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DEEPER WATERS, STRONGER WINDS

By **Daniel Johnson**

The energy transition is without doubt one of the most complex issues of our time. An accelerated growth of renewable energy is needed to meet the challenge and floating offshore wind promises to play a significant role in the required move towards a net-zero society. Approximately 80% of the ocean's wind resource potential is found in areas where the seabed is too deep for traditional bottom-fixed solutions; floating offshore wind provides flexibility.

This nascent industry is poised for explosive growth in the coming decade and, as highlighted in the February 2023 issue of *TNA*, naval architecture expertise will be crucial in the design, construction and offshore installation process. We are already seeing the emergence of floating offshore wind markets in a number of countries, with (amongst others) Norway, the UK, China, Japan, South Korea and the US all moving to grow the technology. Roughly 300GW of floating offshore wind will be installed globally by mid-century, requiring around 20,000 turbines, according to DNV.

In August, energy major Equinor's 88MW Hywind Tampen project, dubbed the world's largest floating offshore wind farm, was officially inaugurated by Crown Prince Haakon of Norway. Located 140km off the Norwegian coast and in water depths of between 260m and 300m, the US$522 million project comprises 11 wind turbines based on Equinor's floating concrete spar Hywind concept. The energy generated by the wind farm will be used, somewhat ironically, to power operations at five oil and gas platforms in the North Sea Snorre and Gullfaks fields. Around 35% of the platforms' annual power needs is expected to be met, thus reducing emissions from the fields by approximately 200,000tonnes of CO_2.

While the acute contradiction of the project has not been missed by environmentalists, Equinor points to a bigger picture, stating: "Hywind Tampen will be an important test bed for further development of floating wind, exploring the use of new and larger turbines, installations methods, simplified moorings, concrete substructures and integration between gas and wind power generation systems."

Also this summer, plans for floating offshore wind farm development in the Celtic Sea off the coast of Wales and South West England progressed a step further with the first in a series of Crown Estate-funded site surveys. The multi-million-pound programme includes plans for further surveys over the next two years which will see data collected on everything from wind and wave patterns to birds and marine mammals in the area. According to the Crown Estate, the studies will be made freely available to successful bidders to support their decision-making and future progress through the planning process.

The surveys follow the publication by the Crown Estate in July of the proposed locations of the wind farms,

CROWN PRINCE HAAKON OF NORWAY OFFICIALLY OPENS HYWIND TAMPEN. SOURCE: OLE JØRGEN BRATLAND/EQUINOR

with four project sites set to deliver up to 4GW of floating wind capacity – enough to power around four million households.

Of course, if floating offshore wind is to fulfil its potential and reshape the energy landscape high levels of investment and political support will be needed.

In the UK, a recent report from The Floating Wind Offshore Wind Taskforce, which includes major offshore wind and port developers and other stakeholders, recommends the investment of £4 billion to upgrade ports for mass deployment of floating wind turbines by the end of the decade.

The taskforce notes that implementing some of its recommendations will result in the installation of 34GW of floating offshore wind in UK waters by 2040, generating up to £27 billion in additional gross value added and supporting 45,000 jobs across the country.

RenewableUK's emerging technologies policy analyst, Laurie Heyworth, who worked on the report, remarked: "Getting onto the front foot to make the most of our enormous floating wind resource is essential to boost Britain's energy security and deliver net zero as fast as possible. At the moment there are no port facilities in this country which are fit for the mass deployment of floating wind, so we need to start revitalising them now as new industrial hubs, so that we're ready for this new sector to take off at scale by 2030. The timeline is tight and we will only be able to deliver on our ambition if we take action promptly and decisively."

RINA will put an important spotlight on the fast-evolving floating offshore wind sector next month when it hosts the Offshore Wind Summit 2023 at the P&J Live in Aberdeen on 3 October. To be held in conjunction with the American Bureau of Shipping (ABS), the event is set to feature several keynote presentations from leading experts in the field. *TNA* looks forward to featuring some of the research and developments discussed at the summit in a future issue. ■

NEWS

RO-ROS

WALLENIUS WILHELMSEN SIGNS LETTER OF INTENT FOR NEW 'SHAPER' CLASS PCTCS

Wallenius Wilhelmsen has signed a letter of intent for delivery of four 9,350CEU methanol-capable and ammonia-ready PCTCs and individual options for an additional eight vessels.

The four vessels will be delivered from mid-2026 onwards by Jinling Shipyard in China.

"We are securing our position as our customers' first choice in shipping and delivering on our strategy to provide a net-zero, emission-free, end-to-end service by 2027," says Xavier Leroi, Wallenius Wilhelmsen's EVP and COO of shipping services.

The new vessel class has been named the "Shaper Class" as an indication of this strategy.

"There is an urgent need for our industry to transform over the next couple of years. As a company, we are determined to shape this industry and lead the way to capitalise effectively on changing circumstances, as we grow with customers and partners sharing our journey," adds Lasse Kristoffersen, CEO and president of Wallenius Wilhelmsen.

SOURCE: WALLENIUS WILHELMSEN

"We believe that methanol is the fastest way to net-zero emissions, and the ordered vessels can upon delivery use alternative fuel sources such as methanol. The vessels will also be ammonia-ready and can be converted as soon as green ammonia becomes available in a safe and secure way," according to Leroi.

TANKERS

HAFNIA INVESTS IN METHANOL-POWERED NEWBUILDS

THE ORDER IS THE FIRST FOR HAFNIA FOR VESSELS EQUIPPED WITH ENGINES CAPABLE OF OPERATING ON METHANOL. SOURCE: HAFNIA

Hafnia, the Singapore-based operator of product and chemical tankers, has ordered four dual-fuel methanol vessels, marking its first step into the methanol landscape.

The deal, signed with China's Guangzhou Shipyard International (GSI) together with Hafnia's joint venture partner Socatra of France, will see Hafnia take delivery of the four 49,800dwt dual-fuel methanol chemical, medium-range tankers from 2025-2026.

"The increasing momentum in green methanol-fuelled vessels highlights its ability as a cleaner marine fuel, with a future-proofed and proven net-zero pathway, furthering Hafnia's ambitions in meeting the IMO's 2050 targets," according to the company.

All four vessels are fixed via time-charter to TotalEnergies shipping entity CSSA for a multi-year period.

Søren Steenberg Jensen, head of Hafnia's asset management, says: "Given the time it takes to build a vessel and the time it takes actually to start moving the needle on carbon emissions, it is important to act now and take proactive steps in decarbonising the maritime industry.

"It does, however, require partnerships with charterers to make the financials work. The cost of the new fuels' technologies, if unsupported by long-term contracts, will have most owners refrain from taking the financial risk of the future fuels' technology alone on otherwise already expensive assets."

To date, Hafnia has invested in LNG as fuel for its newbuilds as part of its decarbonisation efforts. The company took delivery of two of its four LNG dual-fuel LR2 product tankers built by GSI earlier this year, with the remaining two to be delivered up to 2024.

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CRUISE SHIPS

CARNIVAL'S NEXT ROLLERCOASTER AT SEA GETS READY TO THRILL

ULTIMATE SEA COASTER TAKES SHAPE ATOP NEW SHIP *CARNIVAL JUBILEE*

Carnival Cruise Line has announced its third BOLT: Ultimate Sea Coaster onboard its new ship, the *Carnival Jubilee*.

The rollercoaster's 244m track is currently being installed on Deck 19 at Meyer Werft in Germany, where the ship is under construction. The installation is expected to be complete by the end of September while test runs are scheduled for October.

Once complete, the track will carry two all-electric, two-person cars. The riders control the speed of the car, up to 40mph, through drops, twists and turns 57m above the water line.

Manufactured by Maurer Rides in Munich, Germany, BOLT is already available on Carnival's two other Excel class ships and is the centerpiece of the vessels' 'Ultimate Playground'.

"More than 150,000 guests have experienced the exhilaration of riding the only rollercoasters at sea on Carnival Jubilee's sister ships *Mardi Gras* and *Carnival Celebration*," according to Carnival Cruise Line.

BOLT's initial iteration became the first rollercoaster at sea in 2021 with the debut of *Mardi Gras*. It has received several accolades, including an engineering award from *Popular Science* magazine.

The *Carnival Jubilee* will operate year-round from Galveston, Texas, beginning on 23 December 2023. The new ship will sail week-long Western Caribbean itineraries exploring destinations such as Mahogany Bay, Isla Roatan and Costa Maya and Cozumel in Mexico.

CRUISE SHIPS

CUNARD BRINGS SHORE POWER TO ENTIRE FLEET

British cruise operator Cunard says it has reached a key milestone in reducing its emissions by enabling the capability for its entire fleet to connect to shore power where available when docked.

The *Queen Mary 2*, *Queen Victoria* and the *Queen Elizabeth* now all have shore power capabilities while the *Queen Anne*, scheduled to launch in May 2024, will depart on its inaugural sailing with the technology already installed.

Katie McAlister, president at Cunard, says: "By adopting shore power technology, we are taking a significant step in our ongoing commitment to reducing emissions, minimising our carbon footprint, and fostering healthier port environments. The introduction of shore power technology aligns seamlessly with Cunard's corporate vision and values, and we are proud to be able to take such a positive step."

Shore power technology enables docked ships to connect directly to a land-based source and switch off their onboard engines, thus reducing emissions and noise while at port.

QUEEN ANNE IS SET TO LAUNCH IN MAY 2024. SOURCE: CUNARD

The ability for plugging in to shore power is already enabled at many key ports, including the *Queen Anne*'s homeport of Southampton.

As part of the European Union's Fit for 55 programme, all main ports in the European Union will offer ships the ability to connect to shoreside electricity by 2030.

FERRIES

WASHINGTON STATE FERRIES CONVERTS JUMBO VESSELS TO HYBRID ELECTRIC POWER

Washington State Ferries (WSF) in the US, a division of the Washington State Department of Transportation (WSDOT), has awarded a contract to Seattle-based shipyard Vigor for the conversion of up to three of its largest ferries to hybrid electric power.

JUMBO MK II CLASS FERRY *WENATCHEE*. SOURCE: JIM CULP/WSDOT

The contract is for the conversion of two 140m Jumbo Mk II class ferries, the *Wenatchee* and *Tacoma*, for approximately US$100 million, with an option to convert a third Jumbo Mk II class vessel, the *Puyallup*, in 2025. Vigor will also update aging propulsion system controls to extend the life expectancy of the vessels.

The award is the first conversion contract and largest overall contract to date in WSF's US$4 billion electrification programme, which involves the retrofitting six current diesel ferries to hybrid electric, building 16 new hybrid vessels, retiring 13 diesel ferries, and add charging power to 16 terminals over the next 17 years.

Serving around 24 million passengers every year, WSF is the largest ferry system in the US and the biggest contributor of greenhouse gas emissions (GHG) among Washington state agencies.

"This contract is a big step toward providing our ferry-served communities with better air quality and more sustainable service," says Matt von Ruden, WSF's System Electrification Program administrator. "We're tackling the biggest emitters in our fleet first, the Jumbo Mk IIs, which contribute 26% of our ferries' greenhouse gas emissions. When our terminals are electrified in 2026, we expect emissions from these three vessels to drop by roughly 95%."

The work will be carried out at Vigor's Harbor Island shipyard.

NEWS ANALYSIS

ELECTRIC VEHICLE FIRES AND A TANKER ORDER DROUGHT

By **Malcolm Latarche**

Taking over the headlines that followed the widely debated MEPC 80 was yet another fire onboard a car carrier. An event which is becoming all too common in recent years with at least 11 fires since 2015. The *Fremantle Highway* was carrying around 4,000 vehicles including 498 declared as electric vehicles (EVs) from Bremerhaven to Egypt when fire broke out off the Dutch coast in late July. The crew were evacuated by helicopter but there was at least one fatality.

Initially it was reported that the source of the fire was an EV although this has since been questioned. The event was very similar to the case of the *Felicity Ace* in February 2022 which was also carrying new vehicles including EVs from Germany. However, unlike the *Felicity Ace* which eventually sank, *Fremantle Highway* has been towed to Eemshaven where the fire was extinguished.

Confusion about whether the fire began in an EV arose when some press reports quoted representatives from the salvors as saying that up to 1,000 vehicles on decks one through to four were 'reasonably intact' and looked 'normal'. If all of the EVs were stowed on these decks – EVs being heavier are normally stowed lower in the ship – then it would seem that no EV was involved. However, the possibility remains that EVs or hybrids were stowed on other decks as well since no official statement contradicting the initial reports has yet been issued. With the ship safely in port, the truth will hopefully eventually come out.

The issue of fires on car carriers and rules for EVs has occupied the insurance sector some time, now it seems also to have made it on to the IMO agenda with new standards expected to be discussed next year. This may result in a new breed of vessel designed purely with EVs in mind. Whether shipowners will commit to such vessels given the low ratio of EVs to conventional vehicles remains to be seen.

A tentative connection to the rise of EVs on the tanker sector might be made as it would seem that orders for new tankers are at a historic low. The revelation came as part of Frontline's half-year results. According to Frontline CEO Lars Barstad, 12.3% of the VLCC fleet is over 20 years old and the new orderbook sits at just 1.5% of the current fleet. The Suezmax sector has even more older vessels but a slightly better new orderbook. Apparently, the rush for LNG carriers and container ships has made VLCCs less attractive to yards which prefer more sophisticated newbuildings. In many yards a newbuilding slot will not be available until 2026.

Tanker operators may be forgiven for a lack of enthusiasm for new orders given that the intention across Europe was to phase out construction of internal combustion engine (ICE) cars by 2035. On that basis, demand for oil was expected to drop gradually as EVs gained a bigger market share.

However, the energy crisis and subsequent electricity cost rises have caused the EU earlier this year to rethink its future ban on ICE cars with a reprieve for conventional engines running on e-fuels. Through August there has been a decline in EV sales with Reuters reporting that virtually all EV makers are burning through cash but not growing sales. In related news, CNN reported that Germany looks likely to fall back into recession as its auto industry suffered a 3.5% drop in June alone. A weakening of the impeding ban might just persuade tanker owners to commit to a new order burst. ■

FIRE DAMAGE ON THE *FREMANTLE HIGHWAY*. SOURCE: NETHERLANDS COASTGUARD

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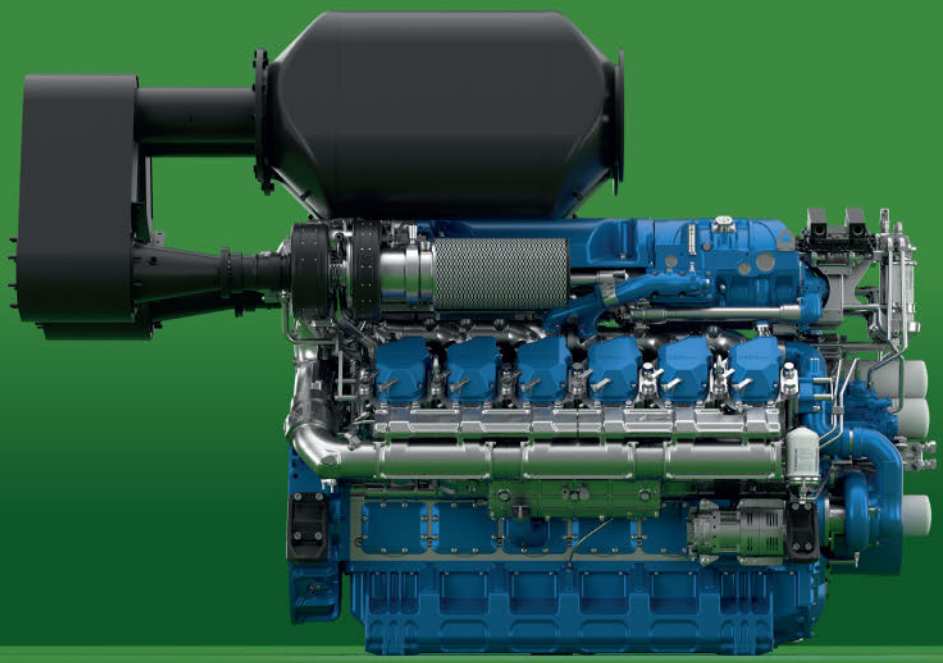

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NEWS EQUIPMENT

WIND POWER

BULKER SETS SAIL WITH WINDWINGS TECHNOLOGY

SOURCE: BAR TECHNOLOGIES

Mitsubishi Corporation's bulker *Pyxis Ocean*, chartered by Cargill, is the first vessel to be retrofitted with two BAR Technologies' WindWings – large wing sails measuring up to 37.5m in height that can be fitted to the deck of cargo ships to harness the power of wind.

Manufactured by Yara Marine Technologies, the sails are expected to generate fuel savings of up to 30% on new vessels, higher if used in combination with alternative fuels.

The installation of the WindWings took place at COSCO's Shanghai shipyard and the 80,962dwt *Pyxis Ocean* is now at sea conducting her maiden voyage.

"At Cargill we have a responsibility to pioneer decarbonising solutions across all our supply chains to meet our customers' needs and the needs of the planet," says Jan Dieleman, president of Cargill Ocean Transportation.

The WindWings project was co-funded by the European Union as part of the CHEK Horizon 2020 initiative.

The performance of the WindWings will be closely monitored over the coming months to further improve their design, operation and performance, with the aim that the *Pyxis Ocean* will be used to inform the scale-up and adoption across not only Cargill's fleet but the industry.

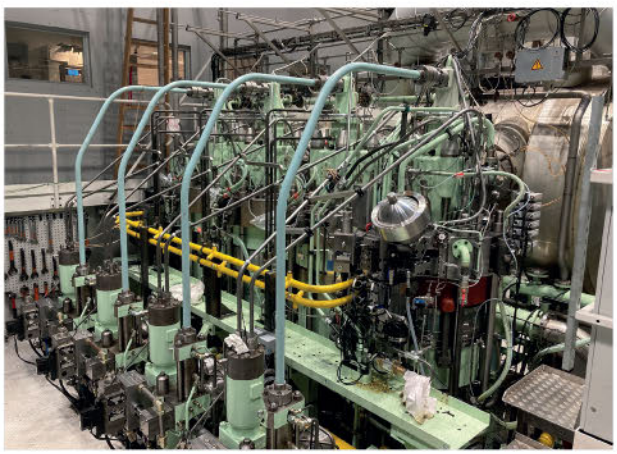
BAR Technologies and Yara Marine Technologies are already planning to build hundreds of wing sails over the next four years and BAR Technologies is also researching newbuilds with improved hydrodynamic hull forms.

ENGINES

MAN MOVES FORWARD WITH NEW AMMONIA ENGINE

MAN Energy Solutions (ES) has successfully completed a first test of a new ammonia-powered engine intended for use on large commercial and merchant marine vessels.

The test of the MAN B&W two-stroke 4T50ME-X type engine was conducted at the company's Copenhagen research centre in Denmark.



THE ENGINE IS EXPECTED TO BE FULLY OPERATIONAL ABOARD A COMMERCIAL VESSEL BY 2026

"This marks a major milestone on our road to developing a full-scale, two-stroke ammonia marine engine," says MAN ES chief technical officer Gunnar Stiesch. Based on results so far, the company predicts the engine will be in full operation aboard a commercial vessel by 2026.

Stiesch adds: "We have gained a deep understanding of ammonia's unique characteristics as a marine fuel, as well as its effects on fuel supply and safety systems. This successful combustion represents yet another, important step towards decarbonising the marine market."

The test included the construction of a custom 'cold hall' that would capture ammonia vapour in the event of a leak. Other safety features such as system ventilation and double-walled piping to secure the fuel were part of the engine's design.

Brian Østergaard Sørensen, head of two-stroke R&D at MAN ES, says: "Over the following months we will execute a testing programme that will study aspects such as heat-release, ignition, safety, pilot-oil energy fraction, NOx and N_2O emissions. We then plan on rebuilding the test engine from one cylinder capable of running on ammonia to a full-scale test engine running on ammonia around the end of this year or early in 2024."

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BATTERIES

MARINE BATTERY MAKER AYK ENERGY OPENS NEW AUTOMATED FACTORY IN CHINA

Andorra-headquartered marine battery specialist AYK Energy is setting its sights on becoming the world's leading marine battery maker with the opening of a new state-of-the-art factory in Zhuhai, China.

The 5,000m² automated manufacturing plant will ramp up production capacity to 300MWh a year, with the ability to scale up to 1GWh a year, according to the company's founder Chris Kruger.

"The new AYK factory will seriously disrupt the marine battery market," he says. "From here we can build the highest quality, safest and lowest cost class-approved batteries in the world. Our team is drawing on all our experience of working on marine batteries for 15 years, including pioneering the first ever marine type-approved battery."

AYK is one of the first manufacturers to secure type-approval for its lithium, iron, phosphate (LFP) cells instead of nickel, manganese, cobalt (NMC) cells.

"This immediately slashes our costs which we can pass on to our customers. LFP is also safer than NMC, evidenced by countries such as China which does not allow NMC cells to be used for any application that involves transporting people," says Kruger.

He adds that the new automated factory is the first of its kind and can be replicated with plans to open factories in Europe and America in 2024 in line with demand to serve the inland waterways and Jones Act markets hungry for green solutions.

AYK'S BATTERIES WILL BE INSTALLED ABOARD *FPS WAAL*

One of the first projects facilitated from the Zhuhai factory will see AYK supply Holland Shipyards Group batteries for a zero-emission machinery retrofit on the 110m container vessel *FPS Waal*, operated by Future Proof Shipping.

The vessel's diesel engines will be replaced with PEM fuel cells, storage for hydrogen fuel, two AYK high-density DNV-approved Aries 88 lithium batteries and an electric drive train.

The order is the first time that AYK batteries will be used alongside fuel cells, making it a landmark contract for the company, Kruger says.

FUEL SUPPLY SYSTEMS

CCS APPROVES LH2 FUEL SUPPLY SYSTEM

SOURCE: CCS

China Classification Society (CCS) has issued an approval in principle (AiP) certificate for a marine liquid hydrogen fuel supply system developed by Weishi Energy Technology Hebei (WETH).

The AiP is the first to be awarded by CCS for an LH2 fuel supply system.

Based in Hebei, China, WETH is a sustainable energy company engaged in the research and development, production and sales of hydrogen fuel cell products.

The company's system design includes a marine liquid hydrogen tank and cold box, supercooled hydrogen storage technology, heat exchange technology, regulated hydrogen supply technology and subcooled hydrogenation technology.

Dual-boost functionality ensures rapid system startup, and the system has been designed to be corrosion and salt-alkali resistant in high-humidity marine environments, according to CCS.

The classification society says that it will further co-operate with WETH on the approval of hydrogen fuel cells, work together to provide product supply and technical support for the application of hydrogen energy ships and work towards the industrialisation of liquid hydrogen technology in China.

CHINA

CHINA'S SHIPBUILDERS CONTINUE WITH GLOBAL LEAD IN H1 2023

By **Daniel Johnson**

Just 20 years ago Chinese shipyards had a market share of less than 10% but massive capacity expansion during the 2000s propelled the country to first place in the global shipbuilding industry by 2009, a position the country has battled with South Korea over in subsequent years. Having claimed the number one spot in 2021 and 2022, China continued to lead in the first half of this year, boasting the biggest international market share in terms of output as well as new and holding orders, according to data released by the country's Ministry of Industry and Information Technology (MIIT).

MIIT's statistics show that China's shipbuilding output reached a deadweight tonnage (dwt) of 21.13 million during the period, an increase of 14.2% year-on-year and accounting for 49.6% of the world's total. The data also reveals a surge in new orders. Up 49.5% from a year earlier, they stood at 26.45 million dwt, representing a hefty global market share of 67.3%.

The country's holding orders totalled 123.8 million dwt, up 20.5% year-on-year and claiming 53.2% of the world's market share.

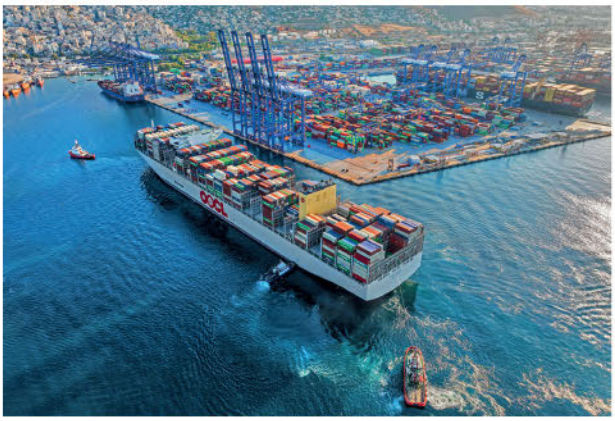
UK research and analysis organisation Clarkson Research also reported that China's shipbuilders ranked first in the world in terms of orders received in the first half of the year. Its data shows that in the first six months of 2023 the total number of ship orders worldwide amounted to 678, with Chinese shipyards receiving 428 of these orders.

Much of China's current wave of output and orders has been driven by demand for eco-friendly shipbuilding and is underpinned by a growing global emphasis on reducing carbon emissions and enhancing environmental standards within the maritime sector. As such, owners are picking designs for highly efficient, often dual-fuel and dual-fuel-ready ships to prepare for the future.

New class of environmentally advanced ships

Early in 2023, China State Shipbuilding Corporation (CSSC) shipyards Dalian Shipbuilding Industry Co. (DSIC) and Guangzhou Shipbuilding International (GSI) simultaneously floated out *MSC Chiyo* and *MSC Noa Ariela*, the first of a new class of 16,000TEU ships for Swiss shipping giant MSC which are being touted as the most environmentally advanced container ships yet built. According to reports from China, MSC's order with DSIC and GSI calls for a total of 13 vessels due for delivery between 2023 and 2025.

The design for the new class was developed by the China Shipbuilding Group and has a length of 366m, a moulded width of 51m, a moulded depth of 30.2m and a design draught of 14.5m. Classed by DNV, its cargo capacity allows it to accommodate up to 16,616 standard containers.



THE CHINESE-BUILT *OOCL PIRAEUS*. SOURCE: OOCL

CSSC boasts that the vessels incorporate new concepts in environmental protection, carbon reduction, and a drag reducing design. They are powered with WinGD engines and hybrid scrubbers but are also designed LNG-ready. The ships are outfitted with air lubrication and a shaft generator and are reported to have an Energy Efficiency Design Index (EEDI) value of 57% lower than the baseline.

DSIC delivered *MSC Chiyo* to MSC in early June.

Chinese shipyard Dalian COSCO KHI Ship Engineering Co. (DACKS) also entered the 'eco-friendly' container ship segment in H1 2023 with the delivery of its first 24,000TEU vessel for Hong Kong-based shipowner Orient Overseas Container Line (OOCL). *OOCL Piraeus*, the first of six such vessels ordered by OOCL and to be delivered by DACKS, is classed by ABS.

DACKS reports the vessel's EEDI exceeds the benchmark value by more than 50%, meeting the requirements of EEDI Phase 3. The design features a newly developed energy-saving bulbous bow, propeller front shroud, and other energy-saving devices including "the world's largest capacity high-efficiency permanent magnet shaft generator system" which saves energy and provides a boost to operations.

The application of new technologies includes an intelligent safety management system that monitors and predicts hull conditions for the entire life cycle of the vessel. The design is also said to employ the first 45ft container double lashing scheme which will improve the economy of the ship's operations.

Largest container ship order

On the new order front, it was announced in April that French shipping company CMA CGM had signed the largest container ship building order placed in China for a total of 16 new vessels to be built by yards within the CSSC group. The contract, estimated to have a value of US$3.1 billion, is for 12 methanol dual-fuel 15,000TEU vessels and four LNG dual-fuel 23,000TEU vessels.

The 15,000TEU ships will be constructed at Jiangnan Shipyard and DSIC. According to CSSC, the vessels will be "researched, developed and designed independently by Chinese shipbuilding organisations and capable of meeting the world's strictest emissions requirements".

The LNG-powered container ships, likely to be an upgrade of the Jacques Saadé class first delivered to CMA CGM by CSSC in 2020, will be built at Hudong-Zhonghua Shipbuilding.

Also in H1 2023, Danish container shipping heavyweight Maersk returned to China to place an order for six mid-sized container vessels with Yangzijiang Shipbuilding Group. All six 9,000TEU vessels will all have dual-fuel engines able to operate on green methanol and fuel oil and are slated for delivery in 2026 and 2027.

Upon delivery, the vessels will replace the existing capacity in the Maersk's fleet. Maersk estimates that the new vessels will reduce the company's annual greenhouse gas (GHG) emissions by about 450,000tonnes CO_2 equivalent per year on a fuel lifecycle basis when operating on green methanol.

LNG carrier orders up

While having established itself as the premier location for building container ships, one area that China lags behind South Korea is the high-technology, high-added value large LNG carrier segment. Since delivering its first vessel in this segment in 2008, China has been making efforts to enhance its competitiveness and chip away at its East Asian neighbour's dominance. China's share of global orders for large LNG carriers exceeded 30% in 2022, hitting an all-time high, and according to data from the China Association of National Shipbuilding Industry (CANSI), from January to July 2023 China undertook 18 of the vessels, accounting for 35% of the global total.

CANSI does flag a potential cloud on the horizon for China's continued bid to seize and maintain the lion's share of the shipbuilding industry, however. The association warns of a labour shortage amid the growing demands from the big increase in new orders and high-quality development in the industry. ■

COSCO LAUNCHES BATTERY-POWERED CONTAINER SHIP, WITH A SECOND VESSEL IN PRODUCTION

By **Tom Barlow-Brown**

Chinese shipping company COSCO Shipping Development continued its move to invest in green technology with the launch of the first of two 700TEU electric vessels.

The first vessel, currently known as Hull N997, was launched at the COSCO Shipping Heavy Industry yard in Yangzhou, China, in July. Powered by portable container-sized batteries, the 10,000dwt NN997 has an overall length of 119.8m, a moulded beam of 23.6m and a designed draught of 5.5m.

The vessel's shallow draught will allow it to operate in rivers and coastal waters, such as the Yangtze River. Once fully operational, N997 will carry goods up the Yangtze to the port of Shanghai, providing a connection from Wuhan in the interior of China to the Yellow Sea, 850km away.

According to the company, the new e-vessels will have the largest installed battery capacity ever placed onboard a ship. They will be powered by two 900kW motors.

The power source will be a unique modern containerised battery system that has 36 interchangeable containers. It is intended that these batteries can be swapped out when the vessel is docked in port along its route. Each of the containerised batteries will be around 20ft in size and have a capacity of 50,000kWh. The battery system is designed to reduce carbon emissions by 32tonnes per 24 hours.

The project is to support COSCO's new campaign of "carbon peaking and carbon neutrality" in the service of green zero-carbon shipping. The intention of the project is also to provide a springboard for further electrification of inland waterways globally.

The two new battery-powered ships are equipped with a state-of-the-art smart ship management system. This will enable them to operate more efficiently through intelligently adjusting energy consumption based on different circumstances and battery capacities. The integrated management system will also plan the ship's sailing velocity autonomously, according to the scheduled arrival time, water flow, weather conditions, and other factors influencing its voyage.

N997 is scheduled to commence sea trials in late September. Once completed it will be operated by Shanghai Pan Asia Shipping, a subsidiary of COSCO. ■

OPTIMARIN TAKES BWTS MANUFACTURING TO CHINA

By **Daniel Johnson**

With an eye on the post-retrofit ballast water treatment system (BWTS) market, Norwegian BWTS supplier Optimarin is in the process of establishing a manufacturing base in China to boost the availability of its systems for the Asian shipbuilding market.

The company is currently pursuing partnerships with several Chinese suppliers to focus on high-quality production of BWTS components at a reasonable cost for delivery to regional yards, according to Tore Andersen, Optimarin's executive vice president of sales and marketing.

TORE ANDERSEN. SOURCE: OPTIMARIN

"We are conducting due diligence when selecting new suppliers to verify that components meet our required high-quality standards and thereby ensure the proven reliability of our robust system is maintained, while making it available at a reasonable price as we expand in this market," he explains.

"In addition, we are keeping our 'dual-supplier strategy' in place to mitigate the risks of potential delivery issues, and make sure we can get systems and components to our customers on time."

Andersen says that he believes Optimarin is well-placed to secure newbuild orders for its BWTS as the flexible modular system can be easily installed on all types of vessels – with installation costs in many cases around half of other systems – and typically has minimal commissioning issues.

The so-called Optimarin Ballast System (OBS), which can be delivered as a compact skid-mounted solution, comes with a full documentation package and verified compliance with the IMO's Ballast Water Management Convention, as well as with US Coast Guard type approval.

The shipbuilding industry has seen a resurgence of ordering activity as global trade has rebounded in the wake of the coronavirus pandemic. Lower-cost Asian yards – mainly in China, South Korea and Japan – have secured 70% to 80% of orders for vessels in various segments including container ships, bulkers, tankers and LNG carriers that are currently under construction, with scheduled delivery in the 2025-27 timeframe.

Andersen points out that these newbuilds will have to be delivered with an IMO-compliant BWTS installed to meet regulatory requirements.

China presence a 'big market advantage'

China has emerged as the dominant player among the big three shipbuilding countries, having secured nearly half of all newbuild orders in recent years.

"We believe having a local supplier presence in China will give Optimarin a big market advantage in terms of competitive price and short delivery time for yards, while we also provide expertise in the project development phase and can assist with a ballast water management plan," Andersen says.

He adds: "The main priorities for yards with a BWTS supplier are the ability to deliver on time and at the lowest cost. But we are also seeing a growing tendency where shipowners determine which system they want installed due to historic reliability issues they may have had with other systems. Furthermore, having in place a global after-sales network for BWTS maintenance and support is also an increasing priority for shipowners to ensure operational uptime."

Consequently, notes Andersen, Optimarin is now taking orders in the newbuild market where especially European owners are looking for reliable systems with low operational cost and a strong service network.

He points to Optimarin's fast and responsive 24/7 after-sales service with global coverage and spare parts availability. The company's BWTS has a 2.5-year service interval, while onboard maintenance can also be performed by crew due to the simple construction of the intuitive and easy-to-operate system, according to Andersen.

"A lot of work has gone into enhancing OptiLink, our cloud-based digital application that enables real-time monitoring of the BWTS, data generation for improved planning of ballasting operations and remote connectivity for online software updates of the system, as well as data-sharing for compliance," he says.

Meanwhile, Optimarin remains focused on the busy retrofit market where it aims to sell as many as 700 systems over the next couple of years (Andersen predicts that many shipowners will miss next year's IMO deadline to retrofit BWTS and that installations are likely to spill over well into 2025).

"Now we are also seeing demand for retrofits of earlier BWTS retrofits as competing systems have fallen short of shipowners' expectations in terms of reliability and support. This shows that it is important to choose the right maker from the beginning," he concludes. ■

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AUTONOMOUS SHIPS

ONE SEA'S SINIKKA HARTONEN AIMS TO PROMOTE DIALOGUE AND COLLABORATION

By **Tom Barlow-Brown**

Artificial intelligence and automation are hot topics these days. Governments, companies and individuals all over the world are wondering how best to integrate them into our lives. The maritime sector is no exception.

Unmanned or semi-unmanned vessels operating on the world's oceans will soon no longer be the stuff of science fiction but reality. Helping shipowners and international organisations draw up new charts to navigate the legal implications of automation for shipping is One Sea.

The multinational organisation was first established in 2016 as an ecosystem to support innovation in the maritime industry regarding automation. "The main idea was to raise awareness that automation and autonomy is something that is coming and being introduced into the maritime world. It all started out with these sorts of visions of vessels going around the world without anyone onboard," One Sea's secretary general, Sinikka Hartonen, tells *The Naval Architect*.

Hartonen was elected as secretary general in October 2022 and has brought substantial experience to the role. After starting her career on merchant ships, she then joined the Finnish Maritime Administration where her primary duties related to Vessel Traffic Services development.

In 2010 she began working at the Finnish Transport Agency where she held the position of deputy director general. Hartonen joined the Finnish Shipowners' Association in 2018 where she worked on regulatory processes at the IMO and EU. This has no doubt been important as One Sea has been deeply involved in the discussions around the legal practises of automation.

Change of focus

Elaborating on the foundation of One Sea, Hartonnen says: "First we wanted to raise awareness, then in 2019 it became obvious that it was time to build a more formal organisation for the ecosystem. Our focus has changed a bit from raising awareness and supporting R&D projects to now supporting the IMO member states and the national administrations in the daunting task of drafting international regulations for maritime automation."

It is always difficult to predict how new technologies will inevitably be used and this is also the case for AI and automation in the maritime sector. "I think that no one has a crystal ball to know when we will see an uncrewed vessel. One thing that is important to note when you are talking about autonomous ships is that everyone has different ideas about what constitutes one. So that is one thing that we now need to agree upon at the level of the IMO," says Hartonen.

ONE SEA SECRETARY GENERAL SINIKKA HARTONEN. SOURCE: ONE SEA

She is keen to point out that fully uncrewed ships will take time. "First we need to have the regulation in place in order for shipowners to make the investments that are needed for building new vessels capable of the technological advancement to go around the world," she says.

Taking the next steps

One Sea is working closely with organisations such as the IMO to work through different solutions to automation in the maritime sector. "But there are so many steps before fully autonomous vessels, and that is something that we need to support in the first place," Hartonen says. "Automation is not only about getting rid of the crew. It's about introducing different kinds of solutions that will assist the crew in their decision making and make them more situationally aware."

Asked whether the traditionally conservative maritime world could be a barrier to the work of automating global fleets, Hartonen is optimistic. "I would say that nothing is impossible. Man has been to the moon, and we have done some incredible things. So I think that the technology will allow us to do different kinds of things and that might be operating uncrewed vessels in the future. But the question that we need to think about is whether we want to do it? Do the shipowners want to do it? What is the incentive to do it?" she says.

Before the shipping world can answer these questions, the right regulations need to be in place. Even if the technology is ready. "I think that is the important message which we always want to highlight," says Hartonen.

"Certainly, it's a slow process because it's also not

AUTONOMOUS SHIPS RUN BY ARTIFICIAL INTELLIGENCE MAY NO LONGER BE THE STUFF OF SCIENCE FICTION. SOURCE: SHUTTERSTOCK

only about the technology. It's also about the culture. Shipping is a very traditional culture because we have many sorts of processes and documents in place in the same format that we've had for hundreds of years. So, it's slow but I think that it's important to note that there is progress, that we are moving forward, even if we are doing it slowly," she continues.

For Hartonen and the team at One Sea safety is paramount, as in any transportation mode. "If something goes wrong, we will put people in harm's way or do some kind of environmental damage. I think it's good that going forward we need to know what we are doing, and we don't rush, but build a solid base to work from," she says.

The IMO's Maritime Safety Committee is in the process of drafting a non-mandatory Maritime Autonomous Surface Ship (MASS) code. Once this document is formally adopted it will be the first piece of regulation directly focusing on automation in shipping. This could be as soon as 2025. The new code will apply in much the same way as current SOLAS regulations for merchant vessels and will augment the current rules.

"It won't be a silver bullet, it won't change the world within 20 years when this regulation is in place, but it's really good start," notes Hartonen.

"There are some challenges because whenever we are talking about the IMO, we need to find a global consensus and how we all understand things," she adds.

Front runners driving automation

Many companies are already taking steps to automate aspects of their fleet. The use of artificial intelligence to monitor vessel data or assist navigation is also gradually being adopted by more and more companies. For example, Stena Line has implemented its AI-assisted 'Stena Fuel Pilot' which aims to save an additional 5% of fuel on routes, equal to 23,000tonnes of fuel and 70,000tonnes of CO_2, when fully implemented across the fleet.

"It's very normal that we have those front runners who are more ambitious and moving forward faster than the others. I would be bold enough to say that our partners are the most prominent players and who are driving automation," says Hartonen, adding: "The more companies we have onboard from different parts of the maritime cluster is always good because what we are promoting is active dialogue."

Part of One Sea's central mantra is the fostering of a communication network between all sections of the maritime world. This includes parties that wouldn't normally have a voice at the table, such as seafarers. "Certainly, they don't have any kind of incentive to join us as members, but we are having an active open dialogue with them. That is something that is a core thing at One Sea. We don't believe that all wisdom lies with the maritime associations or within companies," Hartonen says.

Ultimately the daunting prospect of integrating automation into the maritime world can only be done through all parties working together. That is something Hartonen is keen to emphasise. "Collaboration is the way forward, no one can do this alone," she concludes. ■

SHELL AND ORCA AI PARTNER TO DRIVE INNOVATION IN NAVIGATION

By **Alan Johnstone**, Correspondent

Navigational error resulting in collision or grounding is one of the highest safety risks associated with maritime transport. Safe navigation relies strongly on Officers of the Watch (OOWs) maintaining lookout awareness and making good navigational decisions. The introduction of tools such as AIS, ARPA, VTS and ECDIS has provided more input data, but correct information processing and action response continue to rely on human factors.

As a leading charterer and ship manager, Shell has long recognised the need for new navigational tools to better support the OOW. "There has been a hiatus in novel navigational technologies since ECDIS, and serious navigation incidents are still happening. Among our many R&D initiatives we wanted to explore ways to improve situational awareness and to enhance the safety of navigation. Our aim has been to come to a deep understanding of how AI technologies can support better decision-making alongside existing systems," explains Saurabh Kumar, project engineer at Shell Shipping & Maritime.

Positive attraction

In 2019, Shell Shipping & Maritime R&D department started scanning for potential partners with technology that could be installed on oceangoing vessels. "Most autonomous ship projects focused on smaller vessels and short voyages, but we wanted something that could be scaled for larger tonnage," Saurabh says.

Tel Aviv-based startup Orca AI's automated watchkeeper met Shell's technological requirements: the solution uses a combination of thermal cameras, low-light cameras, and data from onboard sensors to create an accurate image of the waters surrounding a ship in real-time. Advanced computer vision allows the system to identify objects and classify them. The AI algorithm continuously learns the environment in order to understand hazardous situations and alert the OOW based on pre-defined thresholds.

Another deciding factor for Shell was that Orca AI's navigation and collision avoidance system was already mature. As a 'plug n play' system, there is no requirement for complex retrofits.

Green light for a pilot project

Shell invited Orca AI to work on a six-month pilot that kicked off in November 2020, with the system installed on a large LNG carrier. "When we embarked on the partnership with Orca AI, we weren't like one more customer paying a license fee. It's much more productive to work alongside vendors to see how we can develop the product," says Saurabh. "Our ships are like living labs in this respect. We're using every new version on a second LNG carrier with good feedback."

The insights generated by the Orca AI system were significant. "The crew were expecting enhanced radar capabilities, but they soon saw that Orca AI stands on its own merits. It's especially useful in high-traffic conditions closer to shore," Saurabh says.

Orca AI's chief technology officer and co-founder, Dor Raviv, says the pilot project has been key to proving the credibility and reliability of the platform. "The Shell R&D team prepared internal analysis of navigational performance using data generated by the Orca AI system, including close quarters events, from the vessel," he explains. "The analysis clearly demonstrated the capabilities of our platform to improve safety and they are championing its value internally."

Shaping product direction

The pilot project has now morphed into a long-term development collaboration, with Shell acting as a catalyst for designing new features of the Orca AI platform, such as the platform's dashboard and monthly reports. The partnership has also matured into a test bed for the application of AI and machine learning and today Shell is supporting Orca AI in creating a more relevant product suited to any cargo segment, with a focus on actionable insights, learning and awareness.

"We're now looking at security monitoring, detecting fugitive emissions and we will shortly release a brand-new Voyage Comparison module," Dor says. "The module is ground-breaking in that it enables users to see exactly where events occurred on a map display, including route deviations due to bad weather, alongside accompanying images and video. Secondly, users can compare different sections of a route to benchmark different KPIs across their fleet."

DOR RAVIV, CTO AT ORCA AI

SAURABH KUMAR, PROJECT ENGINEER AT SHELL SHIPPING & MARITIME

ENERGY MAJOR SHELL MANAGES A FLEET OF AROUND 20 LNG CARRIERS. SOURCE: SHELL

The partners are also focusing on operational optimisation. Dor points out that whereas today crews have little incentive to choose an optimised route, this will not be the case with a semi-autonomous ship. "There are many suppliers of strategic route planning systems, which are of course helpful, but no one else has a solution for tactical navigation based on high-resolution data," he says. "Today, the captain decides the best collision avoidance manoeuvre. However, our system can recommend a manoeuvre and optimal timing."

Eventually the system will be integrated with the propulsion system, taking control of the helm under human supervision. This will facilitate time and distance savings that will stack up not only for individual ships but across fleets. "That could mean really large numbers," Dor concludes. "The intention now is to develop a full-scale autonomous navigation platform that can provide real-time recommendations for collision avoidance and shore-based monitoring and take shipping operations efficiency to a whole new level." ■

COMMUNICATIONS

KONGSBERG ENTERS THE AGE OF DISCOVERY

By **Richard Halfhide**

When Kongsberg Maritime acquired Rolls-Royce Commercial Marine in 2019 it raised the Norwegian-headquartered company's status as an innovator of maritime and offshore technology solutions to new heights, but one with such a plethora of products, services and research it could be difficult to navigate.

Conscious of the need to streamline its business areas, at the start of this year the company decided to spin its Sensors and Robotics division into a separate business area, now known as Kongsberg Discovery. The new quasi entity includes more than a thousand employees, principally located at Kongsberg's Norwegian offices in Horten, Trondheim and Oslo, but with satellites across Europe, Asia and North America.

Whereas Kongsberg Maritime concentrates on commercial ship design, propulsion, navigation and automation (to name a few) solutions, the 'new' quasi entity focuses upon advanced sensor technologies and the maritime robotics applications it enables. It's an area that Stene Førsund, Kongsberg Discovery's EVP for sales and marketing, says is burgeoning with untapped opportunities.

He comments: "It's very much about sustainability and environmental aspects, but it's hard to get away from security and defence at the moment. We also see a lot of growth around offshore wind, which until recently had been about having the correct sensors to enable accurate seabed mapping and surveying before the installation of the wind turbines. But now we also see we could do much more around constant environmental monitoring during the lifetime of a project.

"We believe if we provide very good systems, like for instance AUV, then you can do things like seabed mining in a sustainable way."

Seabed mapping solutions are at the core of Kongsberg Discovery's business. With around 15-20 new research vessels entering service each year, and many more requiring upgrades, there's a constant demand for new and improved technologies, such as hydro acoustics, robotics, inertial navigation, positioning, laser, radar, and communications. Although ocean monitoring is still in its relative infancy the growth of the so-called blue economy – aligned with new regulatory tools such as the United Nations' High Seas Treaty – is placing a strong emphasis on obtaining quality data while minimising the impact on marine ecosystems.

Kongsberg Discovery's most successful products are perhaps its AUVs, specifically the HUGIN range, but these are essentially just platforms for the most innovative technology, the payload sensors, offering capabilities such as HISAS [High Resolution Iterferometric Synthetic Aperture Sonar].

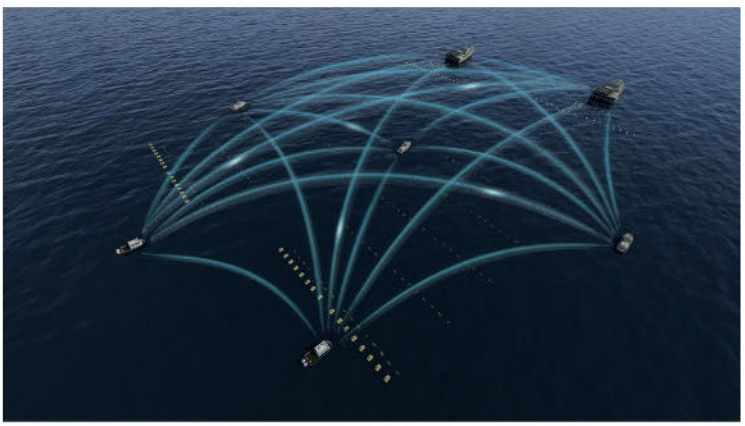
Maritime broadband radio

Among the most intriguing solutions developed by Kongsberg Discovery (or at least its Sensors and Robotics precursor) is one that was developed almost by chance: maritime broadband radio (MBR).

A kind of 'information highway' for situations where reliable high-speed digital communication and data transfer are crucial for efficient and safe operations are needed, its superior signal to noise ratio was seen as a means to ensure communications in remote and confined areas where 4G, 5G or satellite communications weren't an option, e.g. coastguard inspections onboard fishing vessels. With more than a hundred installations since its launch in 2019, including both naval and civilian applications, MBR has emerged as a customisable and robust solution for a variety of different uses.

"It wasn't something we exactly planned to do, to be experts on radio, but then we saw this technology could also be used for other products like position reference systems. Today it's becoming more and more popular with civilian as well as defence applications. For instance, can have an MBR on a person or a small drone," says Førsund.

"The idea was to have a stable and resilient communication link between several assets," adds Henning Langlete, Kongsberg Discovery's director of marketing and communication. "For example, aeroplanes down to the vessel, or between vessels. We can also deploy MBR on AUVs as a high-speed communication link. There are several applications that are beneficial for this communication and many users are using it as the main communication link between assets such as USVs." ■



MBR IS QUICKLY ESTABLISHING ITSELF AS A RELIABLE COMMUNICATION ALTERNATIVE. SOURCE: KONGSBERG

CRUISE SHIPS

SILVER NOVA CHALLENGES CONVENTIONS WITH ASYMMETRICAL LAYOUT

By **Kari Reinikainen**, Correspondent

SILVERSEA'S NEW LUXURY CRUISE SHIP *SILVER NOVA*. SOURCE: SILVERSEA CRUISES

Silver Nova, a 54,700gt newbuilding that Meyer Werft in Germany has recently delivered to Silversea Cruises, part of the Royal Caribbean Group, features a layout that represents new thinking on cruise ships of this size.

Perhaps the most immediately visible feature in the layout is the location of the swimming pool on the starboard side of Deck 10. Usually, at least on vessels of this rather modest size, they have been placed in the centerline of the vessel.

Robert Hagedorn, head of the Shipbuilding Department in Engineering at the Papenburg-based shipyard tells *The Naval Architect* that the aspirations for the project have been from the beginning to create a unique product where asymmetry and the connection to the sea have been drivers amongst others.

"The asymmetry allows viewing angles in multiple ways. Entering the pool deck from one of the inside panoramic lifts allows immediately a wide view over more than 180 degrees including the pool deck but also the sea," he says.

Hagedorn continues: "As a main feature of the deck the pool it was planned to be in a significant size but also not too dominating. Recessing it into the deck was a logical consequence. Arranging the pool on the side of the ship allows a very special view to the sea with nearly no obstructions and at the same time a quite long pool arrangement."

Furthermore, other architectural elements could be located on the opposite side of the ship supporting the multi-level arrangement. "At the same time the vessel also features a special structural arrangement with no longitudinal walls in the mid-firezone and only one centred passenger walkway between the large suites. Recessing the pool into the deck at the side avoided a conflict with the cabin corridor in the deck below and leads to the most efficient arrangement related to the suites," Hagedorn says.

The design of the vessel had to manage asymmetric layouts with corresponding mass distributions from the beginning of the project for many features including the pool weight. "For example," notes Hagedorn, "the main engine casing and the superstructure were also designed asymmetrically. For the pool in its position special tests have been carried out to confirm the shape of the pool based on the dynamic behaviour of the water in certain conditions of the ship."

The fact that the ship has a special structural concept with no mid-longitudinal steel walls in the centre of the ship in the affected firezone was chosen for the benefit of very long suites without any structural interruption.

Transversal bulkheads to carry load of pool

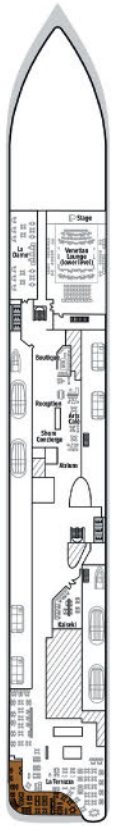
"As a result, the only structural members in the area have been pillars, the outside balcony bulkheads with large openings and the decks," says Hagedorn. "In order to transfer the load, transversal bulkheads have been introduced locally between the suites to connect the pool structure to the pillar grid and load carrying structures below." He adds that global and local analyses were performed to verify strength and vibration with the corresponding scantlings.

As far as piping etc. of the pool is concerned, its main pumps are located in the engine room multiple decks below the pool while the pool equipment is sited very

SILVER NOVA – *Deck Plans*

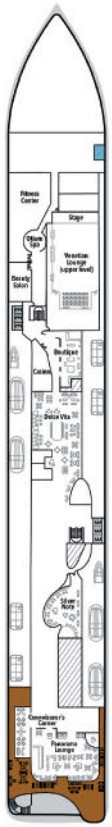
DECK 3

The Shelter
Atlantide
S.A.L.T. Kitchen



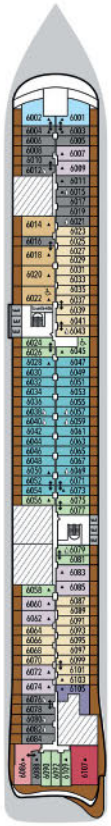
DECK 4

La Dame
Venetian Lounge
Boutique
Reception
Arts Café
Shore Concierge
Atrium
Kaiseki
La Terrazza



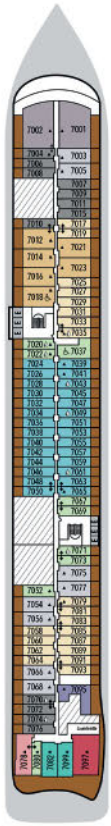
DECK 5

Otium Spa
Fitness Centre
Beauty Salon
Casino
Boutique
Dolce Vita
Silver Note
Connoisseur's Corner
Panorama Lounge



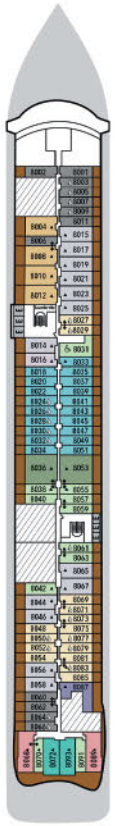
DECK 6

Suites



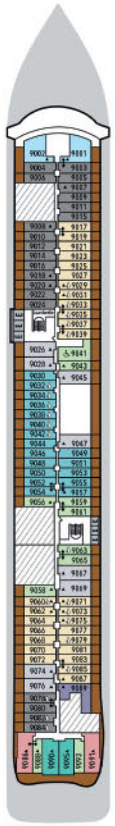
DECK 7

Suites



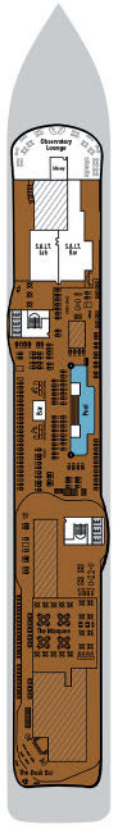
DECK 8

Suites



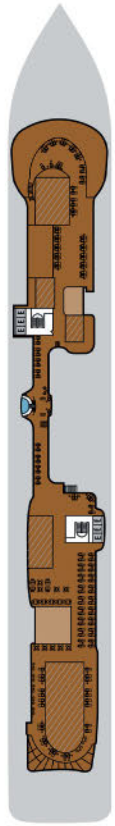
DECK 9

Suites



DECK 10

Observation Lounge
S.A.L.T. Lab
S.A.L.T. Bar
Pool Deck
Pool Bar
The Marquee
The Dusk Bar
Jogging Track



DECK 11

The Cliff Whirlpool

SUITE CATEGORIES

- Otium Suite
- Owner's Suite
- Grand Suite
- Master Suite
- Signature Suite
- Silver Suite
- Junior Grand Suite
- Premium Medallion Suite
- Medallion Suite
- Premium Veranda Suite
- Deluxe Veranda Suite
- Superior Veranda Suite
- Classic Veranda Suite

SPECIFICATIONS

Crew	556
Officers	International
Guests	728
Tonnage	54,700
Length	801 Feet / 244.2 Meters
Width	97 Feet / 29.6 Meters
Speed	19.4 Knots
Passenger Decks	9
Connecting Suites	↕
3rd Guest Capacity	▲
Wheelchair Accessible Suites	♿
Veranda suites with bath & shower	🛁
Technical areas	▨
Built	2023

Deck plans are for illustration purposes only and may be subject to change.

Suite diagrams shown are for illustration purposes only and may vary from actual square footage. Please refer to suite specifications for square footage.

Images are intended as a general reference. Features, materials, finishes and layout may be different than shown.

close to the trunk. "Existing vertical casings have been used as far as possible. Especially because of the suite arrangement special consideration has been taken on noise," concludes Hagedorn.

In cruise ship design, the pool deck usually features facilities mainly used in the daytime, whereas the night-time focused facilities are located several decks down, on the uppermost deck of the hull and the lowermost one in the superstructure. These two main areas of public facilities are separated by several decks of cabins with their own balconies. This is also the case with *Silver Nova* which has four cabin decks between these areas.

Conventional pool deck layout affects cabin design

In a traditional layout, the pool is located in the centerline of the vessel, so that its tank is slotted in a space between two cabin corridors on the deck below. This space also houses technical elements, from ducting, cabling and piping to crew stairtowers and lifts. While such an arrangement is logical and has the benefit of concentrating a wide variety of technical aspects of the ship in the same area over a number of decks, it also has some limitations.

Providing a view of the sea from a swimming pool that is in the centreline position can be worked out by placing one at the very stern of the pool deck, as in the case of a long series of 47,800gt cruise ships that Viking has been building at Fincantieri in Ancona since 2015.

The pool can then have a thick glass wall towards the aft that opens up the view over the ship's wake. But the arrangement has its challenges as well, because the preferred position of the pool is midships. Not only is it less exposed to pitching of the vessel here, but it is easier to integrate it in the services on this deck, as these can be placed both forward and aft of the pool. Viking has solved this by having an infinity pool at the stern and the second one amidships.

The size of cabins is limited in the traditional layout, because two corridors need to be provided, whereby the depth of each cabin will be restricted. On *Silver Nova* there is only one cabin corridor that runs in the centerline of the vessel on the decks between the public areas further down and the ones on the pool deck and above. As Hagedorn points out, the cabins can be made deeper as a result.

Leaving the pool in the centerline would have created a need to divert the corridor around it – in some smaller ships, the designers have been forced to accept this – and it has forced the construction of non-standard cabins in this area on some vessels.

On *Silver Nova* there are four areas on each deck that house the technical elements. The first one is located on the port side forward, the second and third ones are also on the port side roughly two thirds from the stern and the last one is located near the stern of the superstructure on the starboard side.

As lifts and stairtowers are also located on the sides of the vessel, the forward one on the port and the aft one starboard, the cabin corridors run uninterrupted from bow to stern through these decks.

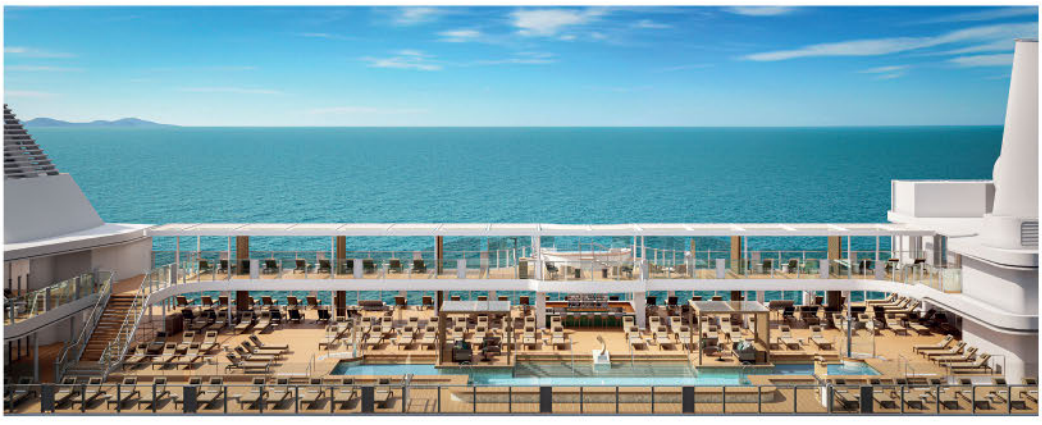
It is probably fair to say that *Silver Nova* represents the boldest development of outside deck areas in vessels of its own size – large contemporary market vessels with up to almost five times the gross tonnage of *Silver Nova* obviously have far more real estate and also a different technical capability to accommodate e.g. pools in various locations.

Open decks have garnered more attention

For a long time, outer deck areas were almost an afterthought and designers paid little attention to them. They were seen as areas for sunbathing and swimming, with a bar and the lido buffet restaurant as the only services on many ships. Besides, up until around the turn of the millennium, the pool would be drained at 6pm, when the bar and the lido would also close.

In more recent years, the outdoor areas in general have been integrated into the overall service concept of the ships, so that e.g. restaurants and bars have both indoor and outdoor seating. In the contemporary and premium market segments, outer decks have also been developed to revenue generating areas e.g. by the introduction of tranquil areas and cabanas, the use of which comes with a charge.

Silversea Cruises is a luxury market operator that does not charge for such things. However, on ships like *Silver Nova* the "reimagined" pool deck, as the company prefers to call it, will probably help it to differentiate its latest ship from competition that keeps growing with a steady flow of newbuildings into the luxury segment of the cruise market. ■



SILVER NOVA'S 'REIMAGINED' POOL AREA IS POSITIONED ON THE STARBOARD SIDE OF THE SHIP. SOURCE: SILVERSEA CRUISES

The Royal Institution of Naval Architects Presents:

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Managing CII and Associated Challenges

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As part of its commitment to addressing climate change, IMO has developed a Carbon Intensity Indicator (CII) for international shipping. The CII is intended to measure and drive improvements in the energy efficiency of ships. CII was adopted in 2021 as part of a package of amendments to MARPOL Annex VI, which were a response to the IMO's Initial Strategy on Reduction of GHG Emissions from Ships. IMO's Strategy sets out a vision to improve the carbon intensity per transport work of shipping by 40% in 2030 relative to 2008.

The CII has been designed as a key tool to assess and monitor the carbon intensity of both new and existing ships, with an emphasis on operational efficiency that was not addressed by other IMO short-term GHG measures. CII requirements took effect from 1 January 2023, so in early 2024 the industry is expecting to receive the first feedback of CII measures. A review of the effectiveness of the implementation of short-term CII and EEXI requirements must be completed by 1 January 2026, and it was agreed at MEPC 80 in July 2023 that this process would commence at MEPC 81 in March 2024.

The Royal Institution of Naval Architects is proposing the Technical Conference as an opportunity for maritime influencers to gather and discuss the challenges and opportunities arising from this measure.

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ENVIRONMENTAL REGULATIONS

WILL THE HONG KONG CONVENTION SOLVE THE WORLD'S SHIP RECYCLING HOT MESS?

By **Nick Walker**, partner, **Valentina Keys**, senior associate, and **Lauren Buchan**, associate, Watson Farley & Williams (WFW)

On 7 June 2023, the European Commission (the Commission) closed its consultation on the much-maligned EU Ship Recycling Regulation (SRR) seeking views on its improvement from shipowners, recycling yards, national authorities and other industry participants. The consultation sought to evaluate how well the SRR is functioning against a backdrop of lacking recycling capacity and take-up of recycling at EU approved facilities.

In the wake of the consultation and in eerily timely fashion, Bangladesh and Liberia ratified the Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships (Hong Kong Convention). This triggered the criteria for the Hong Kong Convention to enter into force in two years' time, on 26 June 2025.

The SRR has long been viewed as the "stricter" version of the Hong Kong Convention and an attempt to plug the gap of a missing global framework for enforcement against poor standards of ship recycling. We now have this framework although, as discussed in this article, this does not automatically mean that the SRR will (or should) be redundant. The additional complicating factor in this regulatory miasma is the Basel Convention for the Transboundary of Movement of Hazardous Waste (Basel Convention) and the Ban Amendment in particular, which retains the potential to prevent a harmonised global system for the environmentally sound disposal of end-of-life vessels.

It seems likely the Commission's consultation was prompted by the awareness that the Hong Kong Convention was close to being implemented; Bangladesh has been working towards the Hong Kong Convention standards for some time, and there have been rumours that one of the big flag states was about to accede for some time too. The Commission is also obliged to review and, if appropriate, amend the SRR no later than 18 months prior to the date of entry into force of the Hong Kong Convention. It is certainly possible that as part of that review required in no later than six months' time it will consider the consultation responses.

While the announcement is fresh and we have two further years to wait, this article raises some of our immediate questions on what the global framework for ship recycling will look like.

The ship recycling regime: a recap

The Hong Kong Convention was adopted in 2009 and aims to improve the safety and standard of ship recycling so that it does not pose unnecessary risks to human health, safety and the environment as well as managing

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WFW ASSOCIATE LAUREN BUCHAN

hazardous materials on a ship. It covers a ship's entire life: from design and construction (with implications for the shipyard), operation through the now familiar Inventory of Hazardous Materials (IHM), preparation for recycling (both with related obligations on shipowners, managers and charterers) and ultimately the recycling itself (with obligations on ship recycling facilities).

There are now 22 contracting states: Bangladesh, Belgium, Republic of the Congo, Croatia, Denmark, Estonia, France, Germany, Ghana, India, Japan, Liberia, Luxembourg, Malta, the Netherlands, Norway, Panama, Portugal, São Tomé and Príncipe, Serbia, Spain, and Turkey.

Meanwhile, the SRR has been in place since 2013 coming into force incrementally up until 2020. It essentially

transposed into EU law the provisions of the Hong Kong Convention. The scope of the SRR is legally enforceable against ships flying the flag of a member state and has limited application to non-EU flagged vessels calling at a port or anchorage of a member state.

Financial instrument – Ship Recycling License

Article 29 of the EU SRR required the Commission to submit a report to the European Parliament and the Council on the feasibility of introducing a financial instrument that would facilitate safe and sound ship recycling by end of 2016. A 2016 Commission study evaluated several forms of financial instrument, including guarantees, insurance and port levies. The conclusions favoured a Ship Recycling License (SRL) – or a hybrid financial instrument with the SRL – which would be required for entry into EU ports.

The Commission's consultation put such an instrument to its participants. While making it clear that this is a work in progress, it would seem that the intention is to require shipowners to pay a contribution for the licence which may also incorporate upfront a premium for the revenue gap between the cost of sending the ship to an EU-approved recycling facility set out on the European List (Approved Recycling) and the more lucrative option of sending the ship to a facility outside of the European List (Non-Approved Recycling). This would be held in a fund in the EU (we note that the consultation currently lacks detail of the logistics of managing and regulating such fund, as well as general regulatory oversight for the SRL).

On sending a ship to a facility on the European List, which usually pay less, the shipowner would be compensated from the fund to cover such revenue gap – effectively subsidising the cost of recycling at approved yards. If Non-Approved Recycling is pursued, this amount would instead be forfeited as a penalty and retained in the fund. The fund would be used to disseminate sound recycling practices across the EU.

The consultation looked at all ships trading in the EU, not just EU-flagged ships. Requiring non-EU flagged ships to hold an SRL to call at an EU port would by implication require that ship to be recycled at an EU-approved facility if it is to get back the premium paid upfront. Non-EU shipowners may, and probably will, claim that this goes far beyond the scope of the EU SRR – particularly in view of the Hong Kong Convention coming into force.

The Hong Kong Convention – gaps and cracks

But just how effective will the Hong Kong Convention be on implementation, not to mention on enforcement? A shipowner can largely avoid the SRR by flagging out. When the Hong Kong Convention comes into force, flagging out becomes more limited but is still an option.

A SHIP BEING BROKEN DOWN IN CHITTAGONG, BANGLADESH. BANGLADESH'S RATIFICATION OF THE HONG KONG CONVENTION HAS HELPED TRIGGER THE CRITERIA FOR THE CONVENTION TO ENTER INTO FORCE. SOURCE: SHUTTERSTOCK

Either the government of the flag state, or the state from which a ship is operated (in either case, defined as the "Administration"), will govern compliance with the Hong Kong Convention. Some NGOs have already expressed concerns about the adoption of "flags of convenience" towards the end of a ship's life and particularly for a voyage to a shipbreaking yard. Sanctions against a ship for violating the Hong Kong Convention requirements are published and enforced on a state-by-state basis by the Administration. By adopting the flag of a state not party to the Hong Kong Convention, sanctions are still avoidable.

Approved ship recycling facilities will also be regulated under the Hong Kong Convention. There is no guarantee that the facilities approved under the Hong Kong Convention will mirror those on the European List, although the SRR indicates that as part of its review in six months' time, it will consider including the facilities authorised under the Hong Kong Convention.

The approval process of facilities under the Hong Kong Convention is currently under question. There has been a proliferation of "statements of compliance" (SoCs) being issued by classification societies to confirm that the requirements of the Hong Kong Convention are met. However, the SoCs do not necessarily carry the degree of weight sought by other sector participants – financiers, for example.

The Hong Kong Convention would instead require "competent authorities", being governmental authorities or authorities designated by a state ratifying the Hong Kong Convention, to approve ship recycling facilities in line with the requirements under the Hong Kong Convention. Arguably, the interpretation of whether those requirements are being met is still subjective, as is the level of expertise of the "authorities" approving the facilities in each jurisdiction.

There is therefore still risk of fragmentation between contracting parties under the Hong Kong Convention in relation to enforcement action, penalties and the standards of recycling facilities.

The Commission's consultation did consider whether ships with Hong Kong Convention certification should automatically be included in the European List. Currently, a recycling facility must apply to the Commission to be included in the list demonstrating its compliance with the EU SRR standards. In view of the above certification practises, the EU – holding its stricter line – might still want to keep in place its own European List of facilities it knows are meeting the required standards; and the ability to remove facilities when they are not meeting those standards, as happened recently with a number of yards in Turkey. This is particularly in view of the Basel Convention's stance on beaching, discussed below.

However, unless the Commission takes the financial instrument, and expanding the scope of the SRR generally, forward, it will have a hard time preventing ship owners seeking to circumvent its higher standards.

Interaction with other frameworks – ships as waste

The Basel Convention and treatment of ships scheduled for recycling as "waste" could assist with circumvention. The application of the EU Waste Shipment Regulation and Basel Convention is not subject to the flag of the ship but its location when it becomes "waste". The interaction between the ship recycling framework and that governing the transboundary movement of waste, including hazardous waste, is, however, complex. Complying with both is also likely to be burdensome because each framework requires specific processes to be followed (i.e. prior informed consent and approval of a ship recycling plan) and documentation to be produced (i.e. notification and movement forms and IHM).

The SRR has gone some way to address this: where EU-flagged ships are covered by the SRR, the Waste Shipment Regulation shall not apply, while ships that are not covered by the Hong Kong Convention nor the SRR will be subject to the Waste Shipment Regulation. Whether this can be replicated on a global basis while closing loopholes remains to be seen.

The Basel Convention also prescribes the use of impermeable floors for facilities used for the treatment of "waste" and necessarily, any substances within it. Such restriction is absent in the Hong Kong Convention, casting further doubt on its effectiveness as a global enforcement tool to clean up ship recycling's act alone or in place of the Basel Convention.

Next steps

It is unlikely that the Hong Kong Convention text will be re-opened to address some of the gaps and developments that have arisen over 14 years – including the questions raised in this article – in the next two years. What is clear is that the Hong Kong Convention cannot just be dusted off and implemented without changes in the near future that consider the new global framework regulating ship and waste disposal that it is slotting into.

WFW will be tracking the Commission's consultation response in view of its obligation to review the SRR in the next six months, alongside the developments of the Hong Kong Convention, with keen interest. We hope at that stage we will have more answers than questions. ■

BACK TO THE FUTURE: HOW ROTOR SAILS CAN PROPEL VESSEL EFFICIENCY

With vessel efficiency front and centre following IMO's recent MEPC 80 session, rotor sails are proving a viable option for shipowners and managers looking to reduce their emissions and fuel consumption

ANEMOI FIRST FITTED ITS ROTOR SAIL TECHNOLOGY IN 2018, TO BULK CARRIER MV *AFROS*

Efficiency is the name of the game for modern vessel designs. With decarbonisation efforts high on the agenda for the global shipping industry, modern cargo vessels are looking to become more sustainable and energy efficient, with current efforts tied closely to the goal-based and technology-neutral regulations of the International Maritime Organization (IMO).

The IMO's 80th meeting of its Marine Environmental Protection Committee (MEPC 80), which took place in July, brought the subject of energy efficiency of vessels firmly to the forefront. Amidst a renewed commitment to reduce the maritime sector's carbon emissions was an aim to review and strengthen the energy efficiency design requirements for ships, including the regulations by which a vessel's energy efficiency is measured, mainly the Carbon Intensity Indicator (CII) and the Energy Efficiency Existing Ship Index (EEXI).

In a bid to meet the IMO's new goal of achieving net zero by or around 2050, the uptake of low- and zero-carbon technologies that can significantly reduce a vessel's carbon footprint and speed up global decarbonisation efforts has picked up pace by shipowners as viable alternative propulsion options begin to take centre stage.

Renewable energy continues to garner more interest from shipowners. While a vessel covered in solar panels seems practically and ergonomically unlikely, wind energy remains a plentiful source of energy that many are looking to take advantage of as shipowners take a page from their history to use sails to transport cargo from port to port.

However, long gone are the days of traditional sails made of cotton or linen. Modern sails for today's fleet are technologically advanced and mechanically capable of providing sufficient auxiliary propulsion that can enable a vessel to reduce its burden on traditional diesel engines and cut its carbon emissions significantly. These modern types of sails are known as Flettner rotors or more commonly as rotor sails.

Simplicity

The technology behind rotor sails remains incredibly simple. It relies on an aerodynamic phenomenon, known as the 'Magnus effect'. As the cylinder rotates within an airflow, a forward thrust force perpendicular to the apparent wind direction is created, delivering additional thrust to the vessel. This thrust can either provide additional vessel speed or maintain vessel speed by reducing power from the main engine. Either way, a vessel's fuel consumption can be minimised and, crucially, its emissions output drastically cut.

"Although first developed almost 100 years ago by German aviation engineer Anton Flettner, who successfully sailed a prototype rotor ship across the Atlantic in 1926, rotor sails had been discounted in

commercial shipping at the time, mostly due to the low cost and plentiful supply of fuel," explains Kim Diederichsen, chief executive officer at Anemoi Marine Technologies, the UK-based developer and provider of rotor sails for the global shipping industry.

"However, with shipowners and managers looking to wean their way off traditional bunker fuels while maintaining full operations, these tall cylinders have picked up steam in recent years as a way to provide auxiliary propulsion and reduce fuel consumption," he adds.

Rotor sails are suitable for almost all types of deep-sea vessels. Their varying designs and installation methods means they have been installed on bulk carriers and tankers, with new designs eyeing up ferries, ro-ro vessels and multipurpose vessels. In fact, most modern rotor sails are designed in such a way that they can be optimised for almost every vessel. Crucially, rotor sails can easily be incorporated into the design of a newbuilding, as well as being easy to retrofit on existing vessels without the need to drydock.

Each rotor sail can be installed in a single crane lift and connected to the foundation of the ship's main deck in less than a day. Notably, the technology is considered a movable asset as compared to other technologies, whereby the sails can be transferred to another vessel as driven by the owner's requirements.

Design flexibility

This design flexibility is crucial if the technology is to become more viable as an alternative propulsion provider for modern vessels. Considerations must be taken into the design and placement of rotor sails on the vessel type in order for the ship to maintain safe and efficient options, as well as ensuring the cylinders do not impact the loading and/or unloading of its cargo.

Anemoi, which was spun out of Greece's Blue Planet Shipping, first fitted its patented rotor sail technology to MV *Afros*, a 64,000dwt geared Ultramax bulk carrier, in 2018. The project marked a notable milestone for vessel design, becoming the world's first bulk carrier to be fitted with rotor sails. Larger bulkers such as VLOC and Capesize vessels traditionally find it more challenging to meet EEXI and CII targets, particularly at a design stage. Nevertheless, these vessel types are ideally suited to rotor sail technology. They have ample deck space and typically operate on favourable trading patterns where the wind is strong and predictable.

Crucially, the fitting of the four rotor sails to the vessel's starboard enabled Anemoi to better understand the practical elements behind installing rotor sails on all manner of vessel types, not just bulk carriers.

"Our background equipped us with the knowledge of how to best adapt the technology for complex vessel operations. As a result, we developed a range of rotor sails with variable heights and, most uniquely, a range of deployment systems and mounting arrangements. This includes a standard fixed mounting; a folding mounting, which enables the cylinders to be lowered from vertical to enable enable the vessel to pass under low bridges and avoid impact to cargo loading and unloading; and finally our patented rail system, enabling the sails to move along or across the deck of the ship so cranes can load and unload without obstruction," Diederichsen says.

Fuel savings

Data from modern rotor sail systems has shown that the technology can achieve fuel savings of up to 25-30%. This means rotor sails are one of the most effective and sustainable solutions for today's shipping industry.

As an example, a 310,000dwt very-large crude carrier trading the Bonny–Ningbo route and fitted with five rotor sails has been estimated to produce an annual fuel and emission saving of 13.5%, which equates to more than 1,600tonnes of fuel and over 5,000tonnes of carbon saved each year.

Anemoi has developed a Fuel Saving Assessment Model (FSAM) to accurately predict fuel and emissions savings from various sizes and classes of vessel. Central to FSAM are four key data sets: rotor sail performance data (harvested from Anemoi's full-scale UK test facility), vessel performance data, route data and wind data. FSAM utilises this data to simulate thousands of historic voyages over a five-year period to ensure the results accurately reflect the wind conditions experienced on the chosen route. Any additional drag and increased generator usage are also included so that the net results are fair and transparent.

This approach enables the rotor sails to be specifically designed depending on the vessel type and voyage. "Each vessel and each voyage are unique. We are continuously gathering data to better understand the impact each of our rotor sails is having on fuel consumption and emissions reduction, as well as finding ways to make them more effective," Diederichsen notes.

Forward thinking

The market for rotor sails has taken off and is growing as shipowners and managers increase their efforts to meet the IMO's greenhouse gas (GHG) targets. According to the UK's Clean Maritime Plan, the market for wind propulsion technologies, including rotor sails, is projected to reach £2 billion per year by 2050, a significant increase from £300 million that is expected in the 2020s.

Anemoi currently has 16 rotor sails in production and is ramping up its capacity to be able to install 50 rotor sails each year by the end of 2023.

This growth is directly linked to the credibility of rotor sails as a decarbonisation technology. As alternative fuels and other eco-friendly innovations become market ready, auxiliary wind propulsion methods can be used in conjunction to reap even more environmental benefits for the shipping sector.

"Wind propulsion and rotor sails have found their place in modern shipping. With pressure growing on shipowners to go green, rotor sails are a visible, viable and cost-effective decarbonisation technology," Diederichsen concludes. ■

NUCLEAR POWER

PROJECT AUKUS: ACHIEVING CRITICAL MASS SCIENTIFICALLY AND POLITICALLY

By **Dr M.J. Cianni**, CEng., FRINA, FIEAust

In order for the AUKUS submarines to operate for 33 years without refuelling they will need to use highly enriched uranium (HEU) at a level of 93%-97%, with a mass in excess of 200kg. Since HEU is highly efficient, enabling a 200kg HEU mass over 33 years would give a use rate of just 6.06kg per year using the new PWR3 reactor.

Rolls-Royce, which produces the PWR2 submarine reactor for the Astute class nuclear submarines, states that "a small spoonful of uranium is all it takes to power a fully submerged submarine on a full circumnavigation of the world".

This can be explained by Einstein's theory of mass-energy equivalence, Energy $E=mc^2$ (where m = mass x c = the speed of light - approx. 300 million metres per second, squared) creating an immense amount of energy for a very small mass, and the nuclear chain reaction being self-sustaining, having reached critical mass i.e. the minimum amount of a given fissile material necessary to achieve a self-sustaining fission chain reaction. This is central to nuclear reactor design (controlled neutron fission), at this point the number of generated neutrons equals that of lost neutrons.

Uranium is a silvery-grey metal and has the density 70% higher than lead, and slightly lower than that of gold or tungsten, hence 200kg of uranium would fit into a small 10litre bucket. Natural uranium mined from the ground consists mainly of an isotope called uranium-238 mixed with small amounts (0.7%) of the key isotope uranium-235.

For the reactor to operate the percentage of uranium-235 has to be increased by 'enrichment'. The level of enrichment is a crucial factor in maintaining a safe and sustainable chain reaction. For AUKUS submarines this will be 93%-97%.

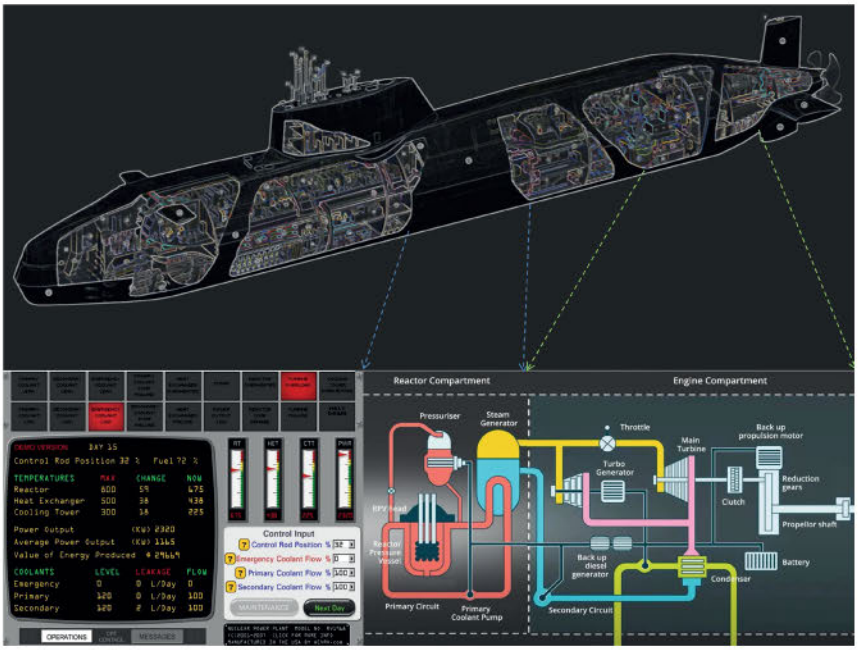
Inside the reactor pressure vessel, the uranium-235 is bombarded with neutrons, causing some of the nuclei to undergo nuclear fission. A moderator material in the core slows down the neutrons released from fission so that they cause more fission to occur. The moderator usually consists of water, alternatively heavy water or graphite can be used. This causes more neutrons to be released and the process continues in a nuclear chain reaction, generating heat. This heat in turn heats the circulating water in the primary loop, which is kept under pressure by the pressuriser so that it does not boil.

The water in the primary loop operates at a temperature of approximately 300°C and the chain reaction is controlled by uranium blocking control rods inserted between the rods of uranium-235 fuel, for example during an SCRAM emergency they can be fully inserted and stop the nuclear reaction in the shortest possible time. In the event of any radioactive contamination in the primary water it would be contained in the primary loop and circulation of the water may rely on natural circulation to eliminate noise and the power requirement that would be introduced by using pumps.

The hot water in the primary circuit is then fed into steam generators, connected to a secondary circuit. The water in the steam generators is converted into steam and passes through steam driers on its way to drive steam turbines, which are in turn connected to the propellers via a clutch and gear arrangement as well as electricity generators, causing them to turn at high speed.

Spent steam at low pressure runs through condensers which are cooled by seawater and return the steam to liquid form. This water is then pumped back to the steam generators and continues the cycle. Water lost in this process is topped up by desalinated sea water added to the steam generator feed water.

SSN-AUKUS RENDER



ASTUTE CLASS NUCLEAR SUBMARINE TRAINING SIMULATOR

Rationale

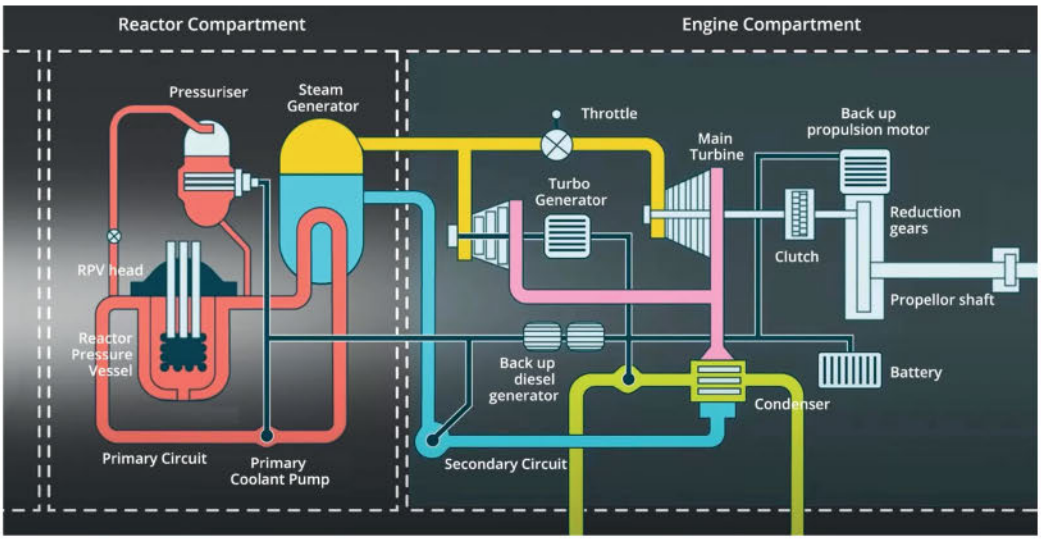
Submarines offer a unique and extreme operating environment. Designed to be submerged for up to six months at a time (in the case of nuclear submarines) but with limited oxygen, the potential of using diesel engines for propulsion for long durations and at depth is limited at best even as a back-up to nuclear, as diesel engines need oxygen and venting of exhaust gas (carbon dioxide), known as 'snorting'. Oxygen generators can help by creating oxygen from the electrolysis of water, but eventually all non-nuclear submarines have to surface to replenish oxygen supplies for the crew and engines.

However, with the introduction of nuclear power, suddenly historically slow underwater vessels turn into warships capable of sustaining 30knots (56km/h, 35mph). Considering the current generation of Astute class submarines have a displacement of 7,400 to 7,800tons, are 100m long and have a diameter of 11m, travelling at 35mph whilst submerged would be impossible with any other form of propulsion, as would remaining submerged for any length of time operating at that speed.

30knots is significant in order to outrun unfriendly submarines and submarine hunter surface ships. The current diesel submarines' 23mph limit makes them susceptible to foreign navies wanting to engage them if they are detected. The Collins class maximum submerged duration is 70 days.

The key strategic advantage of nuclear submarines is to survive a first strike attack, as they are not easily located whilst submerged. The fact that submarines would survive a first strike attack leads to them being a major deterrent for hostilities breaking out in the first place.

System-wide changes rely on critical mass of interested parties, all willing to enter into deep partnerships and collaborations, founded on new levels of trust and commitment to action, not just debate. ■



ASTUTE CLASS NUCLEAR SUBMARINE REACTOR AND ENGINE

ITALIAN AGREEMENT EXPLORES SHIPPING'S NUCLEAR POTENTIAL

By **Richard Halfhide**

Although it's unlikely to offer a short-term solution to shipping's decarbonisation mission, the tantalising possibilities offered by nuclear power continue to attract a small but growing number of proponents among the industry's forward thinkers.

In late July, Italian shipyard Fincantieri became the latest company to declare its interest with the announcement it had signed an agreement with compatriot classification society RINa and Anglo-Italian startup *new*cleo to combine their expertise and innovation experience for a feasibility study for potential applications of its patented LFR (Lead-cooled Fast Reactor) technology in the shipping industry.

Unlike conventional nuclear fuel, which is made of uranium oxide, fast reactor technologies 'burn' mixed oxide (MOX) fuel generated from reprocessed nuclear waste and offer a superior conversion ratio. LFRs are among a range of emerging nuclear technologies known as Generation IV reactors and could potentially mean a ship could go from 10-15 years without the need for refuelling.

Stefano Buono, *new*cleo chairman and CEO, tells *TNA*: "It has always been our ambition to meet the growing commercial demand for clean electricity, and our Generation IV reactors were designed with this in mind. Our 30MWe reactor is highly versatile and therefore has the potential to power large shipping vessels, as well as islands and remote communities.

"We are very excited to be working with two major players in the shipping industry, Fincantieri and RINa, on this feasibility study, which marks a very promising step towards decarbonising this sector."

Citing IMO's 2050 net-zero targets, Buono explains that the 12-month agreement will draw on Fincantieri's expertise in shipbuilding and RINa's expertise in inspection, certification, ship classification and consulting engineering to assess the practicality of deploying newcleo reactors on vessels and identify any obstacles to achieving this.

STEFANO BUONO, *NEW*CLEO CHAIRMAN AND CEO

Although Fincantieri is perhaps best known for its involvement in passenger shipbuilding, he stresses that the study is looking at the feasibility for shipping overall and application for commercial vessels and passenger ships are not currently being discussed. Rather the study will focus upon the practical considerations of marinising nuclear technology and identifying the challenges.

Strictly speaking, LFR technology isn't anything new. During the 1970s two types of LFR were used onboard Soviet Alfa class submarines, offering the advantage of being significantly lighter than water-cooled reactors. However, historically there have been issues around the erosion and corrosion of the reactor's internal parts, requiring the development of specialised materials.

Buono comments: "Lead can indeed have an important impact on materials, and this is one of our main areas of applied research. In addition to tuning the coolant speed and chemistry, we are in the process of designing ad hoc facilities to develop and test novel materials able to withstand the reactor conditions. We leverage on many years of research on this topic, also in collaboration with ENEA, and we are directly investing in setting up dedicated laboratories.

"Our demonstrator, a first nuclear prototype to be built in France, will ultimately give us the opportunity to test our design provisions and technological solutions, also on this topic."

Addressing the inevitable concerns around safety, or potential weaponisation, Buono points out that (according to the World Nuclear Association) there are around 200 nuclear reactors at sea already, powering 160 ships, albeit many of these are for specialised applications such as submarines and icebreakers.

He adds: "Generation IV reactors in particular aim at implementing inherent safety and at increasing the proliferation resistance through design choices. They are the very latest in nuclear reactor design, taking the best elements of previous generations to create an optimal reactor.

"Not only are reactors safe in themselves, but they have the potential to improve safety in the shipping industry more broadly. Using nuclear power on ships would remove the risk of any fuel spills and therefore safeguard the marine ecosystem in the event of an accident.

"With *new*cleo's design, in the event of a shipping accident, the liquid lead inside the reactor would solidify as it cools down in contact with the cold water, enclosing the reactor core in a solid casing, preventing any release of material in the environment." ■

RO-ROS & FERRIES

AN ENGLISH CHANNEL GAME-CHANGER

True to its name, the Guangzhou Shipyard International-built *P&O Pioneer* introduces many firsts on the English Channel. Besides being the first double-ended ferry on the Dover-Calais route, P&O Ferries' new flagship also pioneers the hybrid element. This, together with the double-ender design and a long list of energy-saving technologies, guarantees a 40% fuel consumption reduction when benchmarked against P&O Ferries' 2011-12-built Spirit class

By **Philippe Holthof**, Correspondent

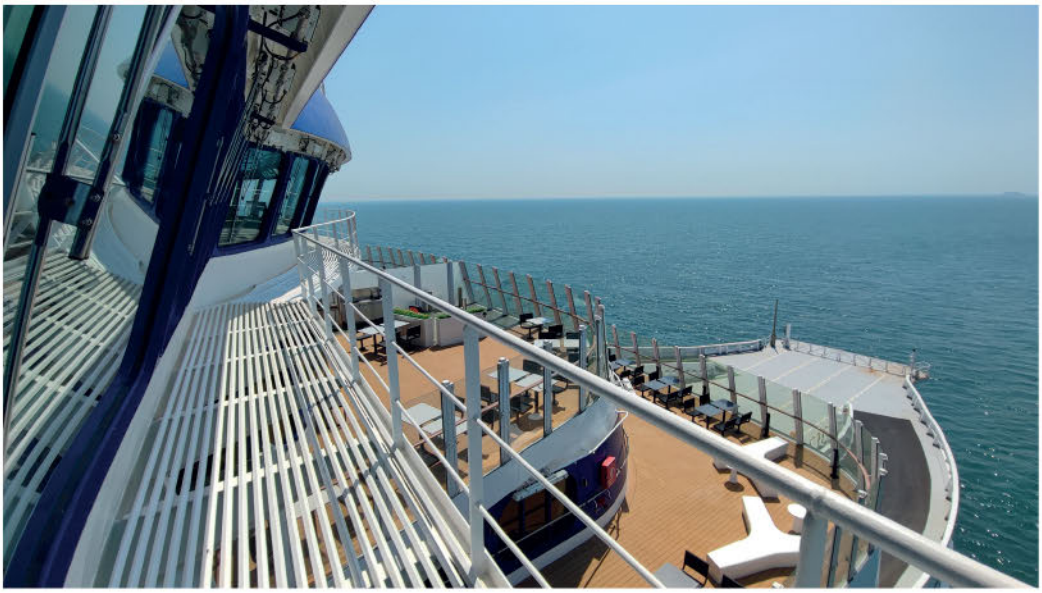
Although a double-ended design had been earlier on the drawing board of Channel House, P&O Ferries' Dover headquarters, it only surfaced again shortly after the so-called Ship of the Future project kicked off in conjunction with the 2017 edition of Nor-Shipping. When the Spirit class sister ships were ordered in 2008, alternative fuel options for large ro-pax ferries, let alone hybrid technology, were still few and far between. Not surprisingly, this resulted in a conservative approach with a conventional propulsion plant of four main engines driving twin controllable pitch propellers and four auxiliaries generating the electrical power. So, the focus was rather on optimising the hullform and ro-ro intake. Indeed, with their impressive vehicle deck capacities of 2,741 freight lane-metres (lm) plus 1,000 car lane-metres on a separate 3.3m-high upper car deck, the Spirit class represented a quantum jump compared with the ships they replaced, the 1987-built Chunnel beaters *Pride of Dover* and *Pride of Calais*.

Like the Spirit class, the new Ship of the Future or Fusion class has the ability to hoover up freight and cars at peak times, but this is where any comparison ends as the design of the newbuilds started from a blank canvas. While all design options were open, building an improved, 'lessons learned' Mk II version of the Spirits was excluded as the DP World-controlled ferry operator was poised to build a best-in-class Channel ferry with the lowest possible emissions footprint per transported truck and car thanks to the implementation of the latest energy consumption reduction technologies.

As the project gained momentum and with Denmark's OSK Design selected to take care of the full design package, all the do's and don'ts as well the pros and cons of a single-ender versus a double-ender design were carefully analysed. On the Dover–Calais route, single-ender ferries typically berth stern-to in Dover and bow-in in Calais, requiring two 180-degree turning manoeuvres in the westbound direction. For the Spirit class, the port manoeuvring time relative to Calais–Dover crossings adds about 15 minutes to the overall berth-to-berth crossing times. To compensate for this lost time, the speed needs to be increased at sea to keep the 90-minute berth-to-berth schedule. Eliminating the 180-degree turning manoeuvres effectively results in a reduction of the top speed requirement from 21.5knots to 17.6knots. With no stone left unturned, the double-ender design proved to be the most sustainable solution. A double-ended platform with the duplication of wheelhouses doesn't come cheap but the fuel savings generated by eliminating up to 10 x 180-degree turning manoeuvres per day during at least 20 consecutive years outweighs the extra cost to build a double-ended ferry.

The hybrid diesel-electric propulsion system with four ABB Azipods is yet another additional cost that ultimately pays off in the longer term on account of lower maintenance

THE DOUBLE-ENDED *P&O PIONEER*. SOURCE: PHILIPPE HOLTHOF



VIEW FROM THE BRIDGE. SOURCE: PHILIPPE HOLTHOF

costs. On the Spirit class, maintenance costs have been high as they each boast four main engines, four auxiliary engines, four shaft generators, two gear boxes, three bow thrusters, two steering gears and two rudders. The maintenance spend for the Fusion class is estimated to be 50% lower while the refit costs on a five-year survey cycle are expected to be 30% lower.

The peculiarity of a double-ended ferry is that it has no stern but rather two bows – one at either end. This is because it always berths bow-in, so instead of stern and bow P&O Ferries rather refers to Dover-end and Calais-end, respectively.

And the winner is...

Although having built ro-pax tonnage in Japan in the early 2000s, P&O Ferries has remained rather loyal to the European shipbuilding cluster. While the Spirit class was completed by STX Finland's Rauma facility, today's Rauma Marine Constructions, earlier ro-pax generations were built by German yards that have been long out of business. As for the Ship of the Future project, P&O Ferries' newbuilding team initially didn't have Chinese yards on their radar. Instead, they had shortlisted European and South Korean yards that had been bidding for the Spirits.

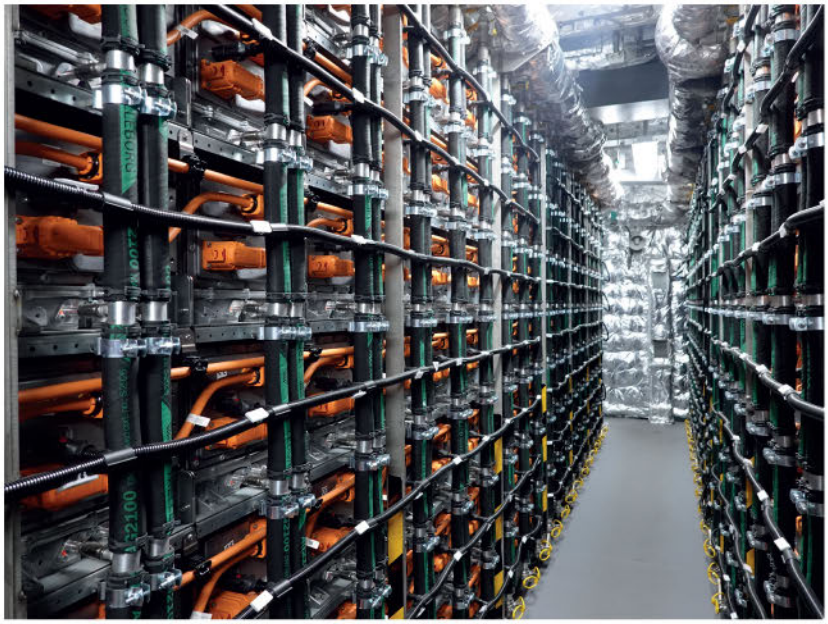
At 47,653gt, the 230.5m-long and 30.8m-beam *P&O Pioneer* and soon-to-be-introduced sister ship *P&O Liberté* are the world's largest double-ended ro-pax ferries. So, logically, P&O Ferries had long negotiations with Flensburger Schiffbau-Gesellschaft (FSG) and Remontowa Shipbuilding which had both built double-ended ferries for Canada's BC Ferries. Whilst the three Coastal class double-enders built at FSG were the then world's largest of their kind, the four Salish class built at Poland's Remontowa were way smaller which was one of the reasons why negotiations didn't lead to an order. Damen, which had also built double-enders, was yet another hot contender and was the only European yard to remain in the running until the very end. It would have built the P&O Ferries double-enders at its then newly acquired Mangalia site in Romania, but due to the poor condition of the yard facilities, the Dutch shipbuilding group couldn't guarantee a 2023 delivery.

It wasn't until DP World recommended taking China into consideration that negotiations started with Jinling Nanjing and Guangzhou Shipyard International (GSI). Other Chinese yards were also in the mix but a €260 million double order with an option for two more vessels was eventually signed with GSI in September 2019. The option for two more sister ships was not exercised as P&O Ferries awaits the installation of plug-in facilities at both Dover and Calais to enable full electric, zero-emission operations.

SRtP compliant by virtue of its design

When the Spirits were built, Safe Return to Port (SRtP) rules didn't apply yet as the keels were laid before 1 July 2010. Even so, P&O Ferries voluntarily incorporated the SRtP rules in their design. While the efficacy of the current SRtP rules can be argued, the separation of the engines and ancillary systems is intrinsic to the double-ender design. An emergency bridge is yet another SRtP requirement. Although it is not mandatory for the emergency bridge to have windows, the most essential

ABB AZIPOD ROOM FOREPEAK. SOURCE: PHILIPPE HOLTHOF



BATTERY ROOM. SOURCE: PHILIPPE HOLTHOF

navigation equipment must be duplicated. As the Fusion class has a Dover-end and Calais-end bridge it automatically complies with the SRtP rules once again.

In addition, OSK Design developed a Safe Return to Sea (SRtS) standard which allows the Fusion class to remain in service even after a minor SRtP incident. Although a voluntary initiative, DNV has meanwhile also added a Safe Return to Sea class notation.

Batteries and Azipods

While the Spirit class's propulsion pack was something of an evolution compared to P&O Ferries' ro-pax generation from the early 1990s, the Fusion class's diesel-battery hybrid system and podded propulsion are nothing short of a revolution. The engine room compartments occupy the best parts of Decks 1 and 2 with a B/5 double-skin spanning almost the full length of the hull. Midships, a ballast water room on Deck 1 and storerooms on Deck 2 separate the Dover-end from the Calais-end engine rooms. When considering the Dover-end as the stern and the Calais-end as the bow, then the hold for the stores trailer is on the portside of the centreline. Already on the Spirits, a stores trailer was no longer stowed on the main deck as it obstructed the traffic flow. On Deck 3 a side-hinged panel opens with the stores trailer lowered via a 15m-long hydraulic lift that connects the main deck with the single trailer hold. The trailer's unloading platform is flush with the storerooms. Actually, all watertight doors on Deck 2 are flush with the floor, creating obstruction-free passageways.

Abaft the midship section, at the Dover-end, is the engine control room. Its mirror view at the Calais-end boasts a machinery and electrical workshop together with a small storeroom and large auxiliary equipment room. Further forward at either end are the engine compartments. Each compartment holds two very compact, side-by-side stowed Wärtsilä 16V31 four-stroke medium speed engines. The ultra-economic engine type has been recognised by the Guinness Book of World Records as the world's most efficient four-stroke engine. With an output of 9,760kW at 750rpm and 100% MCR, the gensets have an advanced fuel injection system, combined with air injection technology, enabling the most efficient and economical use of low sulphur content marine diesel oil. ABB's two-stage Power2 turbocharger technology helps to achieve up to 5% in fuel savings and up to 60% of NOx emissions.

The 22nm stretch of water between Dover and Calais warrants a full-electric operation, providing the ports offer high-voltage rapid charging facilities. While the Port of Calais invested in a brand new three-berth outer port, it didn't provide onshore power supply (OPS) facilities, something critical in the future maritime energy mix. As an OPS system is also lacking in Dover, *P&O Pioneer*'s 1,160 individual XALT Energy batteries are charged when power demands from the gensets are below 85 to 90%. This is during arrival in port, at berth and when leaving port. Located in four battery rooms (two fore, two aft) outboard of the B/5 double-skin on Deck 2, the lithium-ion NMC-graphite batteries deliver a combined power of 8.816MWh. The 17.6knot design service speed can be achieved utilising two generator sets or one generator and the batteries with a 15-minute autonomy when sailing at a 17.6knot service speed. This means that any one generator can be removed from service for maintenance whilst still adhering to the SRtP rules.

On the Dover–Calais route, sufficient power to manoeuvre is a prerequisite. Ships that have not been purpose-built for the route are typically underpowered. Implementing azimuth thrusters is a radical departure from the combination of controllable pitch propellers, rudders, bow thrusters and even stern thrusters. The four ABB Azipods – two at either end – are of the compact DO1600 type rated at 7.5MW each. Unlike the larger versions typically used on cruise ships, the DO1600 allows for easy maintenance which can be performed while the ship remains in operation. Each thruster is fitted with a five-bladed monobloc propeller of 4m diameter.

When on passage, the forward pods are fixed at zero pitch and provide approximately 30% of propulsion power. The aft pods provide 70% propulsion power and

are used to steer the vessel, the steering angel being limited to 35 degrees either side of the neutral position. During manoeuvring all four pods can rotate through 360 degrees and thrust in any direction.

With energy efficiency at the heart of the design, the Fusion class also boasts a waste heat recovery system while its power management system uses software to turn off the lighting and ventilation in empty areas, as well as optimising the utilisation of engines, batteries and energy recovered from waste heat.

As befits a double-ender design, many systems are duplicated. This also applies for 704 Academy's active fin stabilisers with each pair being optimised for use in a single direction, guaranteeing a smooth crossing regardless in which direction the ferries are sailing.

Lessons learned from the Spirit class

On a short route like Dover-Calais, it is critical to find the right balance between lanemetre intake and time at berth as it is pointless to operate a juggernaut if it cannot be turned around in under 60 minutes. With ferries being part of the supply chain, short port turnarounds with fast unloading and loading are key. The 2,741lm cargo capacity of the Spirit class was deemed optimal and a further increase of freight capacity would have come at the expense of port turnaround times. So, instead of further increasing the lane-metre intake, OSK Design and P&O Ferries looked at ways to maximise and further optimise freight vehicle capacity. This has been achieved by increasing the free deck height of the uppermost car deck from 3.3m to 3.6m, allowing for campers and vans to be parked here, freeing up much-needed freight space on Decks 3 and 5.

To speed up unloading/loading operations, the open fixed ramps between Deck 5 and Deck 7 are wider and shallower than on the Spirits, being surfaced with Bimagrip anti-slip coating rather than tightly spaced herringbone bars. The width of all four ramps – two forward and two aft – has increased to 4.25m and thanks to the 42m length, the angle has been reduced to 8.3 degrees. Entering Deck 7 is through 4.25m-wide and 3.8m-high hydraulic top-hinged doors made by Wuxi Dongzhou Marine Equipment which also manufactured the 12m-wide and 4.8m-high end doors on Deck 5. On the Spirits the contrast between outdoor and indoor lighting slows down loading operations. This was especially the case on Deck 7 and has been addressed with ample LED lighting on all three vehicle decks. Up to 182 cars equivalent to 1,066 car lane-metres can be stowed on Deck 7 with four 2.4m-wide lanes on either side of the centre casing.

Two flights of stairs separate the uppermost vehicle deck from the lower accommodation deck – Deck 8. Passengers with reduced mobility can use one of the five passenger elevators – this compares to three passenger elevators for the Spirit class. P&O Ferries has gone the extra mile to make it as easy as possible from the moment that passengers get out of their vehicles. To achieve this, the Fusion class ships have been split up into two colour zones: blue (Dover-end) and yellow (Calais-end). On either side of the centre casing, each colour zone has been further divided into two letter zones: A and B for yellow, C and D for blue. Preceded by the deck number, the colour and letter zones are clearly displayed throughout the vehicle decks.

Deck 3 is the 5m-high main vehicle deck. To fit the berths in Dover and Calais, the two ends on which the lower linkspan is dropped are different. The Calais-end bow spades on Decks 3 and 5 are fitted with a hydraulic flap arrangement to fit all three berths in Calais' new port with the flap down and berths 7, 8 and 9 in the old port with the flap up. Dover-end spades on Decks 3 and 5 are fitted with sliding beam arrangements to fit both portside to berth 8 and starboard side to berths 7 and 9.

The Fusion class is about one truck length longer than the Spirits, something which was necessary to compensate for the loss in lane-metres on account of the double-bow shape. This also means that *P&O Pioneer* has two sets of bow doors and watertight doors. The side-hinged clamshell doors that give access to Deck 3 fore and aft have been supplied by Switzerland's SeaNetGroup. Up to 1,314lm can be stowed on the main deck, spread over eight 3.2m-wide lines – four on either side of the casing. Similarly, 1,278lm of freight can be stowed on Deck 5.

TECHNICAL PARTICULARS *P&O PIONEER*	
Length oa	230.5m (230.8m with Calais-end Deck 3 spade extension)
Length,bp	216.8m
Breadth, moulded	30.8m
Depth to main deck	9.8m
Draught, design	6.23m
Gross tonnage	47,653
Net tonnage	16,754
Deadweight	9,988.9t
Lane-metres	2,592m (+ 1,066 car lm or 182ceu on Deck 7)
Passengers	1,437
Main engines	4 x Wärtsilä 16V31
Output	4 x 9,760kW at 750rpm and 100% MCR
Service speed	17.6knots
LSAs	4 x 150-person Viking Norsafe lifeboats + 4 x Viking VEMC – 1,314 persons + 2 x Viking Norsafe Merlin-615 MKI fast rescue boats
Class (*)	DNV
Class notation (*)	+, 1A, Ferry A, E0, BIS, NAUT (AW, ICS), LCS (DC), Recyclable, COMF (C-2, V-2), Clean, Battery (power), HMON (C, O4, O2, W)
Flag	Cyprus
(*) As built class, transferred to Lloyd's Register	

FOOD MARKET ON DECK 8. SOURCE: PHILIPPE HOLTHOF

Up to 12 accompanied trailers with hazardous goods can be stowed on the three lanes fore and aft of the accommodation. On both Deck 3 and 5 the inside lanes next to the centre casing walkways are 3m wide instead of 3.2m.

Light and airy public spaces

Although Finland's dSign Vertti Kivi & Co provided a draft interior design, P&O Ferries decided to keep the whole design package under one roof, appointing OSK Design's interior architecture division for the *P&O Pioneer*'s and *P&O Liberté*'s interior design. As these ships are here to stay for at least 25 years, OSK Design deliberately chose a timeless yet cosy design that meets contemporary simplicity.

Performing over 3,500 single crossings per year, ferries on the Dover-Calais route are exposed to hard wear and tear so robust and durable materials were chosen. All of the ship's heavy foot traffic areas have highly durable vinyl flooring rather than carpet. Supplied by both Gerflor and Armstrong Flooring, the vinyl floors with wood and tile effects, but also fashionable carpet look, are hardly distinguishable from real wood-, tile- or carpet-covered floors. The vast sundecks that are wrapped around the fore and aft sections are covered with Herculan Marine EcoTeak's easy to maintain seamless flooring, an environmentally friendly alternative to genuine teak flooring. These well-protected, glass-screened open decks are a welcome change from earlier cross-Channel ferry generations with ample fixed low-maintenance lightweight seating and furniture.

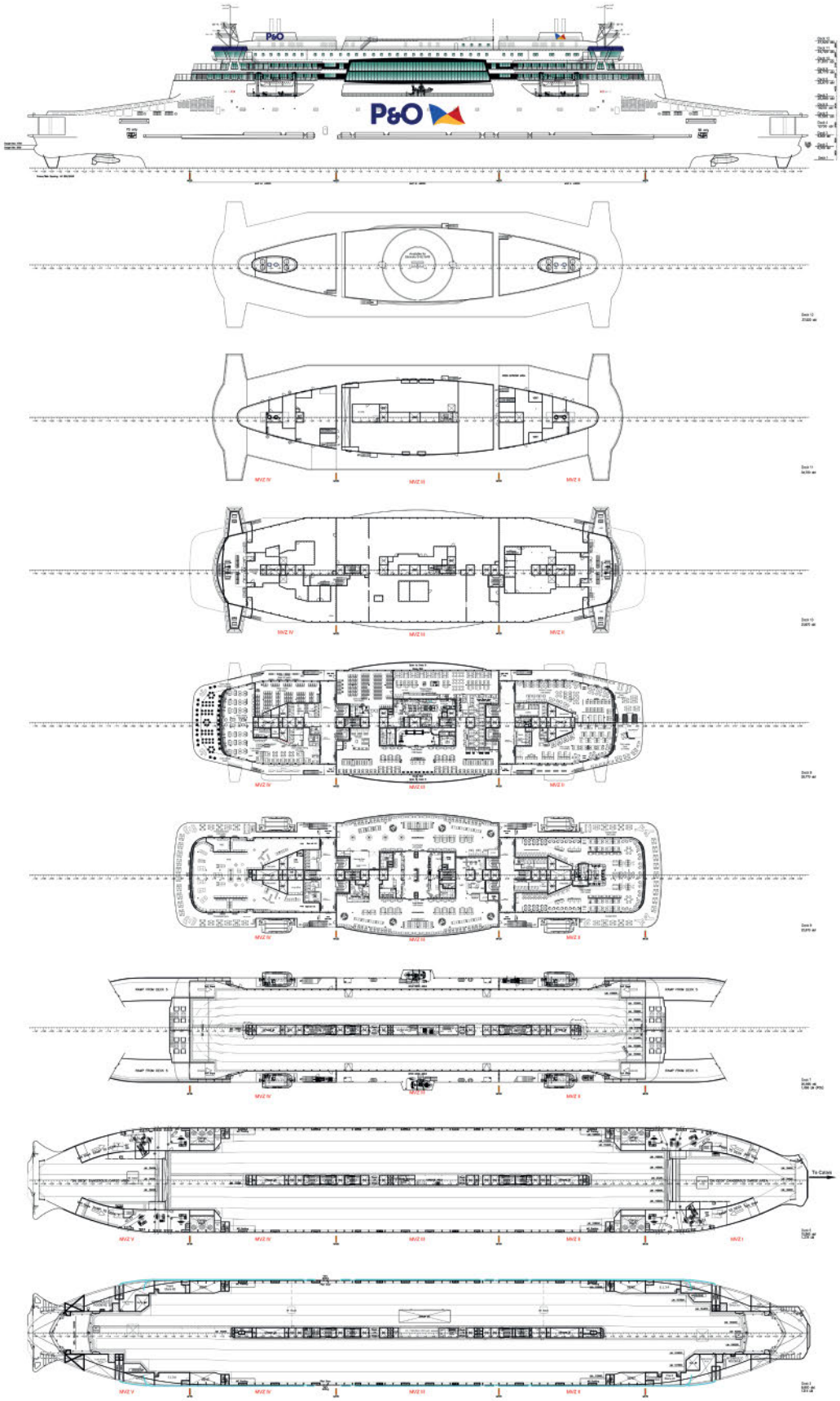
As port stays are typically very short, all public spaces have been designed with easy and quick cleaning in mind. For instance, all swivel chairs self-move back into position – ceiling-hung toilet partitions don't require components to be mounted on the floor, allowing for easy floor cleaning. It's the combination of all these little design details that make a big difference.

The general arrangement of the passenger decks, Deck 8 and 9, follows a symmetrical plan on Deck 8 while Deck 9 is somewhat asymmetrical as it holds the 'destination venues', notably the commercial drivers' facilities, the luxurious Club Lounge, The Pet Lounge, the quiet lounges and The Kitchen, the ship's secondary restaurant. Two full-width stair lobbies divide each deck into three fire zones. Accessed from the Dover-end stair lobby, the large duty-free shop occupies the entire aft part of Deck 8. Its mirror view forward, accessed from the Calais-end stair lobby, is the 287-seat boutique-style The Lounge Bar.

The restaurant facilities are concentrated in the midship section, characterised by its signature cantilevered glass curtain wall on either side. The ship's main hub is the 410-seat open plan Food Market, spanning the full width of Deck 8. The starboard side (when Calais-bound) is open 24/7 as it holds the guest services desk with bureau de

CLUB LOUNGE. SOURCE: PHILIPPE HOLTHOF

GENERAL ARRANGEMENT OF *P&O PIONEER*.
SOURCE: OSK DESIGN



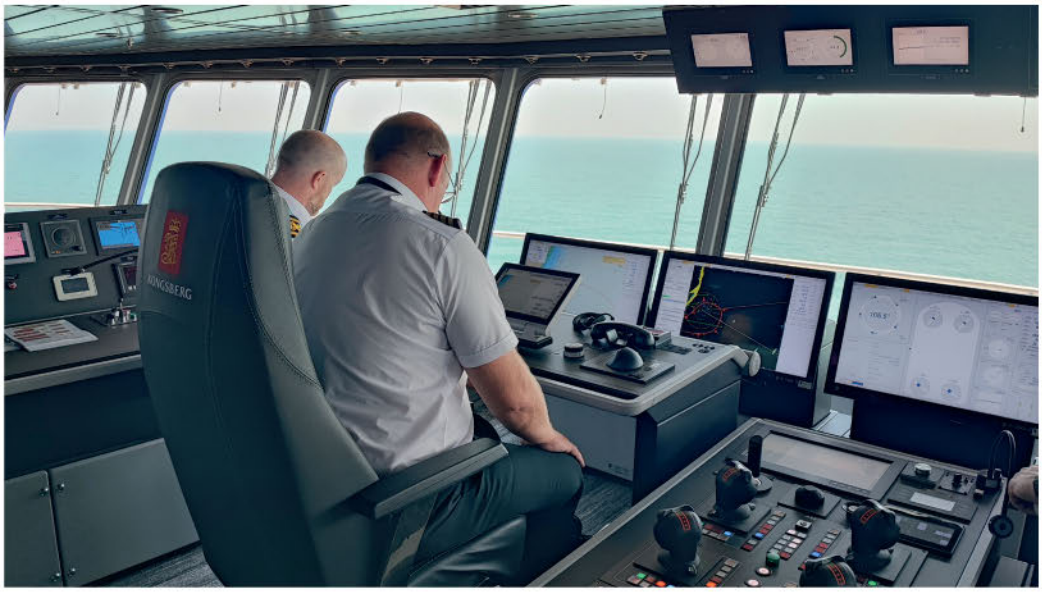


ABB AZIPOD CONTROLS. SOURCE: PHILIPPE HOLTHOF

change and the main children's playroom – one of three playscapes. Finished in a bright and airy pallet, the design elements incorporate greenery and woodland scenes to create a natural, calm feel. The restaurant's central self-serve area has been inspired by the fast-flowing food markets found in high footfall service stations, train stations, airports and shopping centres with grab and go options and self-serve tills. There are glass doors at each side of the self-serve area, allowing for one side of the Food Market to be closed off, making it operationally more flexible.

One deck up, on Deck 9, located between the Dover- and Calais-end stair lobbies is The Kitchen on the starboard side and the commercial drivers' restaurant facilities to port. The Kitchen is a new catering offering, serving fresh hot fast food on an 'order to collect' basis in a similar fashion as in major high street fast-food chains. Thanks to the protruding double-height windows, a two-deck atrium is created, connecting the Deck 8 Food Market with The Kitchen and commercial drivers' restaurant on Deck 9. For acoustic comfort, the Deck 9 'balconies' are screened off by floor-to-ceiling windows. The facilities for the commercial drivers extend forward with a plush lounge accessed from the Calais-end stair lobby. It is a haven of tranquillity with different types of seats, including reclining chairs, chaises longues and even couchettes.

Just aft of the commercial drivers' restaurant is the quiet lounge section. Separated by the Dover-end stair lobby, one lounge boasts 90 reclining seats and the other one 107, allowing for some flexibility as one of the lounges can be kept closed. Adjacent to the smaller of the two quiet lounges is the Club Lounge. Offering a premium experience in a high-end ambience, the Club Lounge boasts a dining area with food and drinks buffets as well as a relaxation area. The dedicated Club Lounge sundeck is designed to replicate the exclusive feel inside with 'luxury' outdoor seating.

The Pet Lounge forward on Deck 9 completes the passenger facilities. The supplement to use The Pet Lounge includes free hot and cold drinks that are available from the self-serve 'Coffee Corner'. As part of their entrance fee, users of The Pet Lounge park their vehicles in zones 7A and 7B, close to the yellow, Calais-end stairway.

Two navigation bridges

Having two navigation bridges is by no means a cheap solution. The bridges' central integrated consoles follow the typical 'cockpit' layout with officers seated in ergonomic pedestal-mounted high-back chairs to better grasp the situation around the ship. P&O Ferries chose Kongsberg's K-Bridge integrated navigation system (INS) which provides a single-user interface to multiple connected systems, enabling deck officers to focus on primary navigation tasks without having to switch their attention between different instruments. Whether it is K-Bridge Radar, K-Bridge ECDIS, K-Bridge Conning which can also be used to view CCTV from different cameras mounted around the vessel, including thermal imaging cameras (to avoid collision with migrant boats), all 18 screens are interchangeable. To offer the best of both worlds, the higher-frequency X-band radar scanner can be combined on a single radar display with the lower-frequency S-band radar scanner, eliminating blind arcs. The seamless overlap of X-band and S-band radars on a single radar display guarantees a 360-degree picture, showing both nearby and far-off targets. The bridge's central control desks and consoles are height adjustable as is the helm station.

Manoeuvring the conventional way using shaftlines, rudders, bow and stern thrusters is a far cry from Azipod manoeuvring. Each Azipod unit has its own lever to control the propeller speed and steering angle. The system also comes with a joystick, combining all four levers in a single device. Each bridge has 12 levers – four on the central navigation desk and four on each bridgewing desk.

The introduction of *P&O Pioneer* also sees the re-introduction of lifeboats instead of an all-MES solution as first adopted by P&O Ferries on the converted Darwin class pair in 2003 and repeated on the Spirit class. One of the reasons to re-install lifeboats is the high maintenance cost of MES chutes, so the P&O Ferries newbuilding team opted for a combination of four 150-person lifeboats and four VEMCs connected to a total of ten inflatable drop rafts. ■

INCAT TASMANIA TO BUILD WORLD'S LARGEST BATTERY ELECTRIC SHIP

By **Richard Halfhide**

THE UNNAMED FERRY WILL HAVE MORE THAN 40MWH OF CORVUS DOLPHIN NEXTGEN BATTERIES INSTALLED. SOURCE: CORVUS ENERGY

In a change to earlier plans, Australian shipyard Incat Tasmania has announced that the 130m lightweight inland ro-pax ordered by Uruguayan operator Buquebús, first announced in 2019 and already under construction, will now be powered entirely by batteries.

The order will now incorporate a Corvus energy storage system (ESS) of more than 40MWh, four times larger than previously used for maritime transportation. An integrated electrical system developed by Wärtsilä will use e-motors to power a waterjet propulsion system.

Presently unnamed, Incat Hull 096 will operate on a route along the River Plate between Argentina and Uruguay, a distance of approximately 45nm. The ferry will have capacity for 2,100 passengers and crew, 225 cars and a 2,000m^2 duty-free shop.

The 40MWh ESS is made possible by the aluminium hull, which reduces the weight by as much as half compared to an equivalent steel vessel. An integrated electrical system developed by Wärtsilä will use e-motors to power a waterjet propulsion system.

Speaking at an online press briefing Robert Clifford, Incat's chair and founder, praised his forward-thinking client for sharing his own company's vision to be at the leading edge of low emission shipping.

He explains: "[The project] began its life some three years ago as a gas-powered vessel but was put on hold because of Covid. That gave us the opportunity to go along with the customer's wishes to be particularly environmentally friendly. So at the client's instigation we changed the specification to electric."

Unique battery arrangement

Although SOLAS dictates that an ESS should be located in a dedicated battery room, the ro-pax will essentially have four separate battery rooms, each comprising an individual power train with a battery pack feeding a DC hub, with each of these in turn powering two electric motors that power either booster or steerable water jets (for a total of eight water jets). Controlling all of this will be Wärtsilä's energy management system, with software that optimises the vessel's operating profile.

Despite the significant scaling up in the ESS compared to any previous vessel – given that just a few years ago a 30-minute journey for a car ferry travelling at 12knots was considered an achievement – battery supplier Corvus Energy is amply prepared for the increase in demand, according to Halvard Hauso, the company's chief commercial officer.

He comments: "We have seen the battery limit growing year by year and there is no size surprising us anymore. When this project came up we thought this was a big system but are already working on a 100MWh ship.

"We have factories in Vancouver, as well as Bellingham in the US and the facility in Bergen, Norway, which we are expanding to build the Dolphin Energy NextGen, which we are using for this project."

The Dolphin NextGen, which adopts a stacking arrangement rather than the more typical battery rack, is based on nickel, manganese, cobalt (NMC) and uses cylindrical cells. Hauso notes that its C rating of 0.5 means it can charge with 20MWh of shore power, making it ample for such a large ESS.

With regard to the potential for further electrification of vessels Clifford and Hauso concur that the only limitation is likely to be shoreside provisions. "With this sort of vessel you can easily cross the English Channel with zero emissions, the challenge is to get enough shore power at both sides to fill up the batteries," says Hauso.

Clifford adds that he has been party to discussions regarding English Channel port infrastructure. "There is progress being made, it's chicken and egg as to which comes first – the ship or the charging – but we're making progress."

The ro-pax is scheduled for delivery in 2025. ■

THE 130M FERRY IS ALREADY UNDER CONSTRUCTION. SOURCE: INCAT TASMANIA

CFD & HYDRODYNAMICS

NORWEGIAN STARTUP DEVELOPS NEW SOLUTION TO PROBLEM OF BIOFOULING

By **Tom Barlow-Brown**

Biofouling is a problem that has long plagued the maritime world but is often overlooked in the wider scope of the industry when it comes to innovation.

Organisms, such as marine species and algae, can have a substantial impact on vessel performance and efficiency. A vessel weighed down by these organisms will see increases in drag force and hydrodynamic volume. This can lead to a significantly higher fuel consumption and as a result increased GHG emissions.

Traditional anti-fouling solutions for shipowners, such as coatings, also create their own problems as they can seep into the water surrounding a vessel. Current methods of removing biofouling, such as jet washes or high-powered brushes, can also be inefficient.

Step forward Norsjór, a Norwegian tech startup founded in 2021, which has developed an advanced subsea laser system for sustainable biofouling removal. Norsjór's solution doesn't damage the vessel's anti-fouling coating, or harm the ocean ecosystem, as some traditional hull cleaning methods can do. Named one of the world's 10 most prominent biofouling innovators by the World Ocean Council and the Ocean Opportunity Lab in 2022, the company is also supported by organisations such as Equinor and Maritime Cleantech.

Norsjór founder and CEO Amalie Eilertsen spoke to *The Naval Architect* this summer about the company and its plans for the future. Eilertsen first decided to look into biofouling solutions during her master's degree in Entrepreneurship and Innovation at university. "When I started looking into it, I understood that it is generally neglected by the average person but it has a huge impact, both on our environment and socially," she says.

Later on she decided to team up with her fellow classmates Kennet Karlsen and Jarle Haugereid. Eilertsen initially worked as a nurse for several years until her master's degree. Her and the rest of the team worked full-time on the initial development of their project while working part-time to help with living costs.

After extensive research they decided that there was a gap in the market which they could exploit. For the Norsjór team the crucial research that spurred their decision came when they had explored all the available biofouling technology. "One day I stumbled on a new huge piece of research where they mentioned laser technology as a good solution," says Eilertsen.

"My first thought was that it was interesting because I've worked in the healthcare industry and we used lasers or radiation to kill organic material. This gave me an idea this might work," she adds.

THE NORSJÓR TEAM

Putting it to the test

Eilertsen and her team started doing tests right away but not all of them were successful. One failed test took place in Sweden during the Christmas period in 2021. "We had not put a lot of money into it, but we didn't have any money to start with, so it felt like a lot," she says. "I remember every one of us going into that Christmas holiday exhausted and frustrated that we had nothing."

The team didn't let this setback get them down though. "During the Christmas holiday we had some time to think so we started again. Then just a couple of months later we had a positive test on the correct wavelength and that could handle all the parameters that we looked at, such as damage to the biofouling and a minimum energy loss in water," Eilertsen says.

Following the positive test, the team received a grant of NOK900,000 (US$86,000) through the STUD-ENT programme from Innovation Norway. They then began rigorous testing. Due to the fact lasers had never been tried as a solution to biofouling there were many unknowns. Eilertsen adds: "You're sort of just making it up as you go along. It's like jumping off a cliff with no clue on how to land on your feet."

Starting a new business and research venture during the midst of the coronavirus pandemic also hindered the team's progress. "Everyone was really not focused. I think that a lot of people that we talked to were kind of occupied with the new restrictions within their own workplace and weren't eager to jump into something

new," says Eilertsen. "We of course met a lot of people that have helped us along the way. But I think during the pandemic it was hard to make people lean into something new and something that was very much on paper that had never been done."

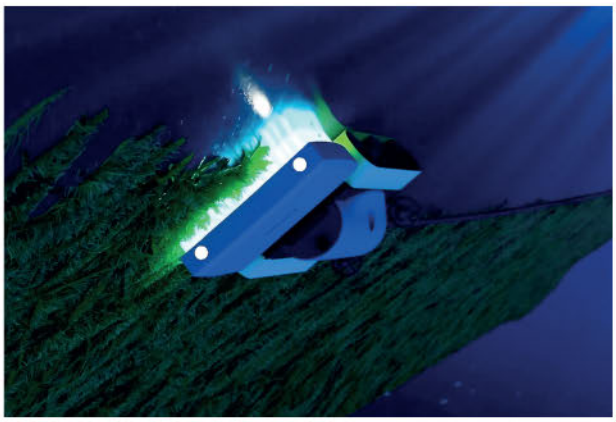
The first upscaled model of Norsjór's hull cleaning robot, named 'Luke Hullwalker', is due to be finished in autumn 2023. Eilertsen says: "We know that every component works and we are now approximately a month away from pilot tests." The final product will be manufactured at the team's HQ in Kristiansand, Norway.

Several potential buyers and investors have already reached out. "They have contacted us," says Eilertsen. "We've gained a lot of interest in posts in the last three months to four months. The reason companies have contacted us is they say that we check all the boxes."

Part of the interest in Norsjór's work is the result of the company's inclusion in the prestigious Equinor & Techstars Energy accelerator, which the team was awarded along with nine other companies.

Promising future

"It's more important to be able to deliver a quality product," says Eilertsen. "A lot of our potential customers all want to know what it will be capable of and if it's compatible with their own range of projects. We have been asked by the offshore wind sector to use it on wind turbine monopiles to remove biofouling there. Other customers have asked if it will work inside pipes, outside pipes, and in other offshore construction."



RENDER OF 'LUKE HULLWALKER'

"This is of course really promising for the future, but we need to also focus for now and deliver the first product," she concludes.

Norsjór aims to scale its product from autumn 2023 and then distribute it to its pilot customers. A full market release is planned for 2024 following final tests. ■

EFFICIENT CFD SIMULATIONS FOR SPEED AND DELIVERED POWER IN WAVES AT FULL SCALE

By **Michal Orych**, managing director, FLOWTECH Int. AB, **Martin Kjellberg**, RISE Research Institutes of Sweden/SSPA, and **Lars Larsson**, Chalmers University of Technology

Computational fluid dynamics (CFD) is presently an accepted tool for predicting calm water resistance and power at model scale. The status of CFD for these applications is well covered by the International Workshops on Numerical Ship Hydrodynamics, see Larsson et al. (2014) and Hino et al. (2021). However, like in model testing, the results must be extrapolated to full scale. This extrapolation is burdened by inaccuracies due to many assumptions. Recently, the interest has shifted towards direct full-scale predictions, and the currently most comprehensive validation exercise is performed within the joint research project (JRP) 'Development of Industry-Recognised Benchmark for Ship Energy Efficiency Solutions', JoRes (2023). Furthermore, ship designers place greater emphasis on real-world conditions, which include environmental factors like wind and waves. Such simulations are still time consuming and computationally expensive when performed using solvers based on the unsteady Reynolds-Averaged Navier Stokes equations (RANS). However, selecting the most advanced methods is not always feasible or necessary. Through careful verification and validation studies, we can identify and use more efficient methods with confidence.

In this article, we introduce a hybrid potential flow/RANS method for predicting the powering performance, including speed loss estimation, of a full-scale ship in irregular waves. The software used is SHIPFLOW, developed and marketed by FLOWTECH International AB in Sweden. FLOWTECH is a spin-off company from Chalmers University of Technology and has provided CFD software to the marine industry since 1989. A newly developed potential flow Boundary Element Method (BEM), Kjellberg (2023), is used in connection with a steady-state RANS solver, Orych (2021). More than an order of magnitude is saved in computational time compared to unsteady RANS, while maintaining accuracy for sea states typical of model testing. This method should interest ship designers who want to minimise required engine power in waves. Additionally, classification societies may find it valuable due to its capability to assess the speed loss in regulations for the Energy Efficiency Design Index (EEDI).

Numerical method

The BEM solver, MOTIONS, is a fully nonlinear unsteady potential flow solver for free surface flows with floating bodies subject to 6DOF. It has an internal automatic mesh engine for the rigid bodies and the free surface. Several measures have been taken to increase the accuracy and lower the computational time. The free surface mesh is dynamically refined in the areas where the waves need to be resolved. Additionally, there is a nonlinear decomposition of the solution into an undisturbed incident wave field and a disturbance field due to the presence of the hull. This ensures that incident waves far from the hull do not have to be resolved by the BEM and these waves are not affected by numerical diffusion. As a result, larger panels can be used away from the hull without affecting the quality of the incident

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wave field. The hull body motions are calculated by summing up the pressure forces calculated on the hull panels and integrating the corresponding rigid body acceleration in time. The total pressure on the hull is given by Bernoulli's equation, and for robustness reasons, an acceleration potential is used to obtain the time derivative of the velocity potential. A fourth-order Adams–Bashforth–Moulton predictor–corrector method is utilised for time integration.

For the self-propulsion simulations, a steady RANS solver is used. The equations are solved with a finite volume method. An explicit algebraic stress turbulence model, EASM, is selected to provide accurate wake representation. No wall functions are used, and the equations are integrated down to the wall. The equations are discretised using the Roe scheme for convection, while a central scheme is used for the diffusive fluxes. An explicit flux correction is applied to achieve second-order accuracy. The momentum and continuity equations are coupled, which increases the speed and robustness of the solver – a crucial aspect for the full-scale Reynolds number. Hull roughness is considered by a modification of the boundary conditions for the turbulent kinetic energy and its specific dissipation, Orych et al. (2022). The propeller is simulated with a body force approach, where the forces are obtained from a lifting line method. To simulate self-propulsion, the program automatically adjusts the propeller rotational speed to achieve a balance between resistance and thrust.

Applications

A well-known Korean VLCC test case (KVLCC2) developed by Korea Research Institute of Ships and Ocean Engineering, KRISO (formerly MOERI), was selected to illustrate the software application for this article.

First, we calculate the added resistance in waves for several ship speeds and wave directions. The simulations are validated at 15.5knots corresponding to Froude number Fr=0.142. Simulated results are plotted in Figure 1 together with the available test data. The measurements were performed at the Maritime Dynamics Laboratory of SSPA and include multiple test series for all wave lengths which is crucial for assessing the measurement uncertainty. The simulations are then compared to the average values to estimate the

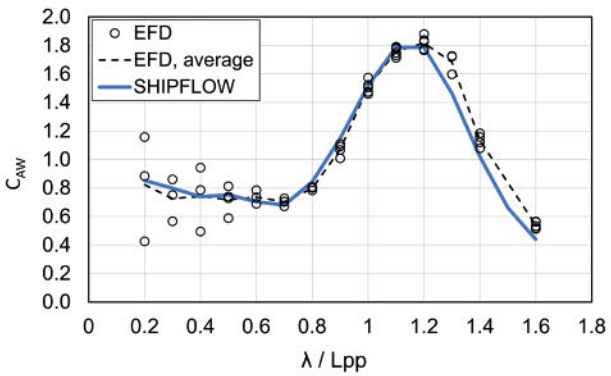

FIGURE 1. COEFFICIENT OF ADDED RESISTANCE DUE TO REGULAR, HEAD SEA WAVES FOR SIMULATIONS AND MULTIPLE MEASUREMENTS

accuracy of the numerical method. It is encouraging to see that the results are within the scatter found in the measurements. This validation indicates a good accuracy, and we can assume that the viscous effects on the added resistance in waves are limited for these conditions and that the method can be confidently applied to our problem.

To determine the delivered power in waves, we first consider the added resistance in waves computed earlier. Additionally, we account for wind resistance, which is estimated using an empirical method. These forces are then included in the RANS self-propulsion simulations. For these computations, a structured grid describes the hull, and this is complemented with overlapping component grids for the appendages. The propeller is represented within a cylindrical domain, and an embedded separate grid is used for the rudder. Both the propeller and the rudder are encapsulated within a local refinement derived from the background, hull grid. In this refinement, each cell is split to produce eight new cells. For our simulations, the average hull roughness at full scale is assumed to be 100μm, a typical height for new ships.

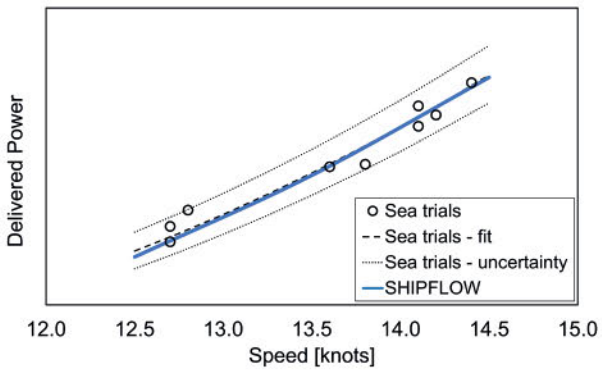

FIGURE 2. DELIVERED POWER FROM SEA TRIALS AND CFD SIMULATIONS FOR A SMALL TANKER

We compare the computed results to the measurements for validation. The model scale average comparison error of the resistance is about 1% for all three considered speeds. The delivered power computations at full-scale are compared to measurements extrapolated to full-scale using the ITTC-78 method, yielding an average comparison error of also 1%. Since KVLCC2 lacks available sea trials, we can only compare with the extrapolated model tests. However, a full-scale validation of a smaller tanker using the same numerical method has been previously published, as shown in Figure 2, Orych et al. (2021). It also shows that the predictions are very close to the sea trials.

With simulations for a range of speeds and wave conditions, the speed loss of a ship in a seaway can be estimated. It can be expressed as a weather factor, fw, which represents the percentage of the ship's calm water speed that can be sustained when encountering Beaufort 6 weather conditions and corresponding waves, Gerhardt and Kjellberg (2017). The added resistance in waves is computed for three speeds: 12.5, 13.5, and 14.5knots, and for three wave directions, 0°

(head waves), 30° and 60°, across a range of regular wave lengths from 0.2 to 1.8 times the ship length between perpendiculars. Then the mean resistance in irregular waves is calculated by integrating the transfer function of the mean added resistance in regular waves with the wave spectrum. For the weather factor calculations, a spectrum recommended by the ITTC with a significant wave height, HS, of 3.0m and zero up-crossing period, TZ, of 6.16s is used. Alternatively, simulations can be performed in irregular waves. Such calculations take about half the time needed for the entire range of wave lengths, as the latter require more wave encounters to provide an average value of the added resistance. For our example case, the weather factor is 0.88 (as shown in Figure 3), and this aligns well with the values in SSPA's database for similar tankers.

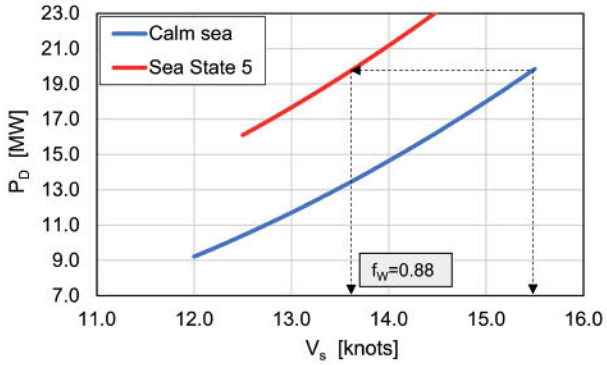

FIGURE 3. SPEED-POWER CURVES FOR CALM WATER AND IN STATE 5 HEAD SEAS WITH BEAUFORT 6 WIND

SHIPFLOW is also used for sail-assisted ships. For example, it has been used for a wind-powered car carrier concept in a Swedish research project, where the concept sailing cargo vessel at that time was equipped with four 80m-high wing sails, Figure 4. CO_2 savings of approximately 90% are considered feasible with such a solution. The prediction and analysis of a sailing ship's seakeeping performance are crucial, not just for understanding sailing dynamics, but also for the comfort and safety of crew and cargo. The analysis, focusing on the seakeeping performance and dynamic behaviour of this wind-powered ship, was presented at the 24th Chesapeake Sailing Yacht Symposium by Kjellberg (2022).

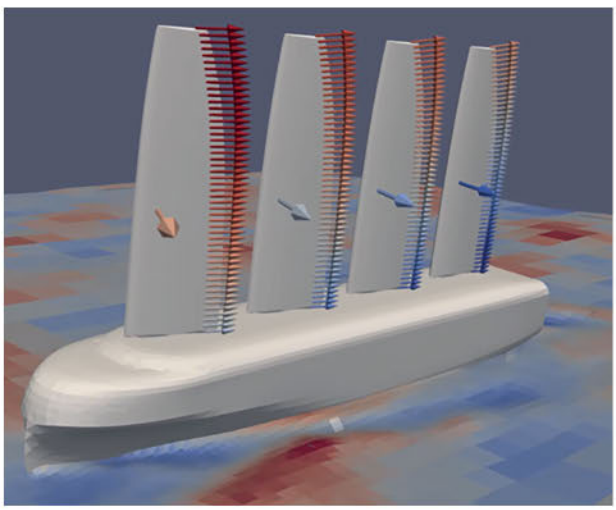

FIGURE 4. THE CAR-CARRIER CONCEPT VESSEL SAILING UPWIND IN SEA STATE 5, KJELLBERG (2022)

Conclusions

This article introduces an efficient and accurate numerical tool to estimate the power requirements in waves. It combines unsteady potential flow simulations in waves with steady state self-propulsion at full scale. On average, the simulations require approximately 1.5h per case in waves and 2h for self-propelled cases on a computer with a 24-core CPU. To have enough data, eight wave lengths for the seakeeping part and six propelled cases are needed to estimate delivered power. Thus, the total time required for assessing the speed loss is approximately one day. The successful validation suggests that the approach could serve as a valuable complement to physical testing, offering ship designers a useful tool for initial design and optimisation. ■

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HYDRODYNAMIC OPTIMISATION OF A ZERO-EMISSION BATTERY-DRIVEN FAST CATAMARAN

By **Yan Xing-Kaeding**, Hamburgische Schiffbau-Versuchsanstalt (HSVA)

FIGURE 1. PHOTOGRAPH TAKEN DURING SEA TRIAL MEASUREMENTS IN STAVANGER (AUGUST 2022)

The optimisation of battery-powered ships for efficient, emission-free coastal passenger transport brings to the forefront a significant emphasis on hydrodynamic design. This intricate process, crucial for minimising resistance and energy consumption, takes on heightened importance due to the unique requirements of these vessels. Operating on short-distance routes and focusing on swift travel, these ships necessitate a streamlined and sophisticated hydrodynamic profile to achieve optimal performance.

The hydrodynamic optimisation is pivotal in achieving several objectives:

1. Energy Efficiency: Hydrodynamic design directly impacts the amount of energy required to propel the ship through the water. By reducing hydrodynamic resistance, the ship can navigate with enhanced efficiency, ensuring that the battery power is utilised judiciously and enabling longer operational durations.
2. Range and Endurance: Coastal passenger transport often involves frequent stops at closely located points. Effective hydrodynamic optimisation extends the vessel's range by maximising energy conservation. This, in turn, influences the ship's endurance, enabling it to cover more distances without compromising speed and passenger service.
3. Speed and Performance: For fast passenger transport, maintaining a high cruising speed is vital. Hydrodynamic enhancements contribute to the ship's ability to sustain higher speeds with reduced energy consumption, meeting the demands of time-sensitive schedules while conserving battery resources.
4. Environmental Impact: As these ships operate with zero emissions, their overall environmental footprint is closely tied to energy efficiency. Effective hydrodynamic design mitigates energy wastage, reducing the overall ecological impact and reinforcing the vessels' eco-friendly nature.

The Horizon 2020 European Research project TrAM (Transport: Advanced and Modular) – a joint effort of 13 stakeholders in the European maritime industry [TrAM, 2018-2022] – is innovative for the introduced zero-emission technology, the design and manufacturing methods, while it should prove that electric-powered vessels can be fast and competitive in terms of offered service, the environmental impact and the lifecycle cost. Intensive research has been carried out on the hydrodynamic optimisation of a battery-driven catamaran's hull form. MS *Medstraum*, a demonstrator of the studied catamaran concept has been built and started operations on a multi-stop commuter route in the Stavanger area in September 2022 (https://tramproject.eu/).

Hydrodynamic optimisation

A preliminary general arrangement of the Stavanger demonstrator vessel (Figure 2) was elaborated by Fjellstrand AS, the shipyard participating in TrAM, where the physical demonstrator was constructed. The external dimensions of the vessel providing the required passengers transport capacity were set equal to 31m for the length overall and 9m for the beam overall. The vessel should be able to carry up to 147 passengers with a service speed of about 23knots, depending on loading condition and fitted e-motors.

Parametric hull model

Based on a preliminary lines plan of a reference vessel, a parametric model for the demihulls of the Stavanger demonstrator was developed by use of the CAESES® software platform (www.caeses.com). The developed parametric model offers the designer the possibility to control/specify the main particulars of the demihull along with the hull form details within a reasonable range of variation of the defined design variables, while at the same time adequate quality (fairness) of the hull is ensured. The designer is enabled to explore the huge design space of automatically generated hull forms

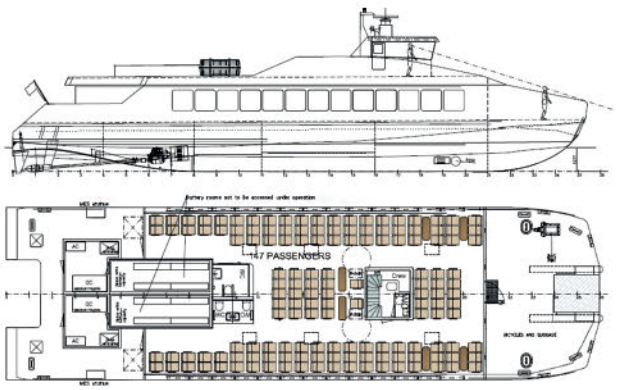

FIGURE 2. PRELIMINARY GENERAL ARRANGEMENT OF THE STAVANGER DEMONSTRATOR

Table 1. Main optimisation variables of hull geometry	
L_{WL}	Waterline length
HB_{DES}	Demihull's half beam
T_{INIT}	Draught
CHINEY $_{ATSO}$	Transom width

and decide on the most favourable ones on the basis of rational, holistic criteria.

A set of 20 design variables was first specified, defining the main dimensions, as well as local hull form details, such as the width, immersion and shape of transom and the shape of the bow area of the vessel. From the set of 20 design parameters, the four most important referring to the catamaran's main dimensions and the transom width were selected as design variables during the first-round optimisation studies (Table 1). The overall beam of the catamaran was kept constant due to design/construction reasons (yard's specification of deck superstructure module). It is of course acknowledged that increasing the separation distance of the demihulls would lead to lower wave resistance, but the increase in lightweight and production cost is expected to outweigh this resistance benefit. It is also noted that the vessel's operational Froude number will be close to 0.70, far beyond the last hump of wave resistance, thus viscous resistance will be dominant at the catamaran's service speed. For the definition of the stern region, where a tunnelled form is fitted, the most important parameters are the transom height at centerline and the height difference from centerline to chine at transom.

Based on the specified values of the main optimisation variables, and the default values for the remaining design parameters, a grid of parametrically defined curves was created in CAESES® (Figure 3a), which is the basis for the generation of a set of meta-surfaces (Figure 3b) and eventually leads the final demihull hull form by use of Lackenby's transformation, through which the hull form's displacement volume and its longitudinal centroid can be adjusted to the desired values (Figure 3c).

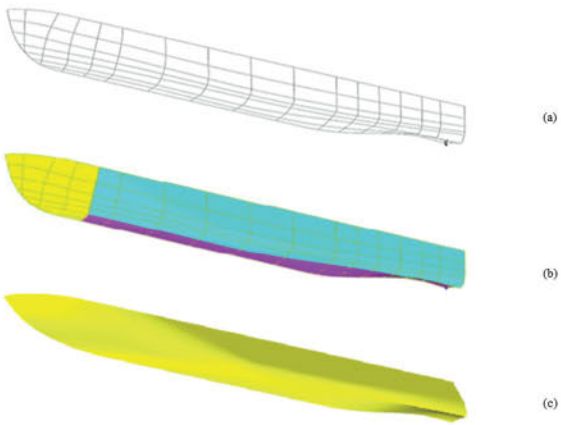

FIGURE 3: DEFINITION GRID (A), RESULTING SURFACES (B) AND FINAL DEMIHULL AFTER LACKENBY TRANSFORMATION (C)

Optimisation methods

The hydrodynamic assessment of each design alternative is based on HSVA's in-house tools, i.e. the panel code for wave resistance v-SHALLO and the RANSE code FreSCo+ for the total resistance and the refined local flow simulations at the catamaran's transom. Since these tools require considerable computing resources, it was decided to explore the possibility provided by CAESES® to pre-compute data for later usage. To this end, a series of so-called Design of Experiments (DoE) have been carried out, to obtain a large number of alternative hullforms, which were analysed by HSVA with the above-mentioned CFD tools. Based on the collected pre-computed data, surrogate models are developed, enabling the sufficiently accurate estimation of the quantities of interest during the optimisation study in practically zero time (in our case the calm water resistance of each design variant at various displacements and service speeds). Apart from drastically reducing the calculation time, surrogate models increase the robustness of the whole process by avoiding the need of remote computing. In the later optimisation stage, the Dakota Optimisation Toolkit of Sandia National Laboratories disposed in CAESES® has been utilised. This toolkit allows comprehensive exploration of the multi-parametric design space by use of proper sampling methods, such as Latin hypercube sampling, orthogonal arrays, and Box-Behnken designs.

Global optimisation studies

A global optimisation study was first performed in order to identify the optimum combination of the selected design variables for the Stavanger demonstrator. The objective of the study was to minimise the calm water resistance of the bare hull in a range of displacements and speeds, which mostly represent the operational profile of the Stavanger demonstrator. A set of constraints was also applied, in order to verify that each feasible design alternative provides sufficient space for the installation of the battery racks and the fitting of large diameter propellers. The optimisation study was carried out by employing the NSGAII algorithm, already integrated in the CAESES® environment.

Some representative results of the global optimisation study are illustrated in Figure 4. Out of 1000 produced designs, 824 were feasible, whereas 176 violated at least one of the constraints [Kanellopoulou et al., 2020]. The optimum design according to pre-defined criteria is marked in the figures with a green circle.

Local optimisation studies

With the best hull form resulting from the global optimisation, the study continued with more focus on the optimisation of the stern region aiming at high propulsive efficiency. While the global optimisation was referring to the calm water resistance, to issues of the easiness of hull construction and the outfitting/maintenance of the main equipment, the local hull form optimisation focused on the propeller tunnel area.

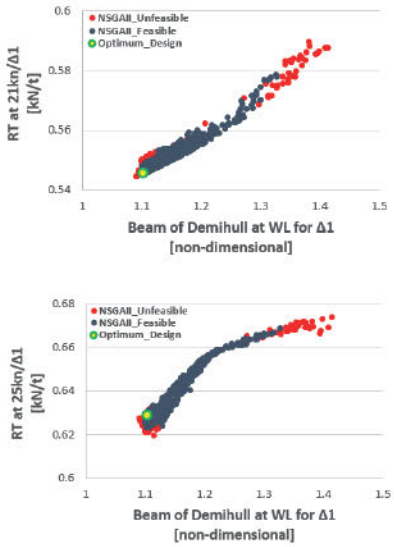

FIGURE 4: CALM WATER RESISTANCE PER TON OF DISPLACEMENT AGAINST NON-DIMENSIONAL BEAM AT WL AT 21KN (ABOVE) AND 25KNOTS (BELOW) FOR DESIGN DISPLACEMENT Δ1

This part of the hull form was mathematically captured by six local form parameters and in addition, five parameters related to the propeller characteristics were introduced, such as propeller diameter, position and shaft inclination. In total nine design constraints were eventually specified, mainly for reasons of seamless fitting of the propeller, its shaft and brackets.

Generated designs were evaluated by use of HSVA's RANS-QCM coupled method [Xing-Kaeding et al., 2017], in which the RANSE code FreSCo+ and the propeller panel code QCM are coupled through the actuator disk method at an iterative basis to evaluate the hydrodynamic performance at self-propulsion condition. In this procedure, the free surface, free sinkage and trim of the catamaran are being considered as well. The numerical mesh applied had around 5.3 Mil cells in total, including a refinement around the free surface region and the propeller/ship transom stern region, as shown in Figure 5.

The identified best design with respect to the required delivered horsepower (DHP) was further fine-tuned to minimise the risk of air suction in the propeller tunnel. For the selection of the best hull form, a range of displacements and speeds were evaluated to assess the performance of the hull variants at various off-design conditions. Figure 6 shows the computed wave field of the best hull form at a design speed of 23knots

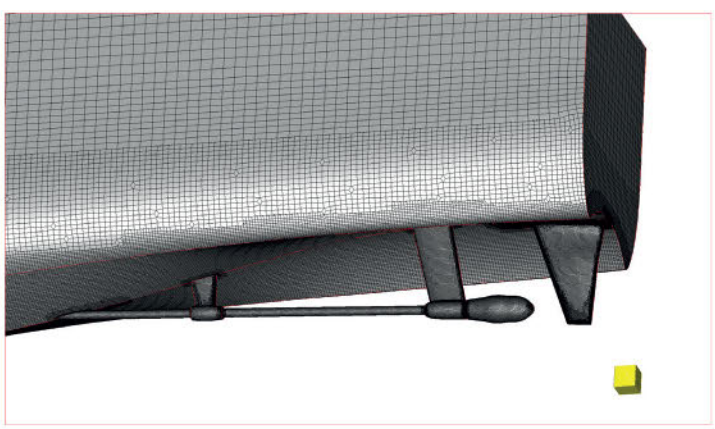

FIGURE 5: NUMERICAL MESH AROUND THE STERN TUNNEL AREA FOR THE LOCAL OPTIMISATION BY FRESCO+ OF THE STAVANGER DEMONSTRATOR (5.7M)

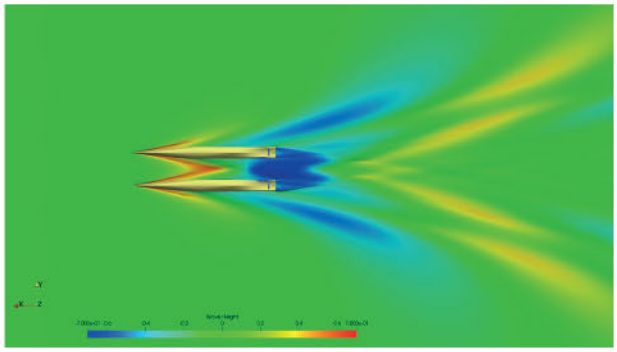

FIGURE 6: FREE SURFACE DEFORMATION AT 23KNOTS

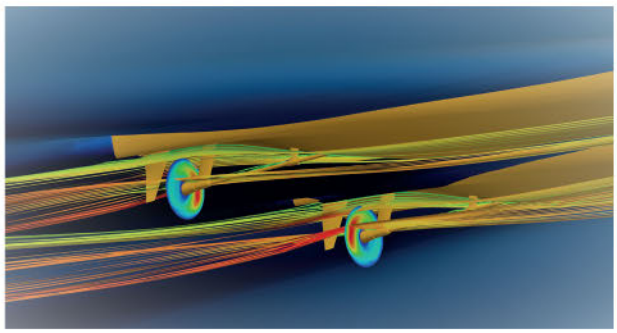

FIGURE 7: STREAMLINES THROUGH PROPELLER DISC AND PROPELLER BODY FORCE DISTRIBUTION AT 23KNOTS

viewed from the bottom. The propeller, simulated as a body force model obtaining the three-dimensional blade forces from the panel code QCM can be observed in Figure 7. More details on the optimisation studies can be found in [Papanikolaou et al., 2020] and [Xing-Kaeding et al., 2021].

Experimental verification and sea trial measurements

Numerical CFD simulations for the optimised hull form of the Stavanger demonstrator were verified by calm water resistance and self-propulsion tests at HSVA's large towing tank, enabling a firm prediction of the speed-power performance of the full-scale ship under trial conditions. The 5.34m catamaran (scale 1:5.6) was fully equipped with propellers, shafts, brackets and rudders, as well as with openings for bow thrusters fitting. An aft view of the fully equipped model is shown in Figure 8.

The conducted systematic resistance and self-propulsion tests for various speeds, displacements and trims confirmed the numerical CFD predictions. It is to be noted that model tests revealed a propulsive efficiency of 78% at a design speed of 23knots and 80% at 27knots, which are outstanding results.

Beside the extensive model testing campaign, the HSVA team also conducted trials in the Stavanger area in August 2022. The speed-trials were performed according to ITTC standards, as also reflected in the ISO standard 15016:2015. Factors, such as current, wind, seaway, displacement, water temperature and salinity as

FIGURE 8: VIEW OF THE TESTED STAVANGER MODEL

well as possible shallow-water effect, were considered for the correction of measured results. A photo of *Medstraum* during sea trials is shown in Figure 1.

An evaluation of corrected sea trial measurements shows that both the model test prediction and the full scale CFD trial prediction have been confirmed by sea trial results, see Figure 9.

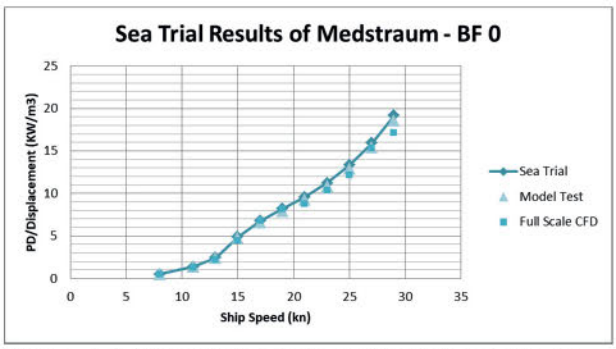

FIGURE 9: SEA TRIAL RESULTS COMPARED WITH THE MODEL TEST AND CFD FULL SCALE PREDICTION

Summary

The hydrodynamic optimisation of a battery-driven ship designed for coastal passenger transport plays a pivotal role in achieving energy efficiency, extended range, enhanced speed, passenger comfort, and a reduced environmental impact. The unique demands of these vessels underscore the crucial importance of hydrodynamic considerations in shaping their overall design and ensuring their successful operation in a sustainable and efficient manner. This optimised hull form with focus on the stern region and a remarkable 78% propulsive efficiency has been reached at the design speed. After successful sea trials that superseded the expectations of designers, builders and operators, achieving a maximum speed of over 27knots, MS *Medstraum* started its operation in the Stavanger, Norway, area in late September 2022.

Acknowledgements

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EVOY'S HEADQUARTERS ARE BASED IN THE CITY OF FLORØ ON NORWAY'S WESTERN MOST POINT. SOURCE: RUNE HELLAND

CAREERS

WHY TODAY'S 'NEW INDUSTRIES' ARE PULLING IN THE CROWDS

When it comes to the question of employment, more and more young marine professionals are re-evaluating their priorities, and many are being drawn in by a sense of 'morals not money'

The UN 2015 Paris Climate Accord (COP21) international treaty on climate change was significant for reaching a binding agreement across participation nations to hold the increase in global average temperature to 'well below' 2°C above pre-industrial levels, with further efforts over the following years to try and limit the increase to 1.5°C above pre-industrial levels.

Since that target was set, the UN's Intergovernmental Panel on Climate Change has indicated that crossing the preferred 1.5°C threshold risks even greater impact.

Annual COP (Conference of the Parties) summit meetings are intended to keep the essential 1.5°C target on track, and to address the many and varied issues and concerns the world's developed and developing nations have in their efforts to achieve this critical global objective.

Unusual weather patterns, such as this year's much publicised forest fires, as witnessed in Greece, were just one of many examples of the effects of global warming that we are witnessing with our own eyes right now.

But leaving the future and well-being of the planet solely in the hands of dark-suited politicians is nowhere near good enough for a rising tide of young (and not so young) members of today's up and coming workforce.

A surprisingly high number of today's new recruits are becoming less motivated by money and material things, and more interested in directing their careers and their thought processes in the direction of fighting for the common good, even bearing in mind the global cost of living crisis.

The draw of electric marine propulsion

In the marine industry, one employer attracting more than its fair share of eco-minded staff is Evoy, the manufacturer of high-output, long-range electric motors for commercial and leisure craft.

Based in Florø on Norway's west coast (and with a second smaller office in Oslo), Evoy is a thriving 'new industry' that started in 2018, with the launch of its first inboard electric motor.

The company now employs over 40 people and successful investment rounds have placed Evoy on firm financial footings, at least if the most recent fund-raising activity is anything to go by, raising €6.4

million capital, collectively, from both existing and new investors, including forward-thinking entrepreneurs and boat builders who can see the future potential in Evoy's already strong foothold in the growing market for electric marine propulsion.

The use of electric propulsion is expected to reach significant proportions by 2030, and ever tightening regulation banning fossil-fuel vessels in eco-sensitive areas is aiding the overall cause.

Having spent the past four years working in the UK for companies including McLaren and Arrival, Italian-born Paolo Perico has recently taken employment with Evoy as the company's new QHSE (Quality Health Safety Environment) engineer.

At 29 years old, Perico has a master's degree in mechanical engineering and his work record to date would probably have allowed him to take his pick of jobs in a number of different industries, but it was the idea of working for a small to medium size company involved in renewables that appealed the most.

"I have always loved the outdoors and grew up in the mountains in Italy and spent most winters skiing with friends and family but, in doing so, I have lived with and seen for myself the impacts of climate change, and in 20 years of skiing the Italian Alps, I can recall only one year of winter when there was considered a lot of snow," he says.

"My parents used to speak about the 'old days' when there was usually too much snow to ski on, but as a teenager you tend not to take notice of this kind of thing, but as an adult you start to realise exactly what is going on."

Perico adds: "In discussions surrounding climate change, there is a lot of talk and publicity given over to activists and campaigning, but not much is discussed about the science and solutions available within the industry. So, given my background in mechanical engineering, I think I can make a real difference and feel I have a larger contribution to the world by working with a company like Evoy.

"A lot of people still don't know the seriousness of what's going on with climate change, and many people don't know how they can make a difference and improve things.

"In my opinion, even a young intern in a large company can still have a voice, so it's important to talk about it, and once a person's feelings get aired it increases awareness and builds the case for change.

"You must give people hope, not bombard them with bad news – it's about not letting people feel completely abandoned."

The question of income

Perico is clearly a man with a deep-rooted concern for the future well-being of the planet, but where does he stand on the question of income, and would a better paid job tempt him away?

"You get to a point where money and benefits won't pay for a dirty conscience, and, as mentioned, I am passionate about the outdoors, skiing and other sports, such that if I retire with a lot of money behind me, yet no snow, what is the point, and what am I going to use my money for if, say, in 40 years, I can't enjoy the world around me?," he says.

Also 29, Thomas Mordt Kolstad is Evoy's sales manager based at the company's Oslo office, who studied naval architecture in his formative years, working for companies such as Rolls Royce Marine and Kongsberg Maritime, supplying designs and equipment to bigger vessels in the offshore and merchant sector.

But it was Kolstad's love of sailing and the sea that put him where he is now.

He says: "I grew up sailing and spending time at or close to the sea, and this was my motivation to pursue an education and career in naval architecture.

"After spending several years working for larger companies, I wanted to be part of the change and work for a company that could make a real and measurable impact to decarbonising the marine industry, and by joining Evoy I get to combine my passion for boating and contribute to a world less reliant on fossil fuels."

Leading the transition

Dino Omerovic, sales development representative at Evoy, is originally from Bosnia, but moved to Norway at a very young age. He says: "We are trying to electrify the marine segment which is starting to realise that this is the future, and even though there is still a lot of room for improvement, we are slowly getting there.

"I think this kind of business attracts young people because this is something new and the newest generation wants to lead this transition into becoming the next big thing.

"For me, Evoy is a special place to work right now and Florø is attracting a lot of educated people from around the world, and a large part of this attraction is because of Evoy."

Omerovic concludes: "I am a local boy who grew up here, but I know how hard it can be to get people to move their life to a new city such as Florø, with such a strong connection to the sea, and where everything is so small and different to where they came from. But the fact they do move here means they must believe this is the next big thing, and that's also something that unites us as staff, and makes us feel we are all moving in the same direction.

"At Evoy I think I have the best possible work colleagues, and sometimes you would rather choose to have a smile on your face when you come to work than having some extra money in your pocket, even though money is of course a big factor nowadays." ■

SALVAGE SECTOR PROVIDES UNIQUE OPPORTUNITIES FOR PROJECT INNOVATION, VARIETY AND COLLABORATION

By **Jouke Maijer**, project engineer, Marine Masters

JOUKE MAIJER

When I joined salvage experts Marine Masters two years ago, I found myself introduced to a fascinating sector that is vastly different from the installation and decommissioning projects of the offshore oil and gas industry where I began my career. Public perception of salvage often focuses on its role in incident response and management, but that limits the vast scope of what the sector actually entails – rapid response, innovative and practical problem-solving, affordability, sustainability, and a chance to engage with almost every sector across maritime.

It's something that everyone working in salvage knows, but which applies equally to career progression: when the obvious way doesn't work, you need to take a different approach to reach your goals – and what I was seeking was a series of exciting career challenges.

Responsive and agile approaches

In many respects, salvage and offshore couldn't be more different.

The offshore sector has to comply with a variety of regulations and safety mechanisms when planning any project, and these have to go through several stages of vetting before approvals are provided. Every move is planned at least a year in advance to account for the considerable red tape involved. This series of multi-stage planning and approval is vital as it ensures safety and environmental consciousness, both for the people working onboard these installations, as well as the marine environment it exists and operates within.

In contrast, the salvage sector has significantly accelerated timelines as the majority of projects are emergency situations where time is of the essence. Our aims have to shift as a result – the goal is still to ensure the safety of everyone involved and do our best to minimise the impact on the environment, but the process of planning and vetting project operations is expedited to account for a quicker response.

This means that salvage project engineering rarely has all the information needed to map the space and account for most potential circumstances. Instead, it requires working with a rough estimate of the circumstances at hand and adapting planning and operations on the go. This flexible response allows us to maintain safety throughout the project – potentially by reducing dive times where possible, or seeking new solutions when a planned action seems less viable once on location. Creative solutions and collaborative problem-solving are routine.

And, as part of a small team working quickly, teamwork and pitching-in is essential.

Adapting for greater collaboration

One of the most important skills in salvage is good communication, which is utilised across lots of stakeholders, from clients to subcontractors, to extract the information you need quickly and to mobilise teams effectively. It also plays a key role in establishing transparency when conducting operations, making it simpler for the company to co-ordinate with insurers, governments, port authorities, local contractors and more.

Given the sheer variety of salvage work across maritime and energy sectors, planning and executing a project can vary widely from one project to the next. Designing plans benefits from a wider approach and allows me to bring to the table a personal background in draughting, structural, geotechnical and heavy-lift engineering. Within Marine Masters I have the unique opportunity to personally witness the impact of my plans in action, and assess and modify them for the future. This advances my capabilities and foregrounds practical, immediate feedback as part of each project.

This is where I think there's useful advice to be had for young engineers starting in salvage – to always keep an eye on the project's end goal.

While many of us may enjoy designing something beautiful and complicated it is vital that the operational and commercial sides remain the focus right from the outset to ensure affordable and sustainable operations.

It is therefore also important to bring in support from all the other disciplines involved to create a collaborative and easy to implement solution.

Remember that there is no real benefit to initiating a plan only to find out a few days later that it is doomed to failure. A lot of junior engineers can easily miss how important that early co-ordination is, and, in an industry where time is of the essence, having the right people at the table to problem-solve is key.

Exploring creative solutions

In my role as a project engineer, I work closely with a project manager and a salvage master who oversee operations. My work begins in the tender phase as we bid for a salvage or recovery project. This requires that I prepare and report a conceptual working method for planned salvage operations including drawings and calculations. I also support the commercial side, which includes budgeting, planning and choosing subcontractors where the project allows.

A rewarding part of the job is the ability to be hands on and be responsible for a broad remit – there's no working in silos or feeling like you are a small cog in a machine. Once we are awarded the tender, I am in charge of co-ordinating, supervising, and potentially modifying planned operations that fall under the scope of engineering. Working as part of a small team, everyone assists each other with tasks that require an extra set of hands – including me. This often requires creative solutions, often developed on the fly, and the ability to agilely switch from one challenge to the next and across different stages of the salvage job. This can mean the mobilisation and sometimes fabrication of equipment, negotiating with and briefing subcontractors, as well as being part of the team eventually executing the project.

For example, a recent project in Israel involving a collapsed crane and jetty required that we adapt our existing strategy to be more flexible and carry out certain aspects of our project engineering while on location. This allowed us to ensure safety by overseeing structural strength checks, weight calculations and details of where to cut the crane once further insight and information was made available by divers on location.

Given that this is an unusual project, the divers were provided with careful instructions and any information they found fed directly back into updated project planning. Once the salvaged crane was lifted, we co-ordinated closely to cut it into segments and load it onto the disposal barge. And, as all of this is taking place, we also fed information back to the client so they had an up-to-date estimation of our progress and eventual success.

This role allows you to flex and grow your problem-solving skills, creativity, communications and can take you out of the traditional office setting – no one project can be alike. Adapting tried and tested salvage techniques and developing, testing and implementing new ones is key to the future of the salvage industry. For anyone looking to apply their engineering skills in a new and exciting way, salvage is for you. ■

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ClassNK is a major supporter of the Digital Era

While the maritime industry is reshaping its structure due to digitalization, ClassNK's role of ensuring the safety of ships and environmental protection as a third party organization remains the same. ClassNK is proactively applying digital technology to strengthen its services based on outcomes from a variety of research in areas including robots and analytic technology.

In light of the growing possibility of Maritime Autonomous Surface Ships (MASS) becoming a reality, ClassNK has published the white paper "Towards MASS social implementation", focusing on ensuring the safety of MASS by leveraging its expertise gained through participation in demonstration projects, standard-setting, related certification, and research on trends within and beyond the maritime industry.

The white paper is available to download
via "Technical Publications" of My Page on ClassNK's website after registration.

ClassNK CHARTING THE FUTURE

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