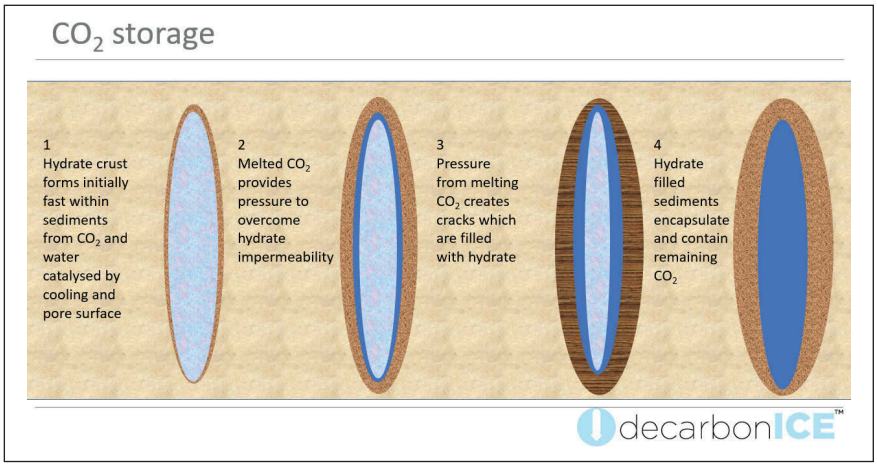
With an expected energy penalty of 10% for HFO/MGO and 7% for LNG (90% carbon capture), the potential opex with decarbonICE initially makes the technology cost effective, but the overall capex of the product remains unclear. Madsen speculates that it may be necessary for vessels fitted with the technology to also be equipped with an alert system to warn nearby submarines when CDVs are being dropped.

But if decarbonICE is to be realised, more manufacturers need to come onboard. "We need partners with competence in handling ship exhaust – typically scrubber companies – and companies with cryogenic experience," Henrik comments.

DecarbonICE's technology is still in its embryonic phase. Madsen confirms that during 2020 the project aims to complete a visibility study, which may include laboratory experiments on descent vehicles. Meanwhile, plans to start an approval process for its technology are already in motion, "we will apply for approval under the London Convention and Protocol, which is managed by IMO, and do not expect any international body to challenge such an approval." *NA*

For more information and enquiries, visit: *mdc.center/decarbonice-home*

Figure 2: The transition phases of decarbonICE CDV's



Laser-engraved metal emulates shark skin

An EU-sponsored project to develop an ultrafast laser system that is the latest technology to attempt to replicate the hydrophobic capabilities of natural structures

The application of biomimetics to coatings technologies and hull surfaces has been a particular focus of maritime research for several decades now. In the early 2000's, the US Navy began funding research at the University of Florida's Materials Science department into developing non-toxic coatings solutions inspired by the surface of shark skin.

The work led to the development of an artificial technology, Sharklet, which has found use in several medical applications. However, the challenges of manufacturing and applying it to a scale suitable for a ship's hull, whilst maintaining the integrity of the sharkskin pattern, have hitherto not been solved.

Elsewhere, researchers from Fraunhofer IFAM and the Hamburg Ship Model Basin (HSVA) collaborated on the FLIPPER ('Flow improvement through compliant hull coating for better ship performance') project, which explored the hydrodynamic potential of a coating solution inspired by dolphin skin, achieving some success in reducing frictional drag (see *The Naval Architect*, September 2019).

Meanwhile, AIRCOAT (Air Induced friction Reducing ship COATing) a project funded by the European Commission's Horizon 2020 programme, is just over halfway through its three-year mission to develop a biomimetic passive air lubrication technology that utilises the Salvinia effect.

Another Horizon 2020-backed initiative is taking a quite different approach to the development of biomimetic hydrophobic surfaces. Launched in January 2019, the three-year MultiFlex project is a consortium of laser specialists, under the umbrella of the Photonics Private Public Partnership, that has joined forces with the vision of making fast metal processing using lasers a reality.

In February this year, MultiFlex announced that it was harnessing new advances in photonics to develop a high-power (1kW) 'dot matrix' ultrashort pulsed (USP) laser system, said to be the first of its kind in the world. The system is capable of carving flow-optimised metal or plastic surfaces that imitates the microscopic 'spike' structures of shark skin, creating a rough surface that reduces drag and inhibits the growth of micro-organisms.

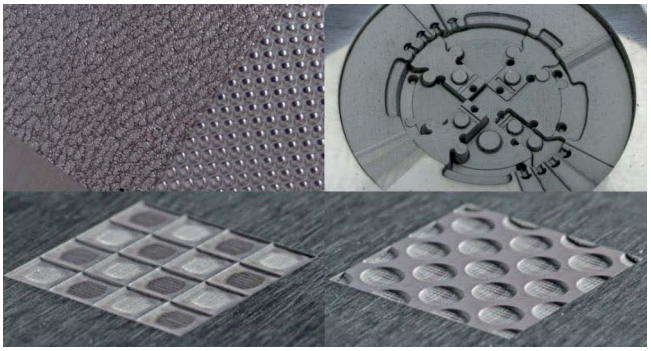


Figure 1: MultiFlex's individually modulated multi-beam array makes it possible to create arbitrary surface structures

According to MultiFlex's coordinator, Dr. Johannes Finger, the idea of applying such technology to hull surfaces began with an earlier project for an undisclosed coatings manufacturer. "We had an industry partner that had developed a silicon-based antifouling solution. We were then able to improve upon it by pre-structuring the surface the coating is applied to," Finger tells *The Naval Architect*.

"Our industry partner said the results were very promising and asked if we could upscale it for larger parts. Unfortunately, we weren't able to because we didn't have the machinery or system technology to achieve that. The laser structuring processes when you use these kinds of lasers are extremely precise and have the benefit of not giving much heat input into the surface, but the downside is that they are very, very slow."

To the naked eye Finger says the laser-etched metal looks almost as if it has been sandblasted but the shark skin effect is at a microscopic level (see Fig.1). Although the basic principle is similar to that of the Sharklet structure, patent restrictions meant that another structure with a different geometry was used, which has shown promising results.

One important consideration was how the metal's skin effect might be compromised by adding another coating on top of it. "In the preliminary study we tried both approaches: structuring the metal first and then applying the coating or doing the structuring over the coating. We found structuring and then coating as better.

"[Our industry partner] tried the treated samples for plant growth and there was some improvement. This might be different in real conditions, of course, so it might not be the final decision… That customer isn't part of the current MultiFlex project so I can't disclose all the details, but it's not about structuring the whole ship but rather specific areas of the hull.

"The idea we are working on now is to build the enabling technologies that can be used for production-scale, large area structuring. Once we've achieved this we want to go back and make these things for real-world applications."

A 'dot matrix' laser being developed applies a similar principle to the traditional dot matrix printer, with a movable head that emits concentrated pulses of energy to ablate the materials. The ultimate aim of the project is to create a processing head using a grid of 64 laser 'beamlets' of 25µm diameter, each of which can be individually tuned and positioned for optimum results (see Fig.2).

"We could easily change it to 10µm but below that it starts to get a little difficult," Finger explains. "At the moment we only have an eight-beam prototype but what we learn from this we'll bring into the 64-beam version."

However, the real significance of the project resides less in its precision than in the speeding-up of a process that can take weeks.

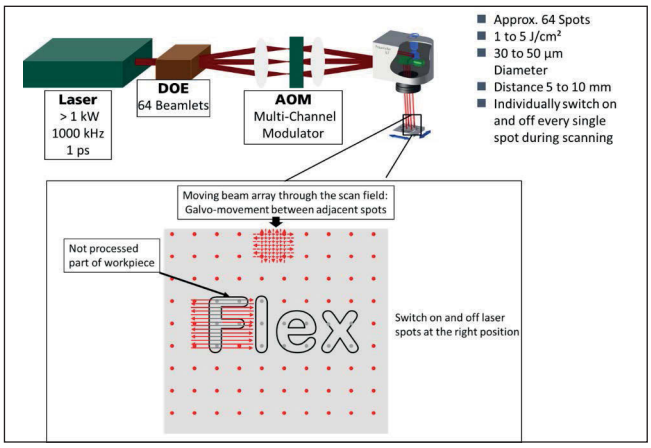


Figure 2: The principle of the 'laser matrix printer'

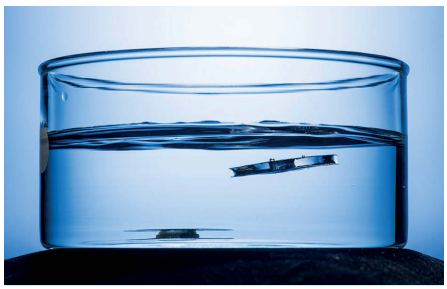
"Our system will ablate more than 150mm^3 in one minute, therefore making it hundreds of times faster than existing technologies."

Beyond hull surfaces, Finger foresees the technology may have wider, and more immediate applications outside of the maritime industry. These include things such as printing and embossing tools, where the faster, more precise and economical production possible with the MultiFlex system could have significant benefits. Another area is the automotive industry, which already makes extensive use of lasers, where it could be applied to micro-structuring for interior lighting, instrument clusters or haptic structures.

"We are now entering the intense project phase where we'll see whether everything we thought is correct, or if there are any problems we didn't foresee. At the end of 2021 we'll have finished everything." *NA*

For further information visit: https://multiflex-project.eu/

Spider behaviour inspires superhydrophobic technology



Superhydrophobic metallic assembly floats to the water's surface

The American Chemical Society (ACS) has released a paper on the results of its superhydrophobic (SH) metallic assembly experiments, which concludes that SH multifaced assemblies could be used to create highly floatable ships.

As featured in the November 2019 edition of *Applied Materials & Interfaces*, the project is inspired by the diving bell spider, which captures air between its SH legs and abdomen to live underwater, as well as fire ants, which survive floods by self-assembling into a raft and trapping large quantities of air between their SH bodies.

"The ability of these creatures to sustain the SH functionality indicates that they evolved to maintain their superhydrophobicity even after being fully submerged in water indefinitely," ACS explains.

ACS's prototype assembly remains afloat as air is entrapped between two aluminium plates attached by a plastic pole. SH surfaces require a contact angle greater than 150°, and ACS achieves this by treating the inwardly facing side of both aluminium plates with a direct femtosecond laser to produce hierarchical micro- and nanostructures on their surfaces.

The practical use of such assemblies is usually limited because once the device becomes fully submerged and wet it will relent its SH properties over time. The surface texture is also vulnerable to mechanical degradation from wear and abrasion, which eliminates its SH functionality.

As such, the ACS assembly design specifies inwardly facing SH surfaces to ensure that they do not come into contact directly with external loads or water, preventing SH failure due to mechanical wear. Durability tests conducted by the society found that after two months submerged, the structure remained afloat and no deterioration to the material was observed.

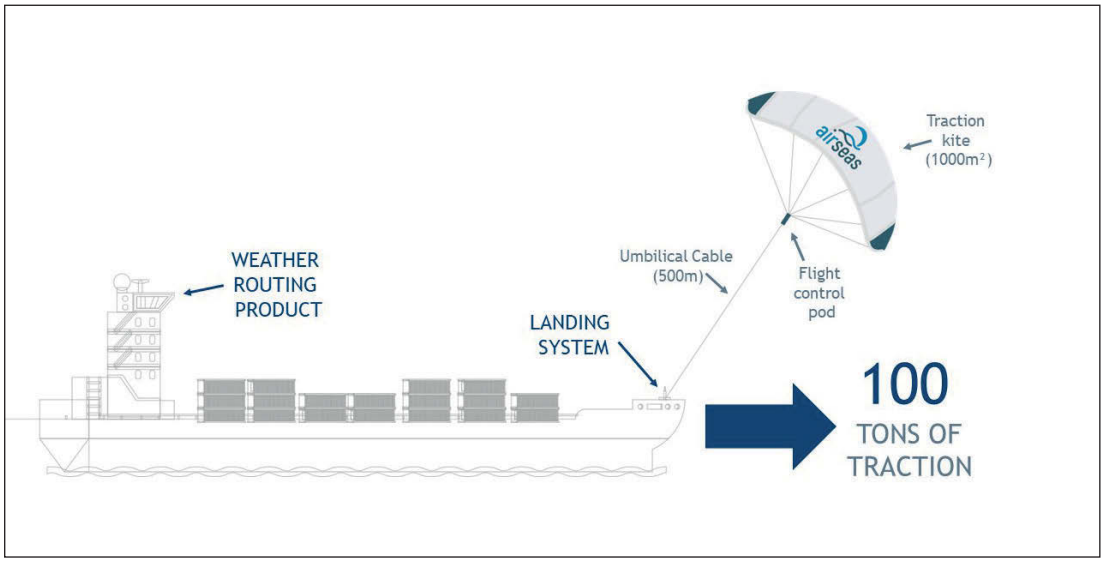
Moreover, the society finds that its device automatically conceals entrapped air even when the SH metal is pierced, and water replaces air within the pierced volume. As such, unlike a damaged ship's hull, the metallic assembly can withstand significant damage by piercing and still satisfy the buoyancy conditions necessary to float.

The study also investigated the limitations of its multifaced assembly's floating capabilities while in water, including maximum loading capacity and distance between plates. ACS concludes that its assembly can, depending upon the radius of the plates and the distance between them, withstand a weight 2.5 times its own and remain afloat.

Although ACS admits more research is needed to account for other conditions such as deep-water pressure, it proposes that using a stack of SH assemblies can further increase the loading capacity per unit surface area, which is more suitable for constructing large aquatic vessels.

What aviation can teach shipping about exploiting wind technology for a zero-carbon future

Taking inspiration from other sectors, such as aviation, could be the key to utilising and developing wind technology for greener shipping, discusses Vincent Bernatets, Founder and CEO, Airseas



French propulsion innovator Airseas demonstrates how its wind technology, Seawing, could operate

Harnessing the unlimited power of the wind is not a new concept in shipping. For thousands of years it was the sole propulsion method and supported the age of discovery. In the industrial revolution, sails largely gave way for steam. In an almost complete full circle, as shipping enters the digital revolution, it could be looking back to wind power as a propulsion technique.

While it isn't being touted as the sole propulsion technique for future fleets due to the size of vessels being operated today, attention should still be paid to the fuel saving benefits of wind. The International Windship Association is now made up of over 100 members, rocketing from the 12 they had since 2014. Amongst the members of the wind industry, we are seeing innovations at different stages of development in ridged and soft sails, kites such as the Seawing developed by Airseas, and rotor sails. The latter have been trailed on the *Maersk Pelican* and resulted in an 8% fuel saving.

Even looking at current costs, it's clear just how much impact even a small percentage of fuel savings would have on a vessel's operations – particularly given the recent disruption to the bunker market from IMO 2020. For example, a large modern container vessel used in a trans-Pacific route with a capacity of 7,750TEU will burn 217tonnes of fuel per day. A 28-day voyage would produce a VLSFO fuel bill of US$3.4 million. This is before any price volatility has been taken account of, and before the advent of potentially very expensive zero-GHG ship fuels. A recent study by the Getting to Zero Coalition has estimated that the prices of future zero-GHG fuels could be as much as US$800 per tonne. Consequently, owners and operators have much to gain from adopting wind propulsion technology as a protective measure against dents in operating expenditure brought on by fuel price increases – even conservative estimates of savings would recoup hundreds of thousands of dollars per voyage.

Smarter Sails

However, exploiting the power of the wind does come with its own unique set of challenges, such as installing the hardware and ensuring safe operations, which can increase the workload and level of technical expertise required of the crew. Integrating wind propulsion into the already complex operation of a ship means compensating for the effect of weather, ensuring that the wind and engine can work together effectively, and that sails stay under control at all times. As such, higher demands are placed on a vessel's digital infrastructure and automation systems – a field which, within shipping, lags behind the automotive or aerospace sectors.

This has to change. However, in order to achieve this, it is essential that shipping has full access to all possible tools when it comes to tackling carbon emissions. This is where the application of digital twin technology is most valuable – and in particular where the sector has the

most to learn from aviation, an area that has a long track record in tackling similar challenges and pioneering digital twins.

Learning from Aviation

Like shipping, the aviation industry is under similar pressures to develop and realise a modern environmental vision balanced with financial sustainability. Initiatives aviation has taken to realise this goal have enabled the sector to make great progress in areas such as automation, aircraft design and route planning.

One example of where this learning carries across is Airseas and its product, the Seawing. Backed by Airbus, it leverages the automation, aeronautical engineering and safety technology already successfully used in aviation. This means that the translation from the flight deck and wings of the most advanced aircraft in the world to vessels is less of a vision and is closer to reality than most people think.

While the technology is on one level simpler – there is only one wing to manage as opposed to two wings seen on an aircraft, and no passengers in the air to limit the acceleration the wing is subject to – there are some challenges and complications here that are significantly different to those in the aviation industry. Firstly, the frame of reference for the wing is spherical rather than on a level surface, as it would be for aircraft, which is mathematically complex. There is also a significant engineering challenge in creating an automated system that reacts to the way that wave activity changes the lift on the kite cable. Simply put, waves go up, lift goes down – and the wing needs to compensate for this, in a manner not entirely unlike kite surfing.

The key to success here is the combination of advanced hardware with digital twin technology. The Seawing's automation systems are underpinned by inbound data streams, which manage almost all aspects of its operation. By receiving and processing inbound navigation, meteorological and seascape data from existing bridge technologies, and combining this with sensor data, solutions powered by digital twins can make independent decisions about the optimum conditions to deploy, retract and adjust its position.

Vincent Bernatets, Founder and CEO, Airseas

Two Digital Twins

The sources of these data streams form two distinct digital twin applications for the Seawing kite. One uses sensors on the wing and attached pod to predict wing behaviour in real time and adjust its profile accordingly. For example, a slight change in air pressure, wind speed or direction results in the Seawing making micro adjustments to its position, or withdrawing if conditions are dangerous or sub-optimal, all calculated within a 300 millisecond response time.

This automation reduces risks significantly – particularly those risks created by errors in human judgement that can either damage the equipment or the vessel. It also creates a failsafe that makes it impossible for a vessel's crew to input excessive commands which take the Seawing outside of its normal flight envelope. This further reduces the risk of damage by being unwittingly deployed in a way that is deemed to be unsafe.

The digital twin also plays a vital safety role in validating sensor data, by comparing inputs from sensors against a virtual model of the system. If these two are out of sync, this implies that there may be an issue with a sensor, identifying a potential risk.

The second digital twin model is based on both the ship and the kite model. The two are coupled to obtain a combined model that considers all aspects of interaction between the ship and the kite, such as traction and waves. This digital twin is integrated into our routing software to see which route would be the most efficient for fuel savings. The technology is highly dependent on ship type, and as such, the algorithm is flexible, to allow the wing solution to work effectively with different engine types and loads. The goal is not to deploy the wing as soon as possible, but to have the biggest possible fuel savings. The software then suggests a route to the captain, which he can choose to follow or not, but would optimise our system's performance if taken.

Wind propulsion evolution

Automation technology and digital twins are core pillars supporting the evolution of wind propulsion. Aside from generating significant optimisation benefits, they are essential in assisting seafarers adjusting to the technology. Compared to other emerging propulsion techniques that require a significant shift in mariner skills in order to use them safely, automated wind solutions require very little extra training. Automated release, flight and stowage at the press of a button means crew can focus on their work as there is no need for manual intervention. By having wind solutions backed up by the appropriate technology, they present a much smaller risk to the crew and to operational expenditure. It allows for the same precision that helps keep a 580tonne super jumbo in flight to be applied to a kite that supports a 10,000tonne ship's propulsion.

In bringing this technology to the fore, we can see how the next generation of vessels needs to evolve. Our best hardware must be carefully integrated into the operations of a vessel, and we need to consider the digital infrastructure of a vessel from the very inception of a project. However, by learning from other sectors, and continuing to integrate these learnings with seafaring expertise, we can ensure that the vessels of the future are cleaner, safer, and smarter than ever before. *NA*

Finnish shipbuilding cluster risks putting its many eggs in one basket

Passenger ships, including cruise ship and ferries, are the main focal point for Finnish shipping companies despite concerns of single sector risks

The Finnish shipbuilding cluster is focusing heavily on passenger ships, which will provide it with a healthy workload for years to come, but also means exposure to risks in a specific sector. However, many suppliers and contractors also serve the wider shipbuilding and repair industry, which mitigates the risk.

Meyer Turku, the largest of the three shipbuilders in the country, focuses solely on cruise ships. Rauma Marine Contractors, some 30 miles north, is building ferries and has also won the largest naval order in the country's history, comprising four 3,900tonne displacement corvettes.

Helsinki Shipyard has built specialist ice breaking tonnage, but it is now focusing on two ice strengthened expedition cruise ships on order from Russian principals. These will be the first ships of this type to be built in Finland since in 1992.

Meyer Turku shipyard begins 2020 with float out process on the *Mardi Gras* cruise ship

Cruise ship ordering may slow down

Following several years of high level of activity, ordering of cruise ships is likely to slow down, according to a report by Maritime Strategies International (MSI), the UK-based consultancy.

"MSI assumes that newbuilding contracting drops off further over the next four years before picking again in 2024. This assumption stems partly from the fact that the sector is already heavily committed on the newbuilding front, and it will take some time for the industry to adjust and absorb the many ships scheduled to hit the water over the next four years," the report said.

Newbuilding prices bottomed out in 2017 but have been on an upward trend since then. Based on MSI's latest shipbuilding forecast, prices will be 4% to 5% higher on average this year compared to 2017, building towards a peak in 2023.

The cluster has specialised in passenger ship building and, to some degree, on ice strengthened tonnage, which is a necessity as building low value-added vessels is not possible in Europe anymore, said Elina Andersson, secretary general of Finnish Marine Industries, ceiling organisation of the maritime industry.

While Andersson acknowledged that this includes a risk, she pointed out that the situation is not black and white. At the moment, both the cruise ship and ferry sectors are investing heavily in newbuildings. This has provided the Finnish shipbuilding sector with good visibility regarding the future workload for years ahead.

Not just one leg

Should the pace of ordering slow down in the future, there would be time to adjust. "Refits and upgrades of cruise ships are a growing business, which is already providing a platform for growth for companies in the Finnish shipbuilding cluster," Andersson pointed out. The world's icebreaker fleets are ageing and Finnish yards are well positioned to capitalise on a potential upturn in the demand in this sector.

Many companies in the shipbuilding sector also sell their products to foreign yards and all types of vessels, so they are not reliant on the domestic yards and their orders. "The sector has several legs to stand on, not just one. Quite often, the cyclical peaks and troughs do not occur at the same time in all sectors of shipbuilding. In addition, many companies also have customers in land-based industries," Andersson stated.

If the present boom in passenger ship building comes to an end, Andersson noted that obviously this would be felt in the Finnish shipbuilding cluster. In order to be able to adjust in changing circumstances, it is vital that the cluster retains its skills and competences and focuses on R&D, she concluded.

While the effects of a possible downturn in the ordering of passenger tonnage might not affect the sector immediately as existing orderbooks are at a healthy level

– Meyer Turku has work until 2025 – the economic impact of the business is felt widely outside the gates of the yards.

Positive effects felt widely

A report compiled by the University of Turku and Meyer Turku that was published this year shows that the yard's purchasing totaled at €933 million (US$1 billion) in 2018, which was an 84% increase on two years earlier. Turnover of the yard and companies that supply goods and services to it rose by 46% to €1.9 billion (US$2 billion) in the same period.

Although a third of the municipalities in the country benefitted from the yard's activities, four fifths of the economic impact were shared by the provinces of Varsinais-Suomi, where Turku is located, and Uusimaa, which includes the capital city region, the report showed.

Shipbuilding is essentially an assembly industry and extensive supply chains are typical for these: Meyer Turku itself only employs about 20% of the people involved in the shipbuilding process, its deputy managing director, Tapani Pulli, said in the report.

History has shown the Finnish shipbuilding sector to be remarkably resilient as it has experienced at least two seismic shocks in the past few decades and survived. In 1989, the collapse of Wärtsilä Marine Industries led to a debt to equity conversion and continuation of activities at all three yards it owned. In 2013, STX Offshore & Shipbuilding, which had become owner of the three shipyards a few years earlier, came into troubles that eventually led to the closing of the Rauma Yard.

Elina Andersson, secretary general of Finnish Marine Industries, ceiling organisation of the maritime industry

Fortunately, all found new buyers, helped by the fact that the supplier network and key competences in their respective locations had not been lost. *NA*

Demographics quandary poses challenge to Finnish industry

Kari Reinikainen reports on the challenges an ageing workforce poses to the country's maritime cluster

At the end of 2019, 21.8% of Finland's population was aged 65 or more and the country's shipbuilding cluster is tackling the situation by various efforts.

The shipbuilding industry includes most sectors of the technology industry, which means that it requires a broad range of skills – from people with degrees in different engineering fields, Masters of Arts in Economics and Business, designers and on to experts in environmental questions, explains Elina Andersson, secretary general of the co-operative forum Meriteollisuus ry (Finnish Marine Industries).

"Such a broad range of requirements amplifies the shortages of people with these skills, because they are also in a heavy demand in various other sectors. The challenges are most obvious outside the capital city region, but so far at least, companies have been able to fill new vacancies," she tells *The Naval Architect*.

There is also a difference between global companies with presence in the Finnish maritime cluster, such as Wärtsilä or ABB on one hand, and of smaller companies on the other. The big names have a well-known brand, compared to the smaller companies that do not necessarily have the benefit of general recognition.

To tackle the challenges that wait ahead, Andersson says it is important to ensure that people with engineering qualifications are trained in adequate numbers. Furthermore, people with the right qualifications but without specific expertise in the shipbuilding cluster can be retrained, as is already happening.

"Finnish Marine Industries has a training course on shipbuilding project management that comprises five modules," she says, adding that various companies have teamed up with public authorities to set up training packages of their own.

ABB Group is one of the global companies with presence in the Finnish shipbuilding cluster, where its ABB Marine & Ports employs roughly 700 persons, a third of the unit's global workforce.

Aino Okkeri, head of human resources at ABB Global Marine & Ports

Pentti Kujala, head of maritime technology research group at Aalto University

Shipping is riding on the crest of technological development driven by digital and electric solutions. As leading developer of these, ABB requires project managers, chief designers plus staff in purchasing, R&D engineering, sales and sales support plus installation.

In all these roles, understanding the entire system in question and customer focus ability to work independently are key requirements, says Aino Okkeri, head of human resources at ABB Global Marine & Ports.

"As a whole, you can say that it is most challenging to find people with understanding of electrical and automation systems and these vacancies have taken the longest to fill."

In sales, many have a business studies background and experience in shipping, while in sales support, technology and R&D roles most people have degrees in engineering. For purchasing roles, either business or engineering degrees are common.

Okkeri believes the maritime cluster is a sector that attracts people and in which filling vacancies is quite easy. However, ABB pays a lot of attention to training and development of its staff and the company ranked second in the Universum Finland survey for technical and science students, she adds.

To help with the availability of people with the right skills, Aalto University in Helsinki has signed agreements with Meyer Turku and Rauma Marine Constructions, two Finnish shipbuilders, on research and development plus multidisciplinary training and education.

Shipbuilding has an image problem

Work in the manufacturing industries is changing as the share of blue-collar jobs continues to decrease in relation to white collar ones. Automatisation will embrace everything and the skills required in the future will reflect this," says Professor Pentti Kujala, who heads the maritime technology research group at Aalto University.

Shipbuilding, however, has an image problem. "When you think of any news report on TV about shipbuilding, the images are usually of welders at work. Yet welding only accounts for one or 2% of a major ship project," he explains.

The industry has become aware of this and it intends to highlight the use of IT and other such aspects to make it look more appealing to young people. "Digital applications will affect every aspect of work – from design to production processes," Kujala points out.

He suggests two things to tackle the challenge: "The first one is that 16-18 year olds should take longer courses in mathematics at school, The second one is that more women need to take up a career in engineering: at the moment, only about 20% of people with degrees in engineering are women."

In a recent study, 52 companies that work with the Meyer Turku shipyard were interviewed and three quarters of them said they need more staff – welders, HVAC system designers, project managers and foremen were most in demand.

Commenting in a statement, Tapio Karvonen, a special researcher at the Brahea Centre of Turku University, says that Meyer Turku itself will need to recruit lots of people in the years to come to replace those retiring. In the future, the need will shift increasingly towards highly educated people.

Work-life balance helps in recruitment from abroad

"In the marine cluster, there is demand for people with both blue and white collar skills," says Pipa Turvanen, network manager at Turku Science Park, which operates a project to attract people from abroad to work in the shipbuilding cluster on behalf of the city council. "The competences that are most needed are in the information, communication and digitalisation sectors," she tells *The Naval Architect*.

Work-life balance is an important consideration for many and here Turku can present a competitive offer, as the balance is recognised as important in Finland and elsewhere in the Nordic region. An informal work culture that encourages the flow of information in both directions in turn encourages innovation and in general terms, means that productivity is high in Finland.

"All these are important considerations and it's vital for the future of the cluster that people can be recruited from abroad: Finland's population is forecast to start to decrease in the 2030s," Turvanen points out.

Experiences of people who have come to live in Turku and to work in the shipbuilding cluster have been overwhelmingly positive, which bodes well for the future. "It's not just a question about meeting the acute needs of the industry, but about its long-term future." *NA*

Short-stroke initiative raises WinGD's game

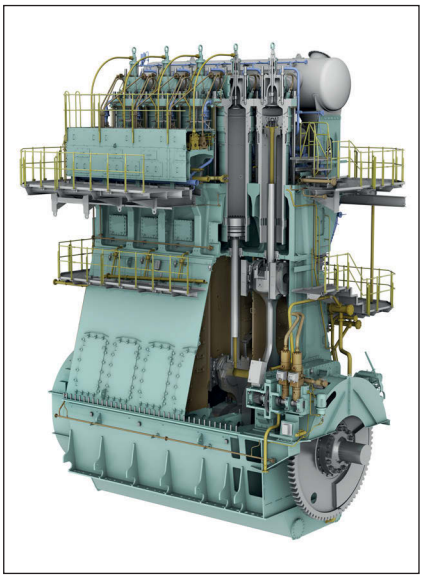
Two-stroke designer WinGD has set its sights on a bigger stake in the engine market for space-constrained, smaller commercial vessels, writes David Tinsley

Four new short-stroke designs in the medium-size, low-speed engine category have been unveiled by Winterthur Gas & Diesel (WinGD) to suit a range of vessel types faced with particular spatial constraints and the need to ensure economy over a varied operating profile.

The latest additions to the portfolio of Switzerland-based WinGD have augmented the two-stroke technology specialist's offering at the 520mm- and 620mm cylinder bore sizes, and embrace both diesel and dual-fuel versions. The power range served by the development as a whole extends from 4,950kW to 21,480kW.

The piston stroke in the X52-S2.0 diesel and the X52DF-1.0 dual-fuel variant has been reduced by 270mm relative to the standard X52, and by 413mm in the X62-S2.0 and companion dual-fuel type, the X62DF-S1.0, in relation to the existing 620mm-bore models.

This plays to the requirements of vessels with a shallow draught, small propeller diameter or low main deck height, such as container feeders, ro-ro ferries, trailerships, multipurpose cargo vessels, and vehicle carriers. "Many of these vessel types are part of an ageing fleet that means we expect significant fleet renewal – and a big opportunity for our new engines – over the next few years," observes Volkmar Galke, WinGD's global director for sales.



Cut-away of WinGD's new X52-S2.0 short-stroke engine

The new X62 engines, in particular, afford a substantial saving in the engine room height needed for installation.

While two of the designs are LNG-capable dual-fuel types, the two diesel series have also been conceived for 'gas-ready' preparedness, reflecting the invariably tougher environmental regimes in which many of the target ship types operate, notably intra-regional and short-sea trade.

Five- to eight-cylinders

The four short-stroke designs will be available as in-line engines in five- to eight-cylinder configurations. Test campaigns are due to be fully completed by mid-2022. All production of Chinese-owned WinGD's engine types is handled by licensees in China, Japan, South Korea and Croatia.

The X52-S2.0 diesel, with a stroke-to-bore ratio of 3.93 compared to the 4.45 of the standard X52, has a maximum continuous output of 1,910kW per cylinder in its top rating at a crankshaft speed of 120rpm, although the power map provides wide scope as to specified maximum continuous rating, down to a running speed of 95rpm. The companion X52DF-S1.0 dual-fuel type provides a maximum 1,500kW per cylinder within the same principal dimensions.

The larger X62-S2.0 diesel displays an even more dramatic contrast in stroke-to-bore ratio, at 3.62, in relation to the 4.29 of the existing X62-B engine. Power per cylinder is a maximum 2,685kW at 108rpm, with similar flexibility to the new X52 type as regards power/speed combination selections, down to 1,520kW/cyl and 85rpm. The dual-fuel variant yields a maximum 2,110kW/cyl.

TECHNICAL PARTICULARS

WinGD X52-S2.0/X62-S2.0 engines

	X52-S2.0	**X62-S2.0**
Type	Diesel	Diesel
Bore	520mm	620mm
Stroke	2,045mm	2,245mm
Stroke/bore ratio	3.93	3.62
Cylinders	5, 6, 7, 8	5, 6, 7, 8
Power per cyl, R1 rating	1,910kW @120rpm	2,685kW @108rpm
Power range, R1 rating	9,550-15,280kW	13,425-21,480kW
Mean effective pressure	21.99bar	22.01bar
Overall power range	5,425-15,280kW @95-120rpm	7,600-21,480kW @85-108rpm
Brake specific fuel consumption, R1	162g/kWh	161g/kWh

As well as rendering the engines more compact, the reduced stroke-to-bore ratio promises savings in manufacturing and component costs, according to WinGD. A new feature is an integrated selective catalytic reduction (iSCR) system, to meet IMO Tier III NOx limits. The compact form of the iSCR is also expected to simplify installation for shipyards.

Pivotal to the performance of the new engine types, two turbochargers are carried by each, and WinGD has listed three options as regards turbo models. In the case of the X52-S2.0, the choice is between ABB's A260-L and the MET48MB and MET42MBII from the Mitsubishi stable. For the X62-S2.0, the options are the ABB A265-L, MET53MB and MET48MBII.

The A260-L, a scaled-down variant of the proven A200-L, was launched last year. Targeted at small and medium-size two-strokes, it offers higher power density in relation to frame size and facilitates new emission control arrangements.

The first of the new engine series earmarked for the testbed is a six-cylinder X62-S2.0, scheduled to be put through its paces towards the end of 2021. The first X52-S2.0 is due to follow six months later. *NA*

TECHNICAL PARTICULARS

WinGD X52DF-1.0/X62DF-1.0 engines

	X52DF-1.0	**X62DF-1.0**
Type	Dual fuel	Dual fuel
Bore	520mm	620mm
Stroke	2,045mm	2,245mm
Stroke/bore ratio	3.93	3.62
Cylinders	5, 6, 7, 8	5, 6, 7, 8
Power per cyl, R1 rating	1,500kW @120rpm	2,110kW @108rpm
Power range, R1 rating	7,500-12,000kW	10,550-16,880kW
Mean effective pressure	17.3bar	17.3bar
Overall power range	4,950-12,000kW @95-120rpm	6,925-16,880kW

Finnish medium-speed for Japanese ferries

The buoyant Japanese long-distance ferry newbuild market has yielded a clutch of orders for the Wärtsilä 31-series engine

Japan's extensive coastal ro-ro ferry fleet, a key part of the national transport infrastructure, is constantly being renewed, and that process has gained momentum under new efficiency and environmental imperatives, in conjunction with increased passenger expectations and service competition.

Powerful medium-speed diesel machinery holds sway in this segment of the Japanese propulsion market, where many operators and builders have shown a predilection for European designs, not least the Pielstick brand. Through recent Japanese contractual endorsements of the Wärtsilä 31 type, widely considered to have raised the bar in four-stroke, medium-speed marine engine performance, Wärtsilä has gained ground in the sector.

The latest delivery by Mitsubishi Shipbuilding, Hankyu Ferry Co's 195m *Settsu*, provides the first Japanese ferry application for the W31 engine, entailing a twin 14-cylinder, vee-form installation.

Hankyu Ferry Co's new generation of long-haul ferry has Wärtsilä power and scrubbers. Second-of-class *Yamato* was launched at Shimonoseki in January

Sister newbuild *Yamato*, due to be commissioned in June, has the same power plant. Furthermore, two 223m ro-pax vessels ordered last year from Mitsubishi by Shin Nihonkai Ferry will each be fitted with four 14-cylinder models of the 310mm-bore diesel designed and manufactured by Wärtsilä.

The Finnish group has a track record with both operators, through the supply of vee-type 380mm- and 460mm-bore medium-speed main engines to previous newbuilds. The uptake of the W31 has added significance because of the potential the design offers as a versatile platform for different fuelling versions, incorporating features that chime especially well among the Japanese coastal ferry-owning community. The dual-fuel variant is understood to have attracted interest in the context of other fleet projects taking shape against the backcloth of increasingly stringent emission requirements in Japanese waters.

Coastal communities

Long-distance ferry routes, those over 300km, play a vital role in connecting Japan's islands and predominantly littoral centres of population, and the country's endeavours to foster a modal shift are abetted by government policy, growing concern for the environment, and a lack of truck drivers, with the shipping industry itself providing the necessary wherewithal through sustained reinvestment. Tonnage is sourced predominantly from domestic yards, a number of whom, having identified ro-pax construction as a core business, continue to refine the product and production processes.

In seeking solutions that meet their environmental responsibilities and targets, Japanese ferry companies are looking towards dependable systems, longer lifespans, higher efficiency, 'smokeless' operation, and lower running and investment costs. For the current newbuilds with W31 power, the ships offer a 6% advance in energy efficiency relative to existing, relatively modern vessels, a mark-up that can be attributed largely to choice of machinery and adoption of new, optimal hull forms.

The W31 achieves high fuel efficiency through a combination of technologies, including common-rail fuel injection, hydraulic valve control, two-stage turbocharging, and the integrated, proprietary UNIC engine management system. While lower fuel consumption equates to reduced greenhouse gas emissions, the patented, twin-needle fuel injector, featuring a dedicated low-load injection nozzle, results in less soot and particles across the engine load range.

Modular units

Most engine makers have moved to modular design principles to reduce production costs and simplify maintenance procedures. Wärtsilä has taken the concept to a new level with the W31 series, by shifting from single parts to larger exchange units. Downtime stands to be reduced because the modular design, with its lower component count, facilitates a move from dismounting and overhauling individual parts to exchanging whole assemblies, such as power units, injectors and high-pressure fuel pumps.

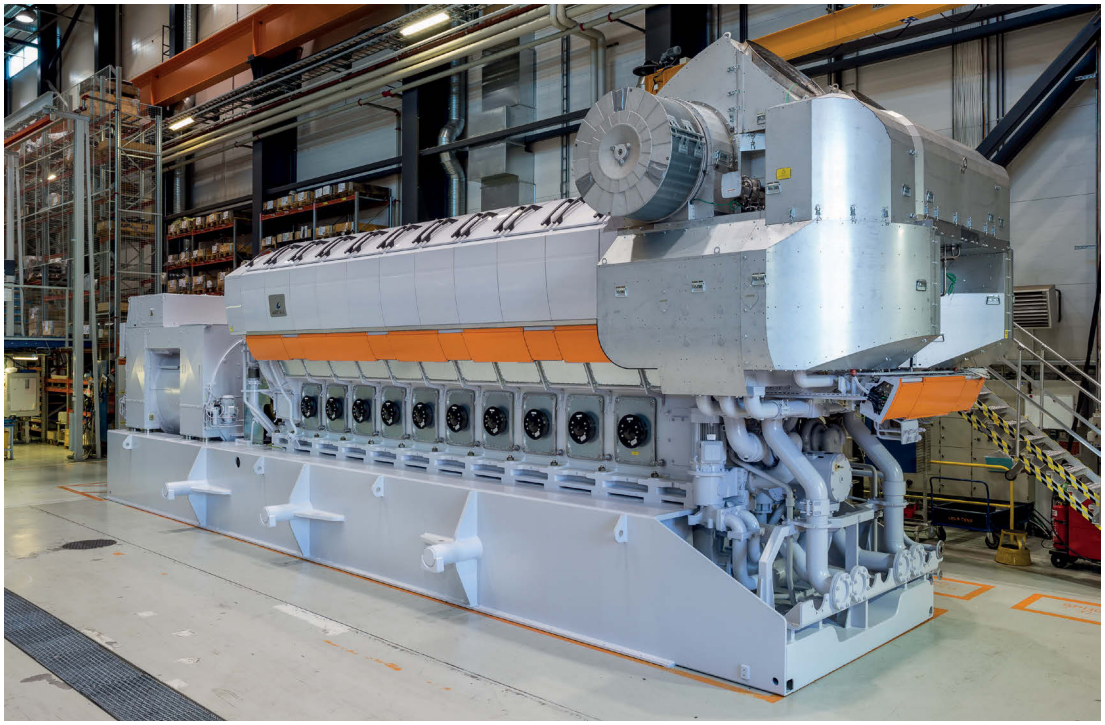
Modularisation and standardisation also better allow for technological upgrades over time, and favours a design 'platform' approach, enabling different versions to be provided, or engines converted, largely by changing components.

Hankyu Ferry's *Settsu* and *Yamato* each have 17,080kW of primary power by way of two 14V31 diesels, to give a service speed of around 23knots. Passenger capacity is 663, and the ro-ro payload equates to about 277 trucks up to 8.5m in length, as befits much of the Japanese road haulage network, plus roughly 188 cars. Both have been assigned to the Shinmoji (Kitakyushu)/Kobe route. Constructed at the Shimonoseki-Enoura yard of Mitsubishi Shipbuilding's parent Mitsubishi Heavy Industries (MHI), *Settsu* was handed over in February this year, and the sistership is expected to make her debut in June.

The two vessels have also been fitted with the Wärtsilä hybrid scrubber system, chosen because it confers the flexibility to operate in both open- and closed-loop mode so that wash water is not discharged into the Seto Inland Sea.

The pair of newbuilds on the orderbook for Shin Nihonkai Ferry at the Tategami works of MHI's Nagasaki complex will each have a potent propulsion installation using four of the 14V31 engines, yielding 34,160kW in total. Due to be allocated to the Yokosuka/Shinmoji(Kitakyushu) service on delivery in 2021, each has been dimensioned for 154 trucks of 12m, plus 30 cars and 268 passengers.

Exhaust gas cleaning systems have also been specified throughout, entailing shipsets of seven Wärtsilä open-loop scrubbers for the main engines and three generator aggregates. *NA*



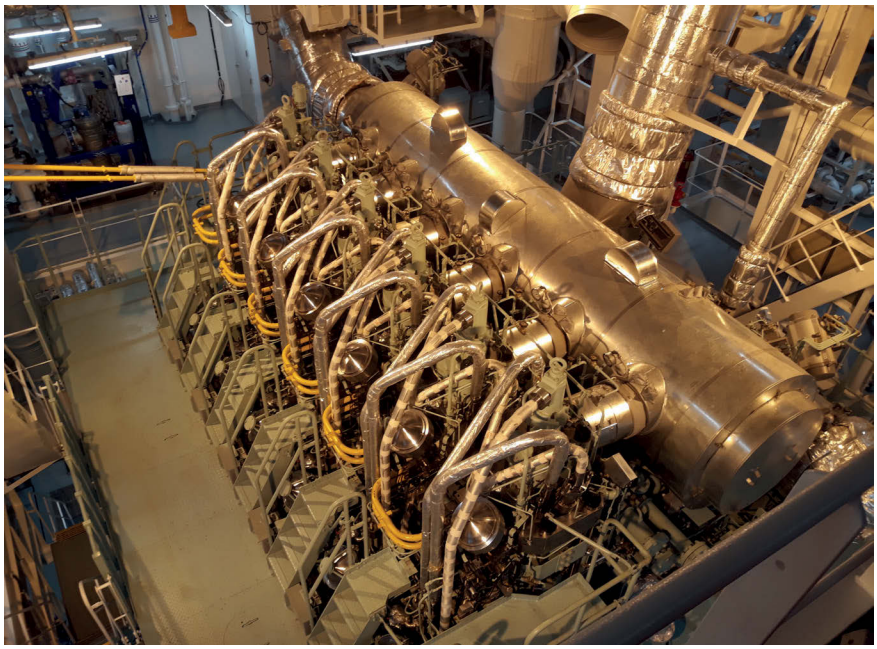
Noted for its efficiency, the Wärtsilä 31 has been a huge success for the Finnish technology company

Emulsified methanol as two-stroke fuel

MAN's ME-LGI engine platform, with its diesel pilot injection concept, offers scope for methanol/water blends

Building on extensive research over the years into the potential of water injection and emulsified fuel as a method of curbing NOx emissions, MAN Energy Solutions has now taken the work forward to the point where the technology is proposed as an effective abatement technology to meet IMO Tier III criteria.

Although it is well understood in the industry that mixing water with the fuel prior to injection can lessen NOx, the achieved reductions were, until recently, not sufficiently large to reach Tier III levels. The problem has been that ignition problems restricted the amount of water used. Mixing large amounts of water into diesel can induce a prolonged ignition delay which may result in knocking and increased hydrocarbon (HC) emissions due to poor combustion.



Methanol-capable dual-fuel ME-LGIM engines are at sea in a series of 49,000dwt tankers. Now an emulsified methanol variant is being developed

However, over the course of the past decade, advances in dual fuel (DF) technology has enabled diesel engine operation on both gaseous and liquid fuels that do not readily auto-ignite. The diesel pilot injection in MAN's ME-LGI engine, for example, ensures stable ignition and combustion of poorly igniting fuels, making it possible to burn water and fuel mixtures with water fractions that significantly exceed previously attempted levels.

MAN has already developed the ME-LGI dual-fuel two-stroke engine for operation not only on marine gas oil (MGO), marine diesel oil (MDO) or heavy fuel oil (HFO), but also on methanol, a low-flashpoint, liquid fuel. When running on methanol, a little HFO, MDO or MGO is used as a pilot fuel, significantly reducing emissions of CO2, NOx, SOx and, according to MAN, eliminating methanol slip.

Seven chemical/product tankers introduced by Waterfront Shipping since 2016 have been fitted with ME-LGI propulsion engines running on methanol.

A series of tests with engines running on water/methanol blends and water/fuel emulsion have indicated that the requisite engine performance can be achieved while keeping NOx within the Tier III limits, obviating the need for selective catalytic reduction (SCR) or exhaust gas recirculation (EGR) systems.

Investigations were conducted using the 4S50ME-T test engine at the Tamano complex of Mitsui Engineering & Shipbuilding (MES). The engine had previously been converted for operation on methanol fuel, i.e. as an ME-LGIM model.

In the case of a water/methanol mixture, the test programme demonstrated that a fuel penalty is incurred, in the order of 2g-6g/kWh of methanol. However, MAN said that this has been significantly reduced through subsequent development work.

Whether for methanol or diesel-water emulsions, the best results are obtained when the engine performance parameters are tuned to the most fuel-efficient settings, whereby higher in-cylinder pressures are employed. NOx is then brought back below Tier III thresholds by using the required amount of additional water.

Using methanol as the main fuel, 20-40% water is needed in the mixture to ensure Tier III compliance, the precise amount depending on engine load. The comparatively low water proportion is attributable to the colder methanol flame, relative to diesel, that gives a 30% reduction in NOx even without adding water. The tested concept was based on the pilot injection of diesel fuel to ignite the emulsion.

The company asserts that the ME-LGIM-W(emulsion) solution offers savings in capital costs and footprint relative to adopting SCR or EGR with a main engine installation. The technical modifications necessitated to introduce emulsified methanol into LGIM engines are not extensive.

One of the factors that must be taken into account is the amount of time that the subject vessel will spend in Tier III zones, as the volume of fresh water to be carried and produced will bear on comparative running costs. *NA*

Stena calls out 'ageist' tanker market

Danish operator Stena Bulk is calling the discrimination towards older tankers outdated and is suggesting that there are better ways of evaluating vessel performance

Criticism of age discrimination against older tankers is not a new topic, and although Stena Bulk president Eric Hånell has been pursuing the pressing issue for some time, little progress has been made. In a company press release in October 2019, Hånell stated his belief that ageism against tankers over 15-20 years old not only jeopardised safety at sea but will also prevent the implementation of new fuels that are crucial for reaching long-term environmental goals and reversing climate change. Speaking in Denmark earlier this month, he elaborated further.

Hånell proposed that customer fixation on historical accidents is largely responsible for age discrimination towards older ships, and he argued that the sound condition of vessels is irrespective of age. "If you look at oil spills and accidents in the world today it's not from older ships but younger ships. It's more the way you run and maintain them. A ship of seven years can easily be in far worse shape than a ship that's 20 years old," he claimed.

Stena Bulk is part of the Stena AB Group conglomerate, which as a designated inhouse R&D division that Hånell said is expensive to run and struggles to make plans since funds must be redirected into priority areas, such as the financing of newbuilding. "It's not cheap and when you're testing there may be 9-10 things that are not working. You hope to learn a lot from that process but to get a real payback you have to be able to think long term."

The requirements and guidelines concerning tanker age are often complex and differ depending upon the charterer and its relationship with the tanker operator. According to its website, BP Shipping does not charter chemical or oil tankers larger than 5,000dwt that are older than 20 years. For vessels smaller than 5,000dwt and LPG carriers the upper age limit is 25 years, with a 40-year limit for LNG carriers.

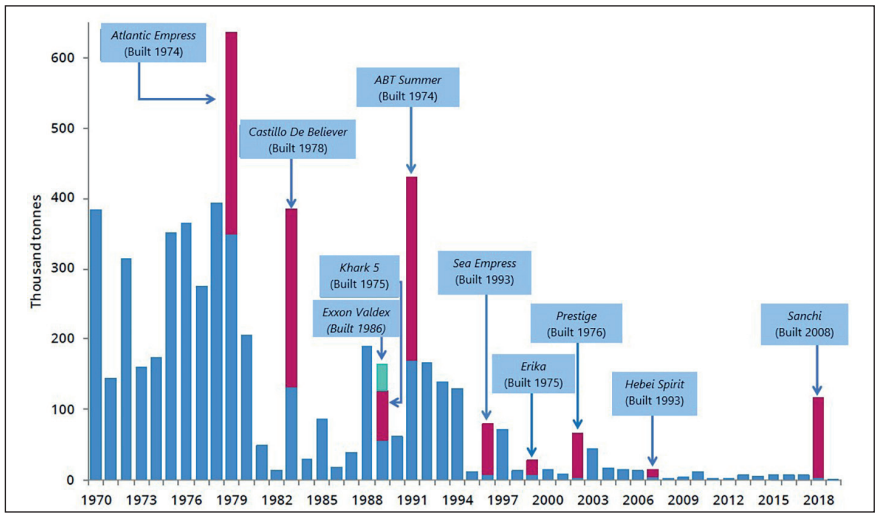
Some measures used to quantify the safety of older tankers are already in place, such as the Condition Assessment Programme (CAP). Classification society ABS states that CAP is a recognised method for shipowners to show the quality and suitability of a vessel for charter. However, Hånell thinks charterers are less interested in older ships with proven, operational experience than newer models, leaving tanker companies with little choice but to dispose of working vessels. "Some of the charters last for 15 years. After that time you get some new hire and it's manageable if you have good ships and good relations, but it's not as good as before."

"There are restrictions in the market and everyone wants all the options in the world when they have a cargo onboard, but they need approval from all the different customers. Based on that, to run a tanker with high-class customers the ships are basically dead at 20 years," he concluded.

Moreover, the cost of meeting the standards set for older ships are so high that the decision to scrap well-functioning ships becomes a simple one. "For a special survey, investments including a ballast water treatment system, probably a scrubber as well, could cost up to US$6-7 million and you still don't know if you can trade them or not. You can hope for the best and just lay them up and hope the world changes, but that costs as well."

Stena Bulk is also reluctant to purchase new vessels due to the rapid developments and changes in the shipping industry. Hånell stated: "Today I would not go and order a new ship. It's not that it's expensive, in fact order prices are quite reasonable, but who knows what technology is going to be valid five years from now? And when considering age restrictions, do you dare to do anything? A tanker that is run on diesel oil six or seven years from now may be valid, but perhaps not in 15 years."

Although Hånell remained coy on the specific technical solutions Stena Bulk could provide, he suggested that keeping technologically current and improving efficiency through the retrofitting of older ships could prove more advantageous than ordering newbuilds, given the fluctuating market. "It's probably easier to look at existing ships than to plan to put something onboard a ship that will be delivered 2-3 years from now. You can take a quick decision then install it. That would speed up the development and innovation of all kinds of equipment," he argued. *NA*



Quantities of oil spilt (7tonnes and over, rounded to the nearest thousand) between 1970 to 2019, including major incidents Source: ITOPF

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Dangerous by design?

An investigation into the 2017 collision between a US navy destroyer and merchant tanker raises Human Factors questions about the safety of digitalised bridge systems

On the morning of 21 August 2017, the US Navy destroyer *John S. McCain* was proceeding westbound along the traffic-laden Singapore Strait bound for Singapore. The weather was calm, there was no more than a gentle southerly breeze and visibility exceeded 10nm. As the *John S. McCain* made its way on the outside of the lane, overtaking slower merchant ships, a single crewmember was at the helm, controlling both the steering and propeller thrust via the Ship Control Console, responding to orders issued by the officer overseeing maneuvering.

At around 05:20, concerned that the helmsman might feel overwhelmed, the Commanding Officer instructed a second watchstander, the lee helmsman, to take over thrust duties and control of thrust was transferred to the lee helm station. However, the helmsman reported that, having done so, he also lost control of steering and the vessel began turning towards port. Despite various attempts to remedy the situation the crew appeared unable to regain control of the steering and the rate of turn only increased.

Meanwhile, the *Alnic MC*, a 50,760dwt Liberian-flagged tanker was also transiting westbound. Its master initially assumed that the turning *John S McCain* would pass between *Alnic MC* and another vessel further ahead, but alarmed by the destroyer's increased turn, ordered his vessel to slow. By now, control of the *John S McCain*'s steering had been reestablished and the destroyer's frantic watchstanders had moved the rudders to starboard.

It was too little, too late. At 05:23:58 local time, the *Alnic MC*'s bulbous bow struck the port side of *John S McCain*, breaching its hull in a berthing compartment where crew were sleeping. Ten of them were killed and a further 48 onboard the destroyer were injured; there were no reported injuries onboard the tanker. The damage sustained by the *John S. McClain* cost over US$100 million (see Fig. 2).

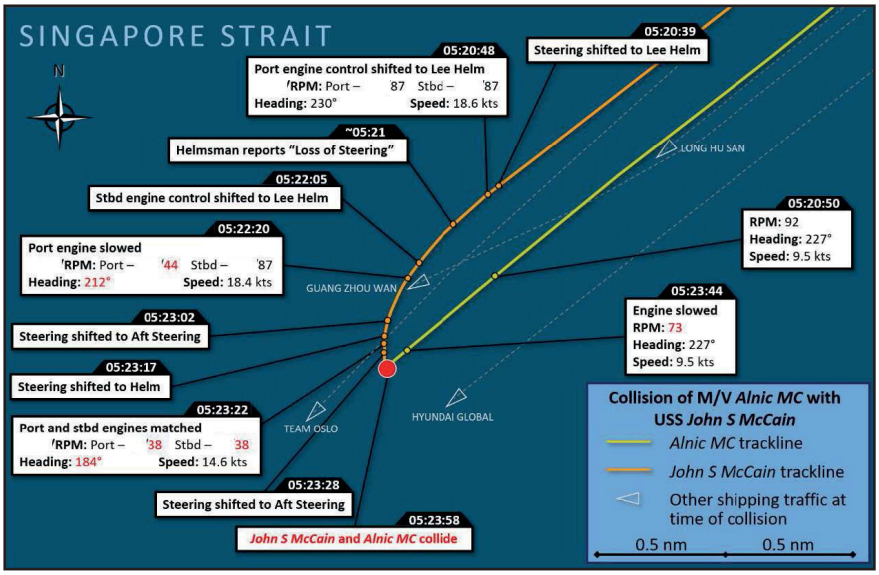

Figure 1. There was little more than three minutes with loss of control and collision

No malfunction

Collisions between naval and merchant vessels are not an uncommon occurrence, albeit few have such tragic consequences. However, it's the findings of the subsequent reviews and investigation reports into the incident by the United States Fleet Forces Command (USFFC), Transport Safety Bureau of Singapore (TSIB) and US's National Transport Safety Board (NTSB) which raise larger implications for shipping.

These reports found that the steering and propulsion systems of neither vessel had been a factor in the accident. Rather, it was that the helmsman had unintentionally transferred steering at the same time as thrust, leading to the perceived loss of steering control by the destroyer's bridge team. Moreover, the NTSB investigation revealed that the design of the *John S McCain*'s digital touchscreen steering and thrust control systems had increased the likelihood of operator errors.

In the aftermath of this investigation, following a comprehensive review and fleet-wide survey of its crew, the US Navy announced last year that it would begin retrofitting its destroyers back to manual throttles and traditional helm control systems, after it was found that crew overwhelmingly preferred mechanical systems.

Such radical remedial action poses wider questions about the efficacy of digital bridge systems and the touchscreen – or graphical user interface (GUI) – systems they employ, whether onboard naval or merchant vessels. Is safety being compromised for the sake of integrating new technology, is there a deficiency in training, or is it something else?

The interactions between human crew and bridge technologies, and the cognitive demands of navigation, are an area of research for Steven Mallam, an associate professor with the University of Southern Norway's maritime operations department. Earlier this month, as part of The Royal Institution of Naval Architects' Damaged Ship V conference, he presented a co-authored paper examining the circumstances behind the *John S McCain* accident and the lessons that can be learned.

Figure 2. The damage sustained by the USS *John S McCain*

Hitherto, few merchant ships have been equipped with digital bridge systems to the same extremes as found on naval and offshore vessels, but the integration of new technologies, whether at the newbuilding stage or as retrofits, are a major part of the transition to 'e-navigation'.

"The reality is that the majority of merchant ships are more conservatively designed and over their long operation life cycles have retrofitting of their equipment," Mallam tells *The Naval Architect*. "For the bridge – and you see similar trends in the control room – it is a combination of 'generations' of equipment layered on top of each other, which typically include digital and analogue displays and so on."

Perhaps the most well-known of these is the Electronic Chart Display and Information System (ECDIS), which has been mandatory onboard all vessels above 10,000gt since July 2018. Another example is the growing use of dynamic positioning technologies which were once exclusively the domain of offshore.

Key information

From a Human Factors perspective, a key aspect of digitalising systems and information is ensuring that end users (in this case the bridge team) have access to key information when they need it and the capability to correctly interpret that information.

"The key information was available and presented in multiple locations around the bridge," says Mallam of the *John S McCain* (see Figs. 3 and 4). "However, the personnel did not recognise that information, and actually seemed to misinterpret system status and try to solve a steering gear problem that did not actually exist. Furthermore, as detailed by the accident investigation, the transfer of control between the differing control stations was not properly understood by the bridge team."

Mallam sees parallels between one of the main design-related outcomes from the incident and his own research into the naval architectural design processes. Both the NTSB and USFFC investigations found poorly designed touchscreen systems contributed to the misunderstanding (something seized upon by the mainstream media) and he suggests those systems might be considered a consequence of larger organisational problems in ship design.

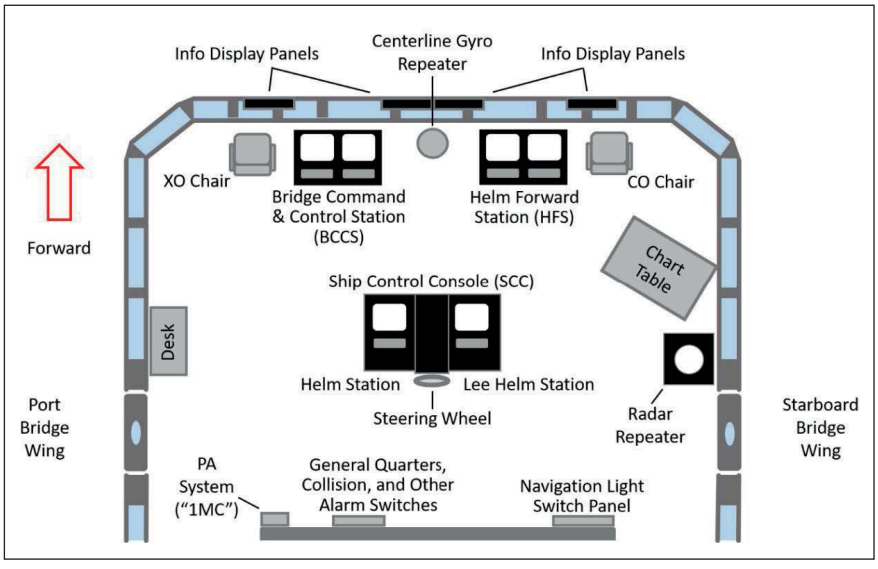

Figure 3. The layout of the bridge onboard the *John S McCain*. Source: NTSB

The ergonomic design criteria for touchscreen bridge equipment falls under the scope of standards organisation ASTM International's Standard F1166, Standard Practice for Human Engineering Design for Marine Systems, Equipment, and Facilities. Although voluntary, the ASTM standard had been approved for use by US Department of Defence agencies, such as the USN, and specifies that human-computer interfaces such as the bridge system's GUI display should follow the design principle of simplifying dynamic interaction. However, one of the findings of the NTSB investigation was that the touchscreen controls onboard the *John S. McCain* required the operator to take separate actions to transfer control of the port and starboard propellers, i.e. unnecessary complexity (see Fig. 5).

"This mirrors my findings in merchant shipping," notes Mallam. "I have argued that it is a systemic issue and a reason we still see design-related deficiencies onboard even newly built ships. Historically, crews have been able to manage by adapting the ship and its equipment to optimise their work practices. However, in a period of rapid digitalisation automation and rising complexity of systems inherent design weaknesses may not be compensated for as effectively by the human operators."

Digital isn't always best

While it may be tempting to see such issues as the symptoms of a luddite crew, Mallam and his co-authors suggest that digitalisation may not always be the best design solution for all bridge devices. As one of the project leaders of the Norwegian OpenBridge initiative to improve and harmonise bridge interface systems (see *TNA*, March 2019), Mallam has been helping to develop a better understanding of which devices might be better left 'analogue'.

He explains: "Take a ship's propulsion as one example. Typical physical thruster joystick controls are a type of generic interaction device that are a powerful physical representation of a larger system. For example, forward versus aft positioning of a physical joystick visually transmits the information of the direction 'forward' or 'aft' of a particular propeller. The relative speed of movement is represented by where the lever is positioned in relation to its sweep angle… This physical representation of propulsion and directional information in this design is information most people in the general population can readily identify, let alone trained navigators."

At the time of the *John S. McCain* collision there were 14 crew on the bridge, all of whom were qualified to perform watch duties under the Navy's Personnel Qualification Standard. Furthermore, the GUI displays were installed and visible in multiple locations around the bridge and bridge wings. Yet there was the unanimous misperception that steering had failed, behaviour that perhaps reveals something about group psychology or, as Mallam's paper suggests, the natural human tendency to match a current situation with previous experiences to minimise cognitive effort.

"Let's build on the propulsion example and increase the complexity a little," continues Mallam. "Now let's say we have a thruster control of an azimuth system. The propulsion power and direction of a pod in any horizontal angle of 360° is represented by a physical object, the joystick control system. The information is available to anybody in eyesight cognitively, research suggests that users build a more complete mental map with physical devices in an instance like this."

"[With bridge design] we look for instances where we can provide end-users with intuitive, consistent designs that require minimal mental processing. Even with highly trained and specialised end-users such as navigators, equipment and work environment design is critical for supporting their work processes and reducing opportunities for error."

When design goes wrong

The Integrated Bridge Navigation System (IBNS) that the *John S. McCain* had been equipped with was built and designed by US-based contractor Northrop Grumman, who declined to answer questions from *The Naval Architect*. But, of course, no vendor would intentionally release poorly designed equipment, so what goes wrong? Mallam thinks that it's typically a lack of resources and a lack of understanding of the importance of Human Factors during the design and development process.

"The USFFC report stated the problem perfectly…their analysis was that if the money and time wasn't appropriately allocated for Human Factors integration of their new systems then they shouldn't even try to implement them.

"Creating well developed, well thought-out and tested GUIs for maritime equipment may not be a prioritisation for some companies based on the allocation of resources. For example, prioritisation and budgeting of resources to hire full-time front-end designers, Human Factors practitioners and seafarers to develop optimal solutions is typically not done.

"The same can be said for naval architecture and ship design processes in general. My research has investigated Human Factors integration in Naval Architecture graduate programmes. They're highly technical, engineering focused and don't provide the educational foundation of Human Factors of end-user demands."

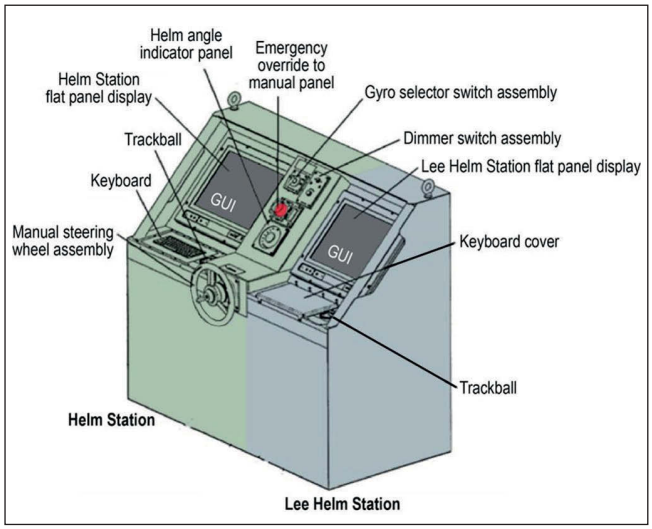

Figure 4. The *John S McCain*'s ship control console. Source: NTSB

Another recommendation Mallam has made in the past is that human operators need to have at least a basic level of knowledge of the underlying functions of automated and autonomous operations, and compares the *John S McCain* to the ongoing concerns with the Boeing 737 MAX airliners, which have been indefinitely grounded after two planes crashed.

"The operators in control of each respective complex, safety-critical transport system lacked sufficient training and knowledge of the underlying processes within the automated systems. As the investigators of the *John S McCain* accident found, the crew were not familiar with all the functions of the relatively new bridge systems, and specifically, there were no transfer of control between bridge stations instructions provided."

Of course, these are wider issues about the human relationship with technology, particularly with regards to automation, and it's a prominent concern as autonomous driving technology continues to develop. As the demand to be actively engaged and make judgements is reduced, so our relationship with those processes becomes increasingly notional and abstract.

At the root of the problem is that we are, by nature, poor passive monitors and finding the 'optimal' zone of arousal and cognitive demand where end-users are neither too bored nor too stressed is a challenge, particularly when designing for highly dynamic operations. "Think of the difference between navigating through a congested waterway or port versus open ocean in the middle of the Atlantic in fair weather," Mallam explains.

"Many of the once 'manual' tasks on the bridge are now automated, requiring more passive monitoring of systems, where crew are waiting to intervene and take action when and if necessary. This could be a routine or emergency action, but the point is that work tasks are much more reactive than they were in the past."

OpenBridge progress

Improving 'sensemaking', so that users perform the correct actions when they are called to do so, is one of the objectives of another ongoing Norwegian Research Council-funded project: Sensemaking in safety-critical situations (SMACS), which identified a need for user-centred design as one of a number of areas that must be addressed if navigational accidents are to be avoided.

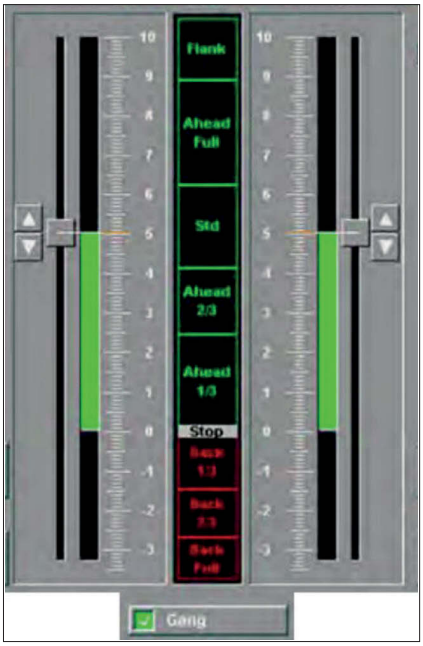

Figure 5. The GUI for the port and starboard thrusters, which had to be transferred separately. Source: NTSB

Meanwhile, OpenBridge, which currently has 26 industry partners and a waiting list for admission, will shortly make publicly available online its OpenBridge Design System and Design Guidelines, a support tool for its user interface architecture and a more intuitive integration of physical and digital solutions within the same system. OpenBridge principles have already been used for two pieces of equipment currently on the market, with Norwegian companies Westcon Power & Automation releasing an integration system, and Lilaas a centre console and thruster control system. Several more products are currently under development from other project partners.

Although there were initially some concerns that vendors might be protective about the design concepts, Hallam says there has been a positive response from not only small and medium-sized industry partners, but also the major equipment suppliers: "We have always highlighted that this is a research and innovation project. The key word here is research and the reason why The Oslo School of Architecture and Design, SINTEF and the University of South-Eastern Norway play such prominent roles."

"At the very philosophical core of OpenBridge and the Design System is knowledge sharing. We feel that if OpenBridge truly is a superior design guideline and adds value then it will naturally be adopted by industry stakeholders. OpenBridge is evolving as we test and apply our system more and more with our industry partners and in differing contexts. Ultimately, all of these inputs are helping us and our partners improve the design guidelines and procedures for implementation," says Mallam. *NA*

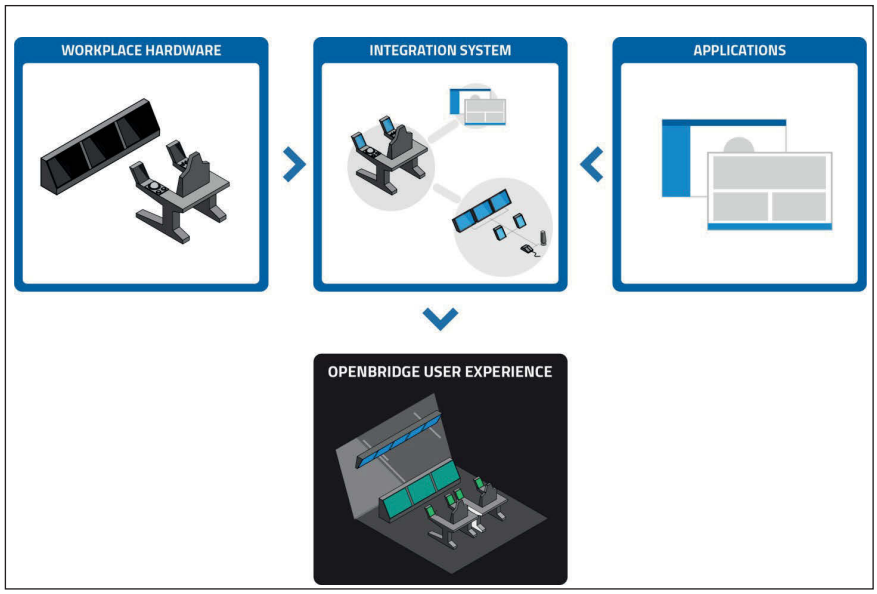

Figure 6. The three main levels of user interface architecture, as defined by OpenBridge

Supporting the green cruising revolution

Sarah Zitouni, business development manager at Lean Marine, discusses how its FuelOpt solution can help cruise ship efficiency in adapting to greener fuels

The environmental impact of cruise ships has been in the spotlight for a lot longer than their cargo ship cousins, given that they are a public-facing sector of the industry under the eye of increasingly environmentally conscious customers. Since the connection between ship fumes, local air quality and negative impact on population health has been scientifically acknowledged, the pressure on cruise operators to minimise air emissions from their ships in port areas has also increased considerably and continues to do so.

In response to customer demand and increasing environmental regulations, cruise operators have begun to invest in green technology solutions across their ships. For example, a growing number of newbuildings are equipped with plug and play shore power connection equipment that allow them to plug into the local power grid when in port, switching auxiliary power demands to using electricity rather than diesel fuel.

Since 2015, lower emission fuel alternatives, such as LNG, have also come to the fore, with many cruise lines having gas-powered ships on order. Carnival Cruise Line has taken delivery of two LNG powered cruise ships: *AIDAnova*, which was the world's first LNG powered cruise ship, and *Costa Smeralda*, which was the fifth largest cruise ship in the world as of 2019. Additional investments in green technology such as exhaust gas cleaning systems (EGCS), optimised hull designs and antifouling coatings are helping the sector clean up its act.

Swedish marine expert Lean Marine has also played a central role in supporting the green cruising revolution through the provision of our automated propulsion optimisation system FuelOpt. While FuelOpt is suited for all vessel types and any type of conventional propulsion system, it is particularly effective for RoPax and cruise vessels, and their owners' operational requirements.

FuelOpt achieves real time fuel savings by controlling the ship's propulsion. It ensures that the propulsive power is optimised automatically, based on the command set on power, fuel consumption and/or speed from the bridge. This removes costly variations in speed and power caused by human operational factors, allowing the vessel to achieve optimal fuel consumption at every given point throughout a voyage. For vessels with controllable pitch propellers, FuelOpt acts as a dynamic tuning system for the propulsion machinery to assure engine and propeller operate at optimal conditions.

With the FuelOpt control panel on the bridge, the ship's master is able to directly control speed and consumption. Using the speed input function, they can ensure that the vessel will reach the next port on time, a factor that is very critical for a liner service or for a cruise ship. Through the consumption input function, the master can limit fuel expenditure in order to automatically avoid costly overconsumption due to adverse weather, shallow waters, hull fouling or off-design losses.

It's also a highly social system, meaning it can be integrated as an 'on top' propulsion automation system in the current chain of tools and processes already onboard. As such, it can take inputs from a weather routing system, route optimising tools, AI systems and more. The technology is also completely independent of the fuel type or energy source and works with both conventional and newer engine designs.

FuelOpt is supported by another smart solution that Lean Marine offers: it creates and gathers vast volumes of vessel data which is sent to the cloud-based performance monitoring software, Fleet Analytics. For cruise ship operators wanting to digitalise vessel or fleet performance data, FuelOpt does this already for you without need for another data gathering system installation. We believe that combining these two solutions allows ship owners to reach the full optimisation potential of their fleet, making Big Data exploitation less intimidating by and more user-friendly.

Fleet Analytics turns data into knowledge for every department of the company. With this new information, our passenger ship customers are empowered to make efficiency a continuous improvement cycle with smooth long-lasting impactful operational changes towards healthy and sustainable operations. *NA*

About Lean Marine

Lean Marine, based primarily in Gothenburg, offers solutions for fuel saving and increased operational efficiency for the marine industry. FuelOpt and Fleet Analytics have so far been contracted for more than 175 vessels, representing over 40 different ship owners.

Further information can be found by visiting: **www.leanmarine.com**

Lean Marine's fuel saving system, FuelOpt

A practical primer for ship design

Reviewed by Jaime Perez Martinez MSc BEng, technical manager, RINA

Ship Design in Practice: First Things First
By Jan Babicz

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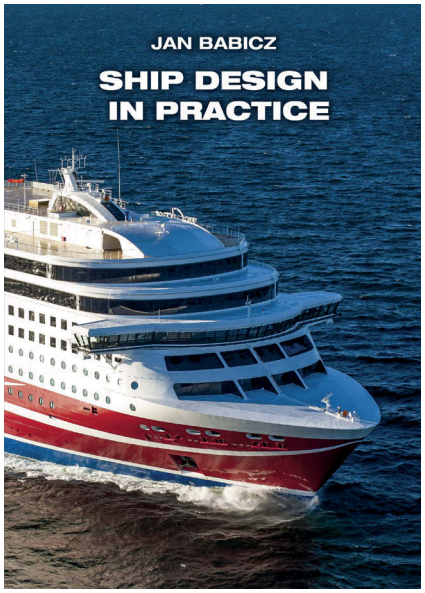

Ship Design in Practice: First Things First is a guide for conventional and practical ship design, in which the reader is able to consult design recommendations and other theorical knowledge, supported by illustrated examples of previously applied solutions. Throughout the five chapters Jan Babicz, previously chief designer at Gdansk Shipyard and a surveyor for Bureau Veritas, tackles various complex designs decisions by applying standard approximations, experience and databases collected during his 40 years of experience as a naval architect.

This book works as a visual reference book, somewhat reminiscent of earlier publications such as the *Wärtsilä Encyclopaedia of Ship Technology*. The reader is introduced to the ship design process, arrangement, equipment and safety which are all analysed, as well as a brief introduction into the basics of Naval Architecture. This publication includes references work carried out by Baobab Naval Consultancy, the author himself, and other well-known ships. The publication mainly focuses upon cargo ships, including container ships, bulk carriers, tankers, ro-ro vessels, car carriers, chemical carriers, LNG carriers and LPG carriers, with some mention of others such as ro-pax ferries and offshore support vessels.

The author mentions various sources that can be consulted, either as further reading on specific topics such as accident reports mentioned, rules and regulations, or other publications deemed of interest. RINA´s own publications such as *Significant Ships* and *Significant Small Ships* are cited as a primary source of basic information on new vessels, while Babicz also includes references to other works written by himself. The rules and regulations cited mainly come from the American Bureau of Shipping (ABS), particularly with regard to ship vibration. IACS and IMO rules are referenced in areas such as ship arrangement and deck equipment among others. IMO's SOLAS convention is used to illustrate the common understanding of major topics such as the navigation bridge visibility.

Clearly one of the biggest contributions of *Ship Design in Practice* are the examples provided in most of the chapters, which give practical solutions to common challenges during the design of vessels. This book includes examples of accidents and real ships in operation, considering the lessons learned from design flaws, cargo operation, and other causes. Those include the tragic *Christopher* and *Honghae Sanyo* bulker accidents in 2001 or visibility restriction cases such as the *City of Rotterdam* collision (2015).

The ship's cargo loading considerations, including the particular requirements when designing for different types of commodity, are discussed in the ship's arrangement. The book gives an overview of cargo and layout decisions and aims to provide the reader with an understanding of the various challenges that may arise while considering the accommodation, cargo hold, engine room and other areas to ensure safe and effective operation of the vessel. The reader can find accommodation layouts to help improve living conditions, but also valuable schematics, pictures and technical drawings which are present throughout this publication to support and illustrate the hints and solutions proposed by the author.

The first part of the book deals with the Ship Design Process, looking at design requirements, the use of reference ships, selection of main dimensions and lightship calculations. Included are guidelines on writing different ship documentation including the technical specification, the capacity plan, and more briefly the stability documentation. It also provides main dimensions and relevant details of different sizes and cargo for reference ships, which serve as the starting point for future designs.

Guidelines on Ship Arrangement is the second part of the publication and where, as the title suggests, the layout of the ship is described with examples to illustrate different cargo ships. Divided into the fore part, cargo hold region, machinery space, aft part and superstructure, the different ship´s parts are considered. Examples include the structural arrangement, accommodation block, collision block and boarding facilities, with recommendations on matters ranging from habitability to deck and cargo arrangements. Cargo areas for bulk carriers, multipurpose vessels and containers ships are compared and exemplified with transverse sections and structural characteristics. The underwater aft part is discussed, mentioning the importance of the right shape selection as well as the rudder type. Design inputs such as the relative position of the propeller and the rudder, and propeller clearance are also considered. Lastly, the chapter includes basic guidelines for engine room layout to achieve a good working condition space.

Deck Equipment comprises the third part, where the author discusses mooring, anchoring, towing and lifesaving devices. Here the reader is able to consult mooring layouts, arrangements and alternatives accompanied by pictures and drawings. Lifesaving devices such as lifeboats, survival craft and rescue boats are discussed with layouts and recommendations for an efficient and safe launching and operation. There is also a brief mention of lifesaving equipment, including immersion suits and embarkation ladders, with recommendations for stowage and deployment.

Safety is paramount and is the primary design factor that is returned to throughout the publication. Most of the chapters include safety recommendations, but chapter four gives particular emphasis to this important topic. Not only are onboard and onshore operations (such as mooring) discussed, but also collisions and flooding. From collisions, the author introduces the buffer bow design concept to increase the energy absorbed by the striking ship to reduce the chances of fatal damage on the struck ship. The notorious *Baltic Ace* collision in 2012 is used as an example to highlight the extreme outcomes that can derive from such incidents.

Naval Architecture itself is briefly covered with basic concepts on ship resistance, propulsion and manoeuvrability in this fifth and final chapter. Conventional methods of hull form analysis, propeller selection and design and rudder design are discussed. Energy saving devices, including Grothues spoilers, pre-swirl stators, wake equalising ducts, Mewis ducts, twisted fins and boss cap fins are also described.

Ship Design in Practice dives into this challenging and multidisciplinary subject of ship design by serving as a toolbox of guidelines useful for newcomers as well as more seasoned naval architects. This book offers a practical approach that rather than be centred on theoretical and scientific naval architecture, offers a visual approach that combines technical drawing with pictures. Included with the publication is a CD-ROM where the reader can consult examples of general arrangements, capacity plans, midship sections, etc., that otherwise would be illegible. *NA*

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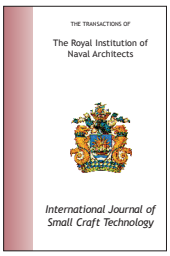

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