THE NAVAL ARCHITECT

JUNE 2025

Competitive Spirit

Team Black Pearl scoops this year's Worldwide Ferry Safety Association student design contest

REVISE THE SIZE:

Chartwell Marine's daughter craft add new dimensions to offshore crew transfers

SAFE AS CRUISES:

Zelim's ZOE keeps an eye on cruise line man overboard casualties

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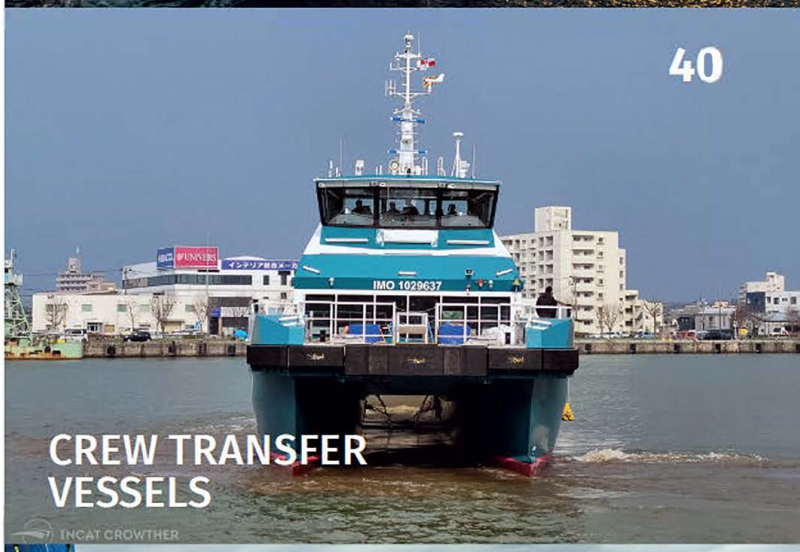

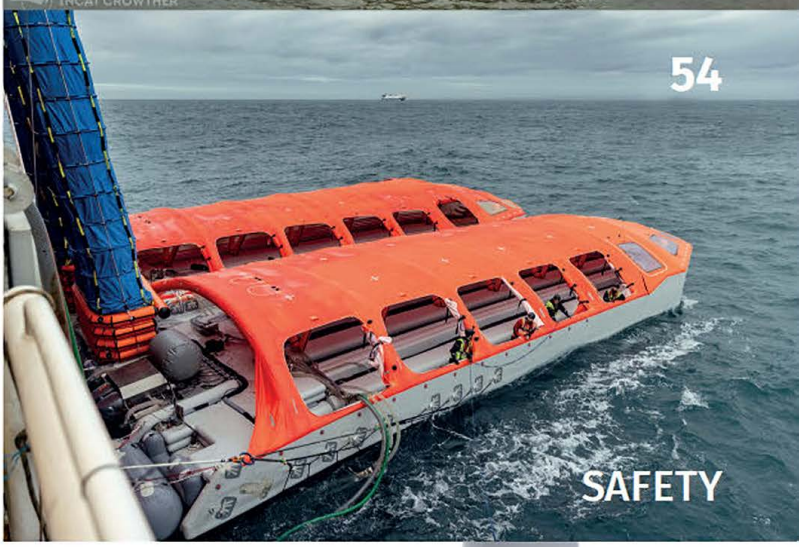

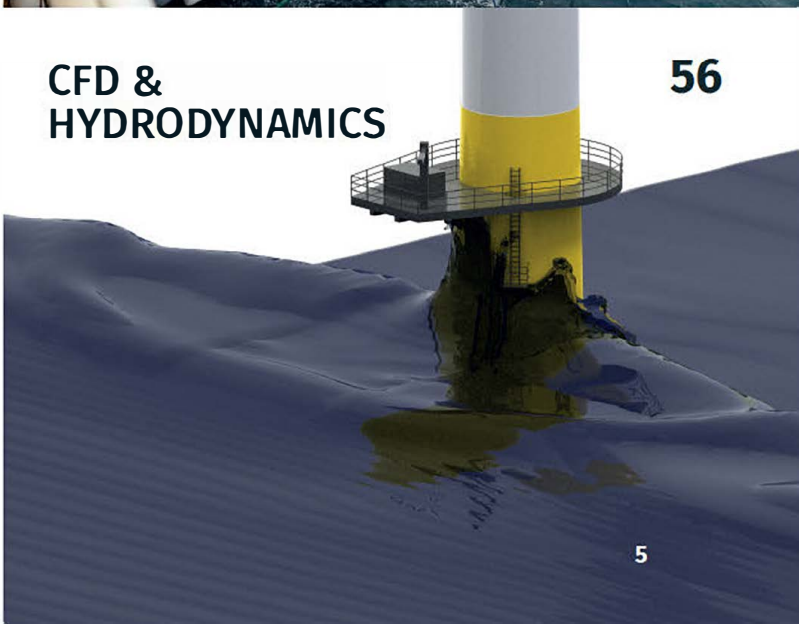

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STUDENT INNOVATION: STILL GOING STRONG

I can't remember the first time I covered the Worldwide Ferry Safety Association's (WFSA's) international student design contest for a safe, affordable domestic ferry, but our report on the 12th instalment of the competition (see pages 30-36) reminds me of the many winners that *Ship & Boat International* profiled over the past seven to eight years – to the point that the contest became an annual fixture of our Ferries reports.

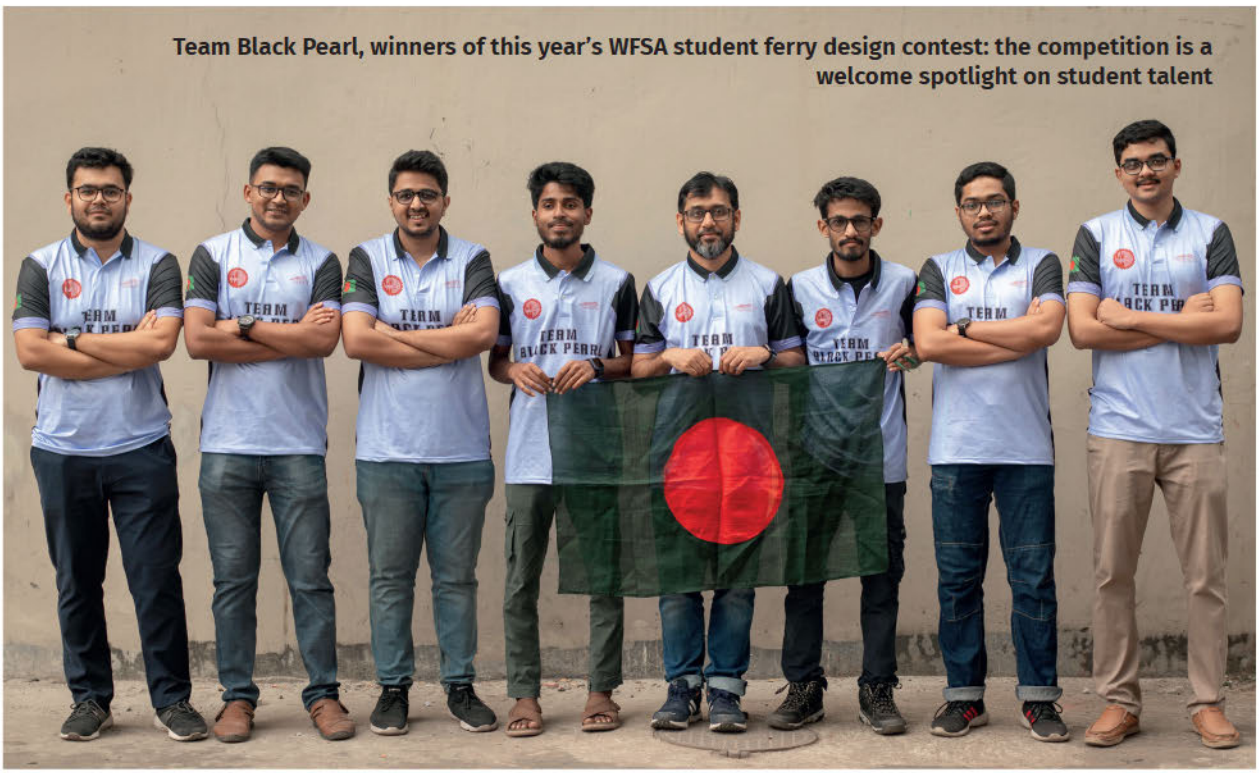
The teams' meticulous attention to detail in their designs is consistently impressive. The briefs present precise challenges: ensuring safe operations, even when experiencing collisions or rough weather; providing stability despite risks like passenger overcrowding, particularly in regions with lax safety oversight; and enabling cost-effective production by local boatbuilders.

This year's winning team, Team Black Pearl of Bangladesh University of Engineering and Technology, wowed the WFSA judges with its design for the 200-pax aluminium catamaran *Naija Spirit*, which underwent extensive weight and stability analyses, including CFD calculations, to finalise the concept. It's all the more impressive given the team's physical distance from the waterways of Lagos – which, as you'll read, necessitated some serious online research. As a sidenote, WFSA contest-related interviews consistently highlight the teams' openness in discussing their design processes in detail, including candid insights into the challenges they faced and the solutions they implemented to address them.

It's a shame we don't have the space to feature the runner-up teams too; one could dedicate the best part of an issue to profiling most of the contest entrants' designs. What's for sure: the WFSA's annual contests clearly demonstrate that skilled naval architecture is far from at risk of extinction. Anyone concerned about its future should follow these events closely: I personally see a wealth of talent ready to lead in the years ahead.

The only drawback is that, to date, few of the winning designs over the past 12 years have been realised. In many cases, the problem is a lack of investment by local governments and maritime authorities, especially those in the highest-risk accident hotspots in developing countries. Perhaps established naval architects and boatbuilders could assist these talented young designers? Investing in their designs (or helping them to fine-tune these concepts) could not only provide a fresh shot in the arm for naval architecture, but would go a considerable way toward boosting domestic ferry safety globally – making a real difference to thousands of lives, while creating myriad new career opportunities. The WFSA contest demonstrates thriving technical expertise; now, capital and commitment are needed to put this talent to work. ■

Martin Conway,
Managing Editor



Team Black Pearl, winners of this year's WFSA student ferry design contest: the competition is a welcome spotlight on student talent

SUPERYACHTS AND MEGAYACHTS

HEESEN DELIVERS SUPERYACHT *SOLEMATES*

Heesen Yachts has delivered the superyacht *Solemates* to her anonymous owner, described as a repeat client. The 760gt, three-deck, steel-built vessel measures 55m x 9.6m and has a draught of 2.85m at half-load.

Solemates was built on Heesen's 55m Steel arrangement, featuring the Fast Displacement Hull Form (FDHF) developed by Van Oossanen Naval Architects – a hull design with the claimed ability to cut fuel consumption by 10-20%, while increasing onboard comfort. The yacht has been laid out for a crew of 13 and 12 guests, with amenities including a full-beam owner's suite, a VIP suite, two double guest suites and two twin guest suites.

The three-deck *Solemates* has a range of 4,500nm at 13knots

The yacht's exterior styling was handled by Omega Architects, while Luca Dini Design and Architecture was entrusted with the interiors. Features include a sundeck jacuzzi area and "continuous sheets of tinted glass on the main and upper deck", Heesen says.

Power is provided by two MTU 8V 4000 M63 engines, each delivering 1,000kW max, and the boat has also been fitted with a 125kW electrically driven bow thruster, supplied by ZF Marine, and two stabiliser fins, manufactured by Naiad Dynamics. The vessel can achieve a top speed of 15.5knots at half-load and a range of 4,500nm at 13knots.

Having concluded trials in the North Sea, *Solemates* is set to make her official public debut at the Monaco Yacht Show in September and will then be made available to charter to select clients through Luxury Yacht Group. ■

LIQUEFIED GAS CARRIERS

ETHANE CARRIER SCOOPS BV APPROVAL

Bureau Veritas Marine & Offshore (BV) has awarded approval in principle to the Marine Design and Research Institute of China (MARIC) for its new 155,000m³ ultra large ethane carrier (ULEC) concept. The vessel, set to measure approximately 274m x 42m, has been designed as a single-screw liquefied ethane carrier, powered by a MAN ME-GIE ethane dual-fuel main engine.

The ULEC would be tasked with transporting ethane globally, but will also be able to carry ethylene, propylene and liquefied petroleum gas (LPG). According to BV: "The design is compatible with both Type B cargo tanks and GTT Mark III membrane tanks, offering a lower boil-off rate [BOR], reduced unloading residue and higher cargo capacity utilisation." A lower BOR in ethane carrier tanks would mean more ethane liquid is retained, reducing the need for reliquefaction or venting, which is expected to save both energy and opex.

BV has granted approval in principle to MARIC's 155,000m³ ULEC design

The vessel will also feature propeller cap fins, a pre-swirl duct and a shaft generator. MARIC says it will integrate its Smart Navigation Software, Energy Efficiency Management System and Machinery Health Management System packages into the build, for enhanced safety and efficiency. ■

BOATYARD BUSINESS

DAMEN INKS THIRD INDIAN YARD DEAL

India's Square Port Shipyard will build Damen-designed vessels for the South Asian market

Damen has signed a memorandum of understanding (MoU) with India's Square Port Shipyard, the intention of which is to use Square Port Shipyard's shipbuilding and repair facility, located some 250km south of Mumbai, to build Damen-designed vessels for the South Asian market.

This agreement represents Damen's third partnership in the Indian subcontinent, following MoUs signed with Yeoman Marine's Ratnagri Shipyard, in April this year, and with Goa Shipyard Ltd, in April 2024.

The deals have been signed as part of the Damen Technical Cooperation, which aims to utilise global yards to build vessels closer to regional clients, while also assisting said yards to modernise their facilities. Fattesingh Patil, director of Square Port Shipyard, comments: "This agreement is a significant step in our vision to transform India's maritime landscape through innovative technologies and sustainable methodologies. Access to the latest shipbuilding technology and processes will give us a competitive advantage and address the issue of capacity constraints plaguing the Indian shipbuilding and repair industry."

Square Port Shipyard was formerly known as Bharati Defence and Infrastructure, which went into insolvency in 2018. The yard's current 164m south jetty and 56m east jetty could be expanded to 231m and 266m respectively, the builder says. ■

CRUISE SHIPS

LION CITY BECKONS FOR *DISNEY ADVENTURE*

Disney Adventure, the eighth vessel in the Disney Cruise Line fleet, has been floated out prior to its scheduled entry into service in December. The vessel was acquired by Disney for €40 million in November 2022, in the form of a partially completed build, *Global Dream*, after the bankruptcy of its original owner, Genting Hong Kong, and of its shipyard, MV Werften.

The 208,000gt ship is now being completed at the MV Werften shipyard in Wismar, Germany, under the management of Meyer Werft, which previously built Disney's *Dream*, *Fantasy*, *Wish* and *Treasure* cruise vessels. Disney is collaborating with Meyer Werft and Walt Disney Imagineers to finalise the ship's design and features.

The 6,000-pax *Disney Adventure* is scheduled to enter service in December

Disney Adventure will be home-ported in Singapore, making it Disney Cruise Line's first vessel based outside the US. Particulars include a length of 342m, a breadth of approximately 47m and a draught of approximately 9.5m. As *Global Dream*, the vessel was intended to accommodate 9,000 passengers, though this has now been downsized to 6,000 passengers in 2,111 cabins, for more onboard space. The vessel will also have 2,300 crew members, a slight increase on the originally planned 2,200.

It is expected that the ship will be powered by green methanol-burning engines, and that it will utilise three podded propulsion units for enhanced manoeuvrability. At the time of writing, though, manufacturer and model info remained under wraps. ■

UNCREWED VESSELS

FIRST CREW-FREE SUB FOR UK ROYAL NAVY

Mid-May saw the UK Royal Navy (RN) formally unveil what it described as its first "uncrewed submarine", named *Excalibur*. The 12m x 2m sub, which displaces 19tonnes and is classed as an 'extra-large uncrewed underwater vessel' (XLUUV), is the culmination of the three-year long Project Cetus, and the largest UUV trialled by the RN to date.

The UUV was built by Plymouth-based MSubs, which specialises in automated submersibles. Since its delivery to the RN earlier this year, the UUV has undergone harbour and sea acceptance trials at Devonport Naval Base.

As a demonstrator, the vessel will not perform operational duties but will shape future concepts and help to accelerate the RN's use of uncrewed technology. Commodore Marcus Rose, deputy director for underwater battlespace capability at the RN, says: "Upcoming sea trials will allow us to rapidly develop our understanding of operating uncrewed vessels of this size underwater. The lessons learnt from this exciting programme will build on our experience from existing programmes, such as the Mine Hunting Capability programme, to inform more extensive use of these technologies in a mixed force of crewed and uncrewed systems."

Excalibur will join the 42m surface ship *Patrick Blackett* within the RN's recently created Fleet Experimentation Squadron. ■

The 12m *Excalibur* will serve as an uncrewed technology demonstrator

OFFSHORE RIGS

RIG UTILISATION LOWEST SINCE 2021

The offshore rig sector's market recovery has stalled, according to a recent report by analyst Westwood RigLogix, which claims that lack of demand has led to the lowest utilisation rate recorded since recovery began in 2021.

The report, authored by RigLogix director Teresa Wilkie, blames this dip on factors including: a series of newbuild rigs entering the market without existing contracts or work to go to; the deferment of several deepwater drilling and plug and abandonment projects; and oil major Saudi Aramco's decision to suspend more than 30 jack-up contracts by up to a year.

Overall, firm demand was recorded as being 18% lower in March 2025 than it was in March 2024, Wilkie writes, and Westwood predicts that the current utilisation rate of 88% will fall further this year, possibly to 85%. As a result, "it seems likely that more rigs could permanently be removed from the active drilling fleet as the year progresses", Wilkie notes.

The report also indicates that the average age of many retired floating rigs has dropped significantly over the past five years: drillships by eight years, and semisubmersibles by three years, for example. At present, though, jack-up rigs are tending to be slightly older when retired, with their average age increasing by one year in the same period. RigLogix says that 87 rigs over 40 years of age are currently active.

Drivers influencing the scrapping of rigs this year include: limited future work prospects; long periods of inactivity (aka 'cold stacking') and the high costs associated with reactivating these units; and the "very expensive" cost of undertaking mandatory five-year special periodic surveys (SPS). "Other factors can be one-off designs in a contractor's fleet, where they may not be able to spread spare parts costs; out-of-favour designs; and...mergers between owners, which often enable easier culling decisions as owners look to streamline fleets," the report hints. ■

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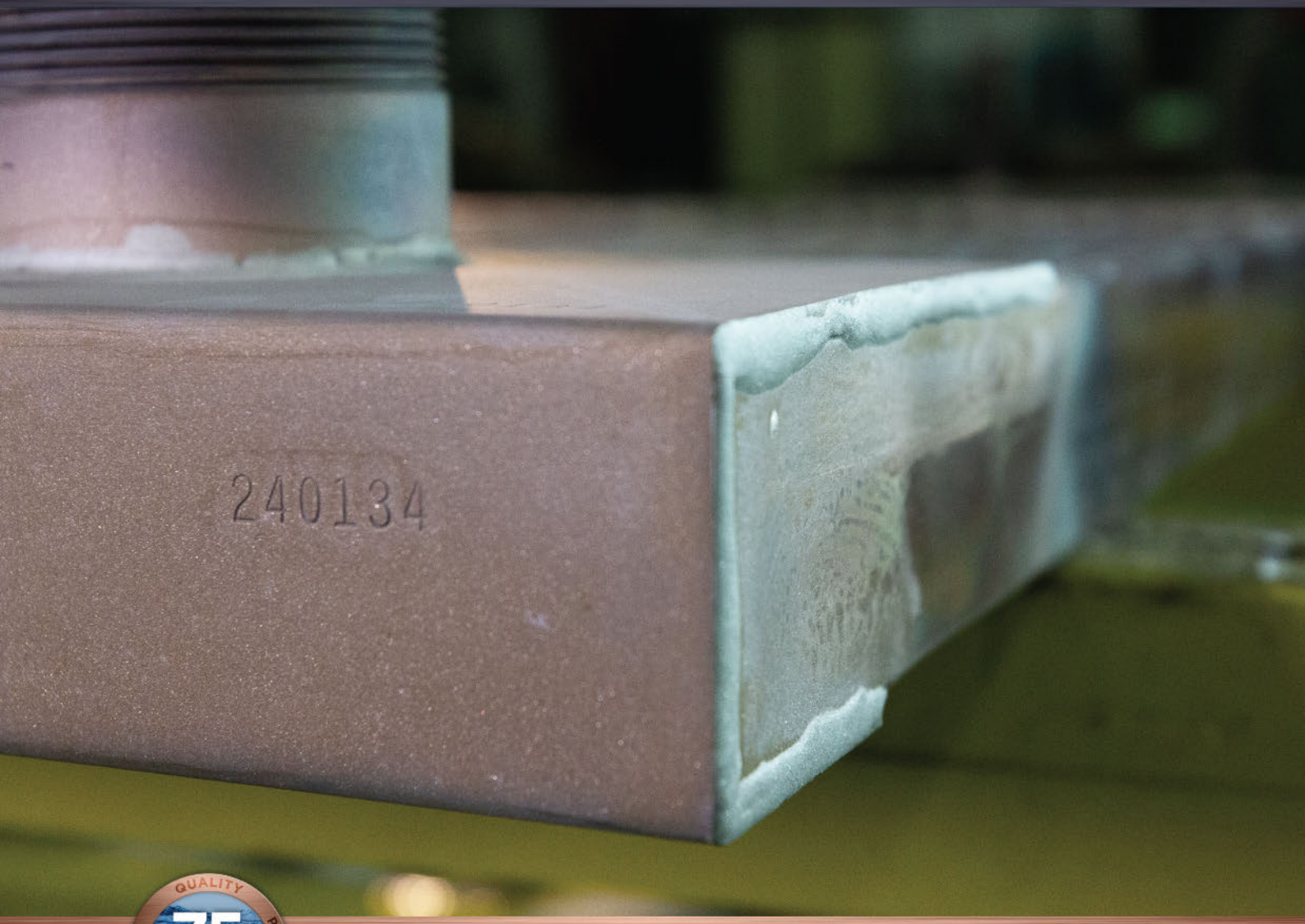

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ELECTRIC PROPULSION

PLYMOUTH HOSTS E-RIB 'CHARGE BACK' DEMO

Marine charging tech specialist Aqua superPower reports that it has trialled its bidirectional charging solution in a demo hosted at the University of Plymouth, UK, as part of the UK government-funded 'Virtual Bunkering for Electric Vessels' (VBEV) project.

Aqua superPower is leading the VBEV project with the support of the University of Plymouth and City College Plymouth, energy company EDF, software developer Fuuse and low-emission vehicle consultancy Cenex. Another key collaborator has been boat manufacturer RS Electric Boats, which supplied an RS Pulse 63 model – a 6.3m x 2.3m, all-electric RIB – for the demo.

VBEV project participants trialled bidirectional charging using an RS Pulse 63 electric RIB

According to Aqua superPower: "Bidirectional charging is a game-changer for the maritime industry. It not only enables electric boats to charge efficiently but also allows boat owners to discharge their batteries and return surplus energy to the grid when the boats are not in use. This capability could help reduce energy costs, optimise battery health and generate income for boat owners by selling energy back to the grid."

The company adds: "The University of Plymouth's research into battery degradation reveals early findings suggesting that vessel-to-grid [V2G] technology, when properly configured, could enhance battery health." For example, some studies indicate that bidirectional charging can improve battery health by enabling shallow discharge cycles, reducing time at full charge and minimising stress on battery cells, all of which could preserve battery longevity. In turn, City College Plymouth hopes to create "educational resources for students and apprentices to gain expertise in installing marine charging infrastructure" through its participation in VBEV, Aqua superPower notes. ■

PERSONAL PROTECTIVE EQUIPMENT

CYCLONE IN A WOMAN'S CUT

Viking Life-Saving Equipment has launched an immersion suit specifically tailored to women working in the offshore wind sector, redesigned to accommodate "shorter torsos, and different hip and chest proportions", to prevent the risk of snagging.

The female-fit version of the Viking YouSafe Cyclone suit was developed in collaboration with sustainable energy majors Ørsted, Siemens and Vestas, and following feedback from women working in offshore wind and aboard crew transfer vessels (CTVs). It is made from high-vis GORE-TEX NARVIK and approved to the same SOLAS/Marine Equipment Directive (MED) and CE/ISO standards as the male version.

Features include compatibility with all standard offshore harnesses, as well as: Neoprene cuffs and neck seal; retro-reflective piping, for enhanced visibility in darkness and low-vis conditions; and a maintenance-free zipper. The suit also includes integral braces, "which hold suit pants for free leg movement when climbing and allow the wearer to doff its top part to move around freely," Viking Life-Saving Equipment explains.

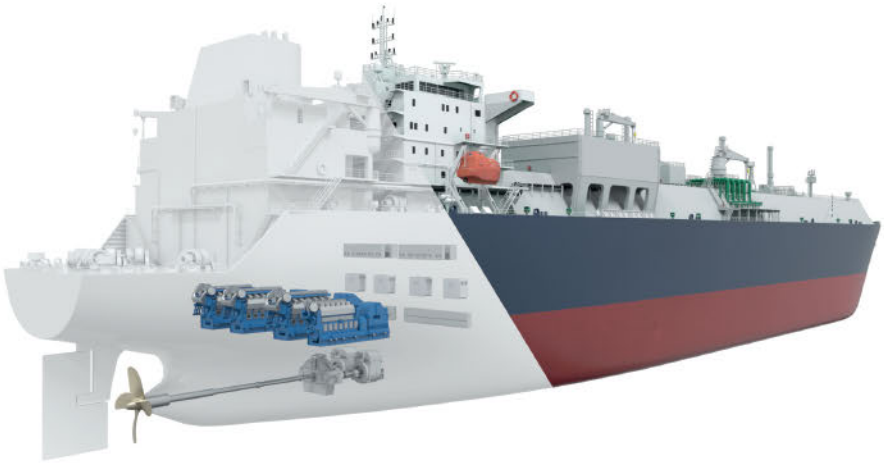
The company cites the UK's Offshore Wind Sector Deal study, which aims to increase the representation of women in the offshore wind workforce to at least one-third by 2030, as a motivator for the new suit design. ■

Viking Life-Saving Equipment has launched the first women's version of its YouSafe Cyclone immersion suit

ENGINES

WÄRTSILÄ WAGES WAR ON METHANE SLIP

Tech giant Wärtsilä has launched an upgrade to its dual-fuel Wärtsilä 50DF engine, which runs on diesel and LNG. The upgrade, described as 'Spark Gas Conversion for Wärtsilä 50DF', changes the engine to work better with LNG, making it burn fuel more efficiently and cutting methane emissions by up to 75% more than the standard Wärtsilä 50DF.



The 'Spark Gas Conversion for Wärtsilä 50DF' can reduce methane emissions by up to 75% more than the standard engine (image: Wärtsilä Corporation)

The upgrade involves adding a special valve to improve how the engine burns LNG, reducing methane waste to about 1.1% of the fuel used. Wärtsilä says: "The new solution is optimised for LNG as fuel, therefore producing a better energy output per unit of fuel. This means fuel gas savings of up to 4.6%, as well as lower methane emissions."

This solution was developed with Chevron Shipping Company, and the upgrade is available for any ship with a Wärtsilä 50DF engine. Roger Holm, president of Wärtsilä Marine and executive VP at Wärtsilä Corporation, says: "The use of LNG and cutting methane emissions is one of the most effective ways to decrease overall greenhouse gas [GHG] emissions from marine engines over the next decade, complementing other efforts to reduce CO_2 emissions." ■

WIND-ASSISTED PROPULSION

FINE-TUNING WAPS FOR NEXT-GEN TANKERS

Anemoi Marine Technologies has signed a joint development project with tanker company Hafnia Limited, shipbuilder Guangzhou Shipyard International (GSI) and class society DNV to develop a new generation of Rotor Sails suitable for installation aboard 50,000dwt medium-range (MR) tankers, as interest in wind-assisted propulsion systems (WAPS) continues to gain traction.

As part of the project, Anemoi and Hafnia will also conduct engineering studies to determine how to safely install Rotor Sails upon these vessels' decks, and how to determine and develop the layouts for the sails' associated electrical systems and control mechanisms.

Anemoi says: "The studies will include calculations to examine how Rotor Sails can improve the Energy Efficiency Design Index [EEDI] and Energy Efficiency Existing Ship Index [EEXI] values of existing and future MR tankers." GSI will develop technical documentation for integration of the new Rotor Sail design, to be reviewed and approved by DNV.

Nick Contopoulos, chief production and partnerships officer at Anemoi, adds: "There is growing interest within the tanker sector for novel technology that can help reduce the carbon footprint of their vessels and increase their value, particularly as the MR tanker fleet is expected to grow in the coming years. Our partnership with Hafnia, alongside GSI and DNV, will ensure a new generation of MR tankers that utilises Rotor Sails to improve [its] efficiency and sustainability credentials hits the water in the not-too-distant future." ■

Nick Contopoulos, Anemoi: collaboration with Hafnia, GSI and DNV will ensure "a new generation of MR tankers that utilises Rotor Sails"

NAVAL AND DEFENCE

SINGAPORE SELECTS CREW-FREE MINESWEEPERS

ST Engineering has been contracted by Singapore's Ministry of Defence (MINDEF) to deliver a series of uncrewed mine countermeasures (MCM) systems to the Republic of Singapore Navy (RSN). The package will include a mixed fleet of sensor-equipped AUVs and USVs, plus a command and control (C2) centre, enabling users to coordinate the drones to work in tandem to detect and eliminate underwater mines.

The AUVs and USVs will send real-time data to the C2 centre via a secure communications network, also to be developed by ST Engineering as part of the contract. End users can run the C2 centre either from shore or from aboard a mothership, enabling personnel to maintain a safe distance from MCM operations.

Singapore's Bedok-class vessels (RSS *Katong* and RSS *Bedok* pictured) will be replaced by the new AUVs and USVs

ST Engineering will also deliver a high-fidelity simulation system to the RSN, enabling its operatives to "practise decision making, refine operational techniques and execute dynamic MCM scenarios safely", the company says. Low Jin Phang, group president for digital systems, adds: "We aim to push the boundaries of USVs and AUVs for MCM operations with AI, enabling real-time data analysis for faster, more informed decisions."

Phased rollout of the drones to the RSN will commence in 2027. According to a MINDEF statement issued in May: "These capabilities will progressively replace the Bedok-class MCM vessels, which continue to remain operational." ■

NEW DRONES

ENDURANCE BOOST FOR NEW OCEANUS12

Zero USV has launched the extra-long-range (XLR) version of its Oceanus12 USV, which is intended to ramp up the 20 days/2,500nm endurance of the original Oceanus12 to 60+ days/7,500nm+. Zero USV says: "[The XLR Oceanus12] is built for missions in remote areas or regions where access to traditional fuelling points is limited, ensuring that operations can continue uninterrupted."

The XLR Oceanus12 boasts an endurance of 60+ days and a range of 7,500nm+

Other modifications include a lengthening of the USV, from 11.55m to 13m. The drone's fuel capacity has also been increased, from 1,200litres to 4,000litres.

Matthew Ratsey, Zero USV founder and MD, comments: "Uncrewed vessels are a force multiplier. The ability to conduct sustained operations at sea without the need for regular refuelling or crew-related logistics is becoming increasingly crucial as operational pressure on resources and time becomes more demanding."

The XLR Oceanus12 features an aluminium hull with a 2.33m beam, draws 1.76m, displaces 8tonnes and can accommodate a payload of up to 1tonne – enabling it to carry kit such as Marine AI's GuardianAI suite and an autonomous sensor suite featuring an HD radar from Navtech. Powered by a hybrid diesel-electric powertrain, the USV has a cruising speed of 6knots and a sprint speed of 10knots, depending on payload. ■

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MATERIAL RISKS?

Could the Royal Navy be missing out on the benefits of innovative alloys and welding processes due to a risk-averse over-reliance on 'traditional' shipbuilding materials and methodologies? **Stevie Knight** reports

These days of political unrest mean directly facing another set of challenges: how innovation meets the new realities (not to mention the liabilities) of warfare. This isn't just a matter for the UK's military, but its industry and academic partners too.

In fact, the recurring theme of the latest United Kingdom Naval Engineering Science & Technology (UKNEST) event made clear that difficult but necessary conversations are on the cards.

So, what is the issue? "Rightly or wrongly, current procurement processes are risk-averse," says UKNEST's Science & Technology Working Group co-chair, Jake Rigby. He outlines how the speakers at the organisation's Advanced Materials conference shared a clear message: this approach to risk can slow, or even completely derail, the acceptance and integration of new technologies and materials at a moment when we may not be able to afford that luxury.

For example, Robin Oakley, principal materials and corrosion engineer for QinetiQ, asks of the many potential developments he's seen over three decades: why is it that so many haven't made good on their promise? You can have "brilliant new materials, lots of amazing benefits", he says. But the inevitable question that follows is: "Are you sure you're not bringing any new risks to our established design space?"

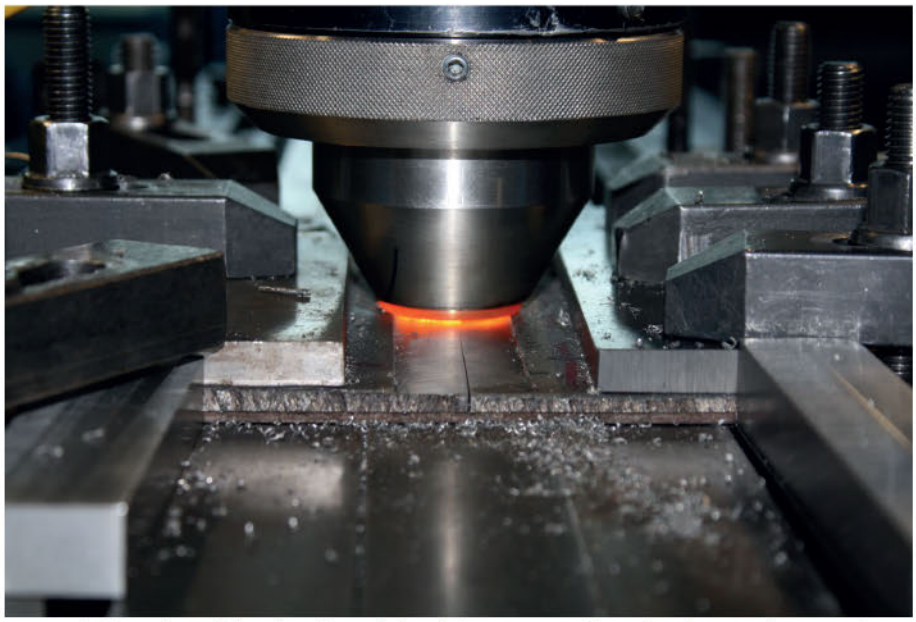
Oakley points out that a lot of current material choices were made in the late 1950s to early 1960s. "They're low risk, you know where you are," he says, "[but] do you try something different? And, if you do, how do you then de-risk and validate it?"

Use of alloys

Submarine developments highlight all these risk concerns and add another dimension.

"As we push the boundaries in terms of engineering scope and what's expected from the actual ship or the boat, material, physical and mechanical properties are being pushed as well," says Ben Turner, Copper Alloys MD. He quotes from a Rolls-Royce senior submarine design engineer:

Innovative alloys could extend lifespan and reduce Royal Navy costs (image: Copper Alloys)



Friction stir welding (FSW) can join tricky or unusual steels – but can it cross the culture barrier? (image: The Welding Institute)

"With shock loads increasing with each class, we are finding traditional materials are simply not strong enough."

Therefore, Copper Alloys' part in a case study on doubling the life of the Royal Navy's Dreadnought-class submarine has focused on an alternative metal. That might not seem profound, but Turner explains: "Just to give you an idea, on one of those boats there might be millions of components." Problematically, the current offerings don't necessarily last particularly long *in situ*. Turner adds: "You'd be surprised how much has to be replaced just to give [the submarine] an extra 10 or 15 years in the sea."

Look closer, and the number of metals found in these parts is surprisingly low. That's not because better alternatives can't be found; it's because the lists of 'acceptable' materials can be years or even decades out of date, claims Turner, adding: "Really, there are just five to 10 metals underpinning all of that complexity. If you could improve on just one of these [affordable, primarily copper-based alloys], you could indirectly improve the lifespan of tens of thousands of components."

This is where a tougher material that can be manufactured at a reasonable cost, and to timeframes and at scale, comes in. CNC-1 (CuNi30Cr2) is a copper-nickel-chromium alloy in a wrought form, which quadruples the strength of the cast material. Combined with advances in machining capability, it has enabled the production of parts for an equivalent or lower cost than casting structures.

So, while CNC-1 can't compete with the strength of nickel-based super alloys or super duplex stainless steel, it's still the toughest of all the copper alloys, retaining electrochemical compatibility with onboard systems and resistance to biofouling.

Plus, the expected lifespan of wetted parts is over 50 years. In short, "it hits all the bases" for a practical, cost-effective alternative, says Turner.

Despite these benefits, there is no guarantee that CNC-1 will be adopted and used. "Design engineers have to work from a range of alloys that the organisation says is acceptable," says Turner. "It's like a straitjacket...this becomes the limiting factor." Turner adds that it might be high time the sector begins "designing alloys around the engineering requirements instead of engineering requirements around the alloys".

Friction stir welding

Even something as fundamental as joining materials can be tangled in the web of risk-averse processes. "A lot of fabrication is actually done using arc welding because it's tried and tested," comments Robert Scudamore, former associate director of The Welding Institute.

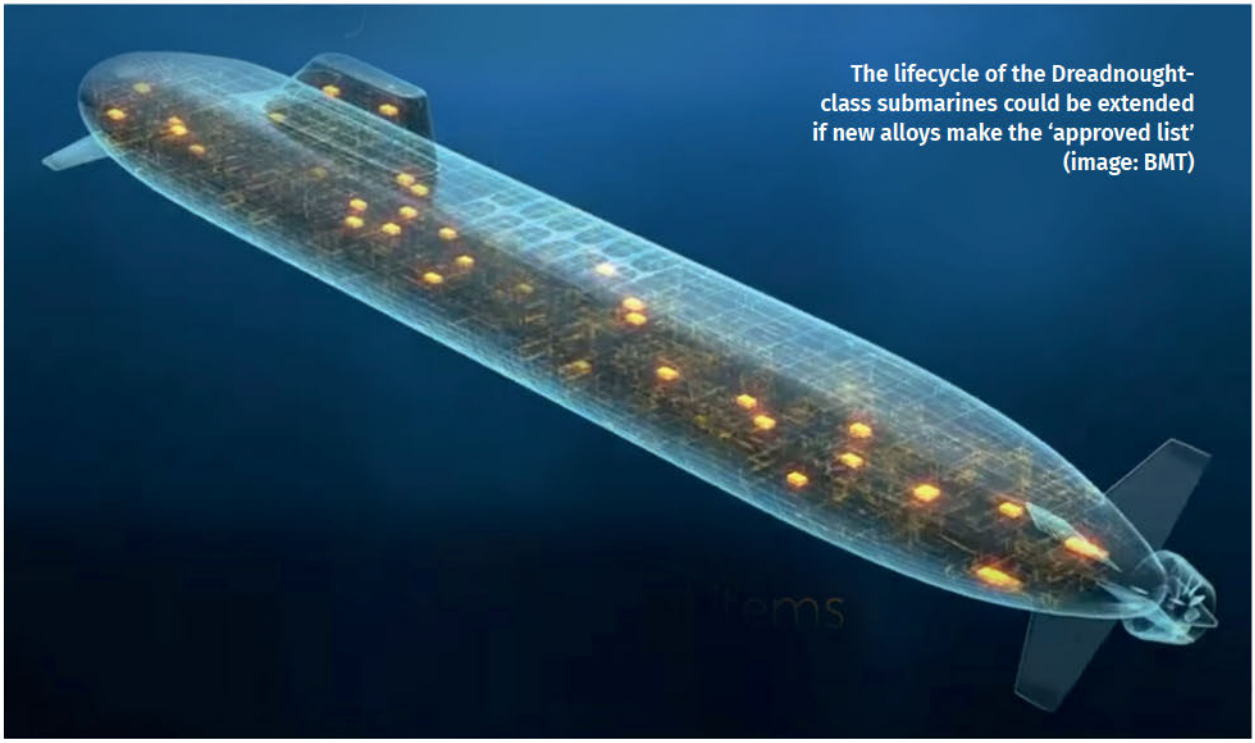
That's despite the potential drawbacks of multiple passes, such as thermal stresses and distortions, and despite the availability of other alternatives.

However, Scudamore hopes that a crossover from friction stir welding (FSW) could make a difference. Initially developed for aluminium, FSW doesn't melt the material itself, says Scudamore: "You have a pin plunged into the material and it stirs the joint together" – resulting in a thermo-mechanically forged join.

Users are now beginning to adapt FSW for more challenging materials: "What we're trying to do now is progress into steel," Scudamore adds.

While FSW does require a very hard 'pin' and more robust equipment, there are advantages. Take plate strengthening, where the usual approach means adding molten metal into an angle. This requires multiple passes, which create a large heat-affected zone with potential for cracking. Neither are the resulting thick welds particularly easy to inspect.

By contrast, the FSW method uses rolled T-sections with a symmetrical, one-shot butt weld and an extremely reduced heat zone. The result is higher strength joins, increased consistency and reduced distortion. Moreover, that small 'forged' area means that these steel welds often have better mechanical properties than the surrounding region. In fact, Scudamore notes that the tensile strength of the joint is typically 25% higher than that of the parent material.



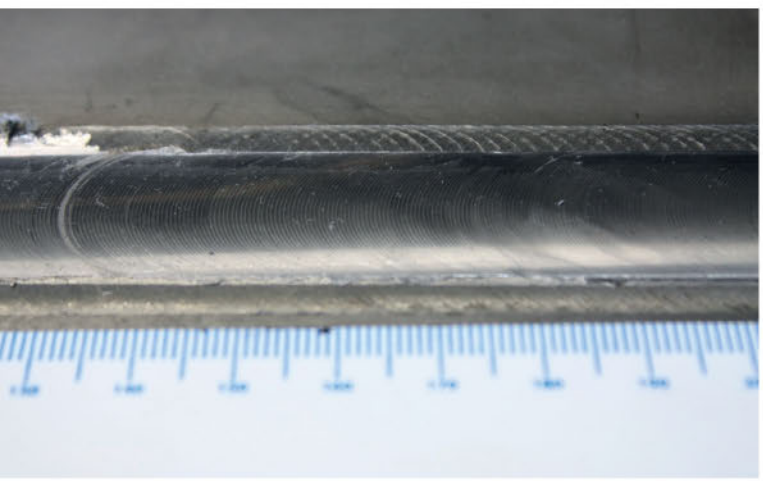
The lifecycle of the Dreadnought-class submarines could be extended if new alloys make the 'approved list' (image: BMT)

More FSW benefits

The process could also be used to improve previous weld sites. Take, for example, the standard V-prep, multiple-pass arc weld. "If we go across that with the friction stir head, we can get a refinement of the grain structure and a consolidation of the weld itself," Scudamore explains.

Additionally, this can all be done underwater. "One of the things we've been looking at is repairing ships so they don't have to go into dry dock," said Scudamore. That's important for the commercial fleet as well as the navy, proving a very useful fallback for ships in challenging regions. In fact, The Welding Institute has demonstrated how an FSW robot and ROV could weld a 6mm steel plate over a hole in the hull to create a clean, fully watertight seal.

FSW techniques can yield high-quality steel joins (image: The Welding Institute)



There are other things the new technology can offer in design and build: one potentially large advantage is the welding of different materials. This could be an option if their properties have similar softening temperatures. "We can actually join things like carbon and super duplex stainless steel," says Scudamore. Therefore, designs could utilise more advanced materials where necessary, yet make other choices where the demands are different, he explains.

Despite all these benefits – and the fact that FSW is perhaps one of the more established technologies – it may not be that easy to convince yards to move away from 'tried and tested' arc welding methods and into unfamiliar territory.

A tough call

So, how does the industry move forward? Solving the risk conundrum is essential if the Royal Navy and its partners are going to bring the necessary innovation across the 'valley of death' between inception and technological readiness, says Rigby. As he points out, neither end customers nor defence companies can carry all the procurement challenges: "We need to find a way to share the risk...and embrace innovation and reward," he says.

It remains a tough call, though Rigby says there are ways into the discussion, getting stakeholders around the table and asking them what needs to change: it could start with identifying the challenges and the blockers, perhaps moving onto the procurement system or even broader supply chain. Whatever the answers, the UKNEST membership looks like playing an important role in a new approach to the much-needed collaborative effort ahead. ■

COLLECTIVELY SMARTER

Advanced Navigation tells **Stevie Knight** that creating a network of USBL devices could be the most cost-efficient way of monitoring port and offshore infrastructure and subsea assets

If you want to set up regular monitoring of subsea assets, environmental areas or even port infrastructure and security, the best, most cost-effective way to do it may not be to buy a couple of AUVs or ROVs and individually kit them out.

In fact, Chris Sundstrom, product manager for subsea at Advanced Navigation, argues that your best option could be to set up an ecosystem utilising ultra-short baseline (USBL) devices. However, Advanced Navigation promises more from this type of array than most – and for far less outlay – with a device housed "in a package the size of a large cinnamon bun", Sundstrom says.

Generally, USBL works by setting multiple hydrophones in a head that measures a signal's echo delay and offset from a transponder. Given that the usual surface-based systems can't penetrate water, it's become the go-to for fast and flexible tracking, as the transceiver can be pole-mounted beneath a vessel and the transponders are easy to hook onto ROVs, AUVs or other elements.

Despite being the size of a large cinnamon bun, the Subsonus has integrated INS, saving considerable cost and effort for operators who require accuracy (image: Advanced Navigation)

But the company's Subsonus device "is not your everyday USBL", says Sundstrom. Despite the 'bun' size, it has eight hydrophones rather than the usual four. "What that gives us is more advanced beamforming [focusing] between USBL transceivers and transducers and far higher resolution positioning," he explains. Interestingly, the Subsonus incorporates an inertial navigation system (INS): not so usual on systems costing less than half a million dollars, he remarks, adding that the integration means there's no need to buy and patch one in, avoiding significant cost and effort.

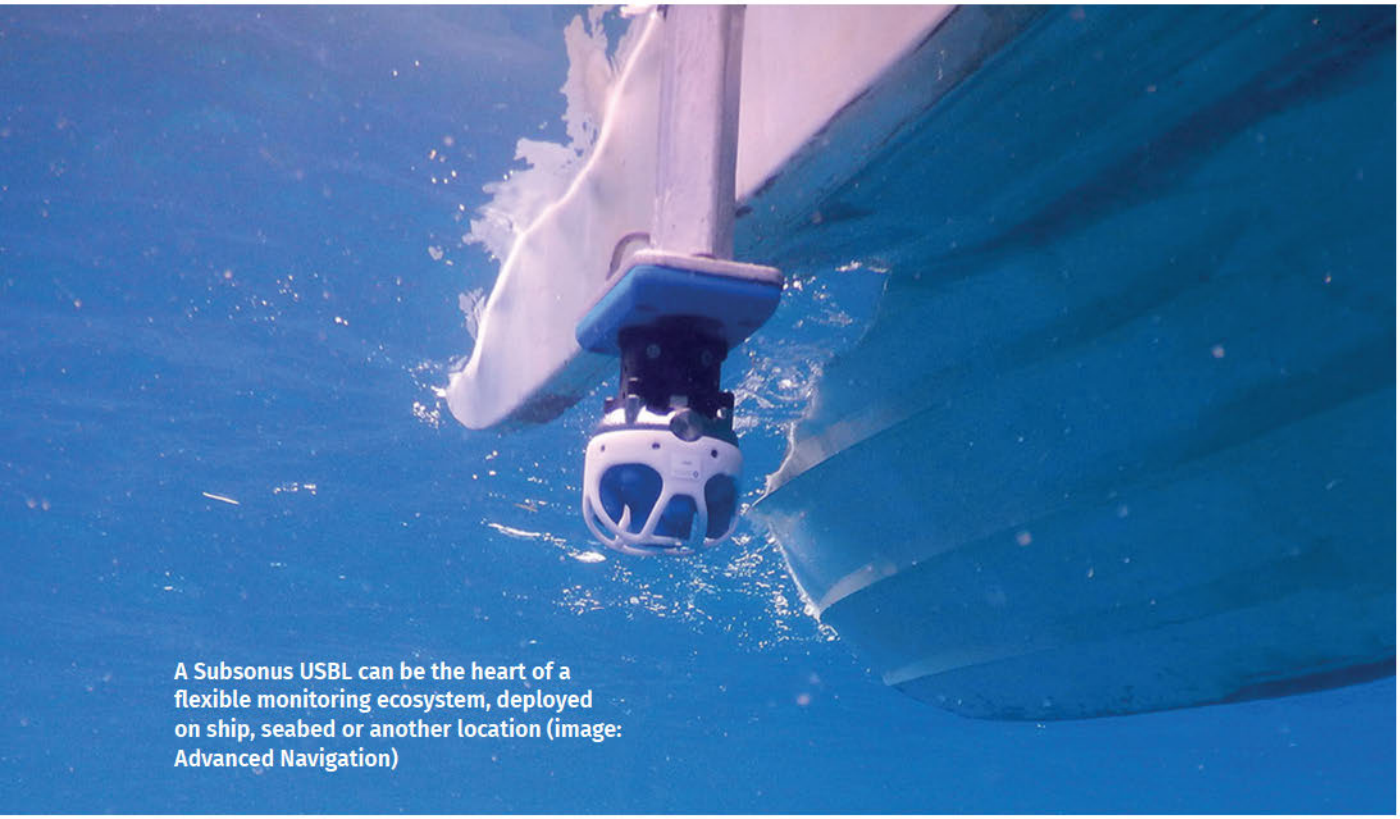
Visual ranges

Why is all this focus on accuracy so useful? "Even in typical conditions, your underwater lights just form a bubble of illuminated space, maybe a 5m visual sphere," Sundstrom explains. The sonar feed from a vehicle doesn't really help with situational awareness: observation may be directed 10m ahead, but it's limited to a thin fan shape.

Further, conditions can be a whole lot worse. "I've seen visual ranges down to half a metre or even less caused by sediment, krill or plankton," he adds. "It's like putting your head into a bucket and trying to work out what's going on around you."

Knowing exactly where your assets are located is critical when you have divers deployed alongside heavy kit, especially since there can be strong crosswise currents blowing through at different depths. The soda-can-sized Subsonus Tag transponders can be hooked onto ROVs, crane loads and heads, divers, towed arrays or points of interest, and each can be straightforwardly named at set-up with no fuss. "It's like fitting that bucket with a video screen," says Sundstrom. "It really helps you visualise where everything is."

It's also flexible: the Subsonus can be inverted with Tags at the surface, or used in multiple arrangements – something that's already proving useful for challenges such as intermittent, shallow-water operations. It can handle depth too, down to 1,000m. Most importantly, the device also operates as an underwater modem, possible because sound waves in water travel at roughly four times the speed of those in air, and retain more energy. Therefore, creating a Subsonus



A Subsonus USBL can be the heart of a flexible monitoring ecosystem, deployed on ship, seabed or another location (image: Advanced Navigation)

network – what Advanced Navigation calls 'USBL^2' – adds enormously to the potential gains.

Interconnected hub

When linked together, there's continuous, roughly one-second-interval information sharing between these devices. Each has enough onboard intelligence to process and filter the information, accurately resolving position and headings.

Further, a surface connection (such as an ROV, which can also have the Subsonus integrated with its DVL) provides a cross-network, synchronised GNSS time server, as well as a channel to pull the data up and send it home.

Every Subsonus can directly serve all the software for AUVs or other drones, as well as acting as an interconnected hub, blossoming out into any number of Tag transponders (technically, up to 65,000 of them per device). That also means tracking could continue around tricky corners or infrastructure that would otherwise create an acoustic shadow.

Despite its potential scale, Sundstrom underlines that the entire set-up is pretty straightforward: "You do not need additional survey software," he says. "All you need is a Chrome browser to log in, and you can run everything from there."

The USBL is also independent of electromagnetic signals, which could prove useful for different applications. For example, Sundstrom points out that military monitoring of harbours could see a USBL transceiver fixed on the bottom with a swarm of autonomous surface vessels operated from it – with no risk of electromagnetic jamming.

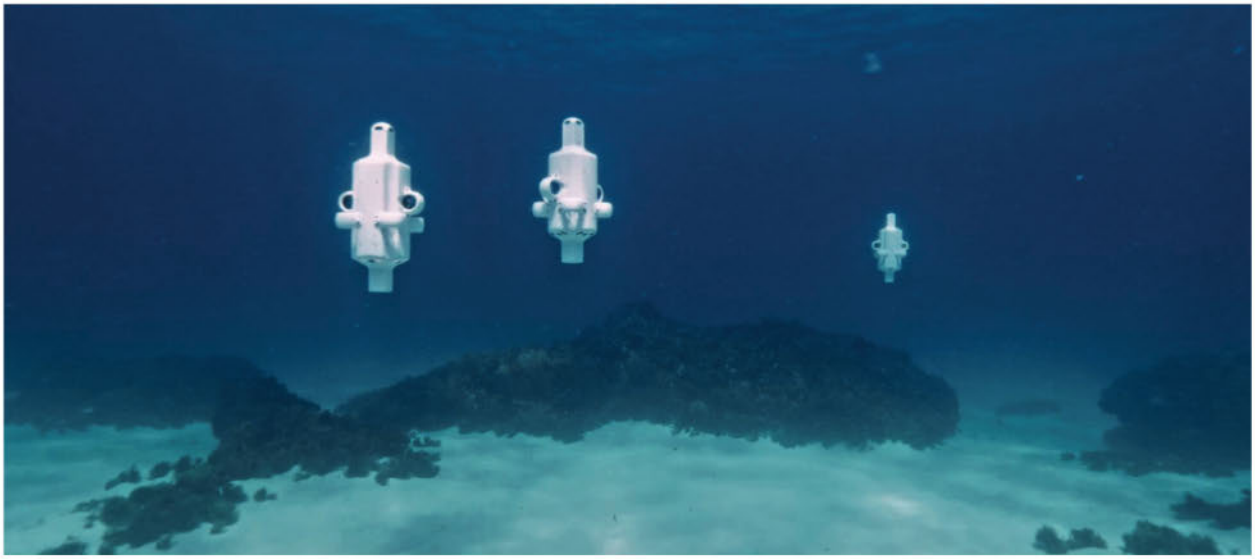
Subsea installations could likewise utilise USBL. "Quite often, when you're operating in a construction field, you'll have a dozen radars and possibly 30 different radio frequencies, plus all the WiFi and other surface communication – it can be an electromagnetically crowded environment," says Sundstrom. "Sometimes it's actually quieter underwater. There may be a need for utilising that."

Additionally, even a big construction fleet sometimes needs to run for shelter to avoid hurricanes, something that has happened to Sundstrom twice inside a couple of weeks. "If we'd had a USBL transceiver mounted at a fixed location on the bottom, we could have come back and immediately locked into our previous positions," he says. The team didn't, and it took quite a bit of time and effort to restart operations.

Hovering AUV

These aren't the only advantages to USBL. "Not only do you want to know where everything you're working with is underwater, but something that's becoming very, very important in the market over the last five to six years is the digital twin," says Sundstrom. "There are lots of companies out there who are now producing point clouds, acoustic or non-acoustic imaging and stereo optical cameras that generate 3D renders."

"All of those technologies are great," he remarks. "They give you an amazing picture of the structures, but you still don't know exactly where



The Hydrus hovering AUV can work in conjunction with USBL technology as part of a fleet (image: Advanced Navigation)

they are. And again, that is where USBL systems come into play as they allow you to not only locate those digital twins, but to repeatedly return to different points on them."

In fact, Advanced Navigation has brought all this together in its Hydrus, a micro hovering AUV for rapid, georeferenced underwater imagery that can be used to build up digital twin datasets.

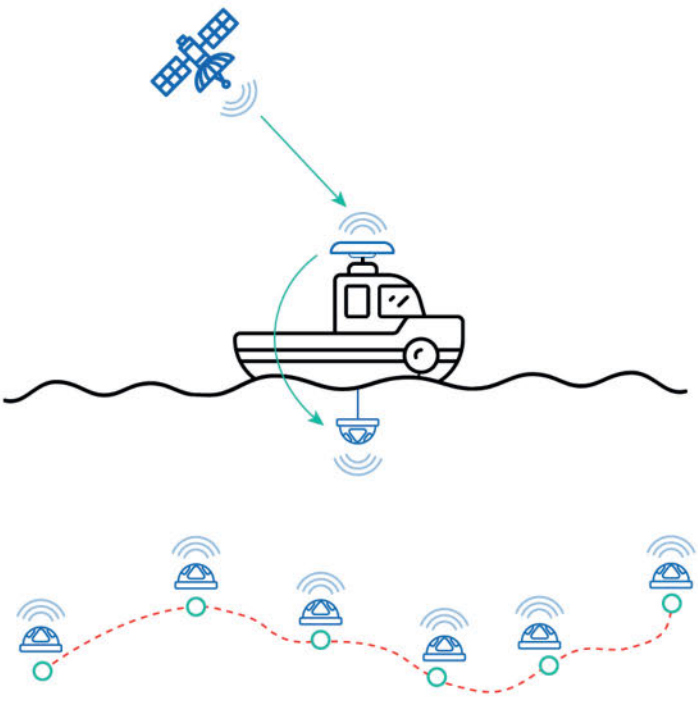
That 'hovering' capability is important, says Sundstrom: while cruising AUVs tend to look in one direction and scan a broad swath, the Hydrus is designed for investigating smaller areas in far greater detail, with nine degrees of freedom (9DoF).

The Hydrus is very compact, measuring just 520mm x 264mm x 235mm, and, Sundstrom explains, that means inside an enclosed space such as a tank it can image the bottom, walls and roof, or return a more complete picture of, say, a coral reef or habitat.

Based around the company's other intelligent systems, it also takes advantage of the range of information sources – and it too has an INS. But unlike many other AUVs, it also integrates USBL capabilities. "It's a different method of operating these vehicles," Sundstrom says, "because [for repeated, detailed scans] you need to know where you are within that space, and the usual basic sensors are just not going to cut it. You won't get enough information."

"Of course," he adds, "being able to operate the Hydrus in conjunction with everything else makes it part of the wider ecosystem."

So, what's in the future? While Hydrus can currently take advantage of Advanced Navigation's technology, Sundstrom says an easy-to-integrate, OEM USBL^2 system will shortly be available for other AUVs and drones. The important point is that intelligence doesn't have to be entirely accommodated on board, which allows these vehicles to get smaller, more accurate – and collectively smarter. ■



A single underwater Subsonus unit can track a multitude of assets, moving or not (image: Advanced Navigation)

CARBON CAPTURE GAINING TRACTION

A number of pilot retrofit projects, and the emergence of a range of technologies, suggest that interest in carbon capture is reaching a tipping point, writes **Clive Woodbridge**

As shipowners and operators explore technologies that will enable them to meet demanding new environmental regulations on the road to net zero, one avenue that seems to be gaining more traction is carbon capture. A recent study by the Global Centre for Marine Decarbonisation (GCMD), *Project Colossus*, concludes that onboard carbon capture and storage (OCCS) is "a promising way to decarbonise shipping in the medium term, as fossil fuels will still play a major role in the global fuel mix for the next few decades".

Among the possible carbon capture technologies and configurations, GCMD suggests that monoethanolamine (MEA)-based capture with onboard CO_2 liquefaction is the most promising from a techno-economic perspective and that, while it can be applied to a variety of marine fuels, LNG is the best match among fossil fuels due to system-fuel synergies that halve the fuel penalty.

However, it adds, biofuels offer even more benefits: "The combination of OCCS operating at high capture rate with biofuel blends can achieve net negative GHG emissions, thus effectively removing carbon from the atmosphere, with biomethanol and biodiesel from used cooking oil being the most advantageous fuels."

Captured CO_2 can be permanently stored or used to generate products that can displace other carbon-intensive processes, such as building materials or fuels. However, the report cautions: "CO_2 captured from onboard operations remain more expensive than CO_2 captured from the flue gas of power generation and industry. Therefore, its economic attractiveness for use as input CO_2 material for any valuable product highly depends on specific conditions and local context."

Major impact

The deployment of OCCS is very much in its infancy, certainly in relation to many other environmental abatement technologies in the maritime world. However, there have recently been clear signs that interest is gathering pace.

One notable milestone is the decision of maritime technology systems supplier Wärtsilä to start commercially marketing its carbon capture solution (CCS) to the global maritime industry. According to Wärtsilä, the technology is proven to reduce vessel CO_2 emissions by up to 70%, thereby presenting an opportunity to have a major impact on the industry's efforts to reduce GHG emissions.

The launch follows the installation of the world's first comprehensive, full-scale solution onboard Solvang ASA's 21,000m³ ethylene carrier *Clipper Eris*, for full-scale testing and optimisation. The solution, which has been in operation since *Clipper Eris* set sail from Singapore in February 2025, will support Solvang ASA's commitment to reducing carbon emissions.

Clipper Eris was already equipped with a range of Wärtsilä products, including exhaust scrubbers, making it an ideal candidate for the project. Separately, for newbuild vessels currently under

Wärtsilä is now actively marketing its carbon capture system

Carbon capture tanks being loaded onto *Clipper Eris* during its retrofit in Singapore earlier this year

construction, Solvang has worked closely with Wärtsilä, and other partners, to ensure these ships are CCS-ready. This includes CCS-ready scrubber systems, as the engines will operate on HFO, as well as necessary space reservation and utility requirements.

"While the shipping sector continues to explore options for lessening its environmental impact, CCS provides a significant shortcut for achieving meaningful sustainability," suggests Edvin Endresen, CEO of Solvang ASA.

Wärtsilä offers different scalable CCS sizes and configurations to suit various vessel types and operator needs, both on newbuildings and retrofits. CCS can be applied to the exhaust from any carbon-based fuel, such as HFO, methanol, LNG and MGO, and is designed to work alongside other emission reduction technologies, including SOx scrubbers, NOx reduction systems and particulate matter filters.

While launching the pilot testing is an important milestone, for OCCS to be a success on a larger scale, Solvang believes more shipping companies and industry stakeholders must see the benefits and join in. Endresen points out: "CO_2 can be recycled and used in land-based industries, but the global infrastructure for discharge for shipping needs to be developed fast. In addition, IMO must implement global regulations with benefits and penalty schemes for achieving the set goals. Predictability is necessary for the industry to invest in solutions for reducing CO_2 emissions." This pilot project is a collaboration effort between not just Solvang and Wärtsilä, but also MAN Energy Solutions and the research institute SINTEF.

Circular carbon economy

Another Norwegian shipping company exploring carbon capture is Berge Bulk, which has installed a carbon capture retrofit aboard its 63,000dwt Ultramax vessel *Berge Yotei*. Developed by Value Maritime, the system integrates carbon capture with an exhaust gas cleaning mechanism known as Filtree. The carbon capture system has been designed to capture up to 15tonnes of CO_2 daily, which could lead to a 30% reduction in emissions during operations, according to the company.

The captured CO_2 is absorbed into a reusable amine solution, which can be offloaded at port for regeneration or reuse. This approach supports various applications, including greenhouse cultivation, beverage production and other industrial uses, thereby promoting a circular carbon economy, Berge Bulk suggests.

Berge Bulk CEO James Marshall comments: "While we remain committed to optimising fleet efficiency, installing decarbonisation technology and switching to new fuels, we must also capture carbon at the same time."

Value Maritime has also installed a carbon capture system with a Filtree exhaust gas cleaning system onboard the 75,000dwt *Nexus Victoria*, an LR1-type product tanker owned by Mitsui O.S.K. Lines (MOL). Value Maritime's 15MW next-generation Filtree system can filter sulphur and (ultra) fine particulate matter, and can capture 10% of the vessel's CO_2 emissions with potential scalability to 30% if needed.

Nexus Victoria is now the largest vessel to incorporate this SOx scrubber with carbon capture technology and the first-ever LR1 tanker to sail with this system. The installation was completed in Singapore under the supervision of a specialist team from Value Maritime. "This system represents a crucial step in decarbonising vessels that

"This system represents a crucial step in decarbonising vessels that cannot yet transition to next-generation fuels"

Berge Bulk recently retrofitted *Berge Yotei* with a Value Marine exhaust gas filter and carbon capture system

cannot yet transition to next-generation fuels," says Hiroyoshi Kubo, executive officer at MOL's Tanker Unit. "Together with Value Maritime, we are committed to advancing carbon capture solutions and building a CO_2 value chain that contributes to a sustainable, carbon-neutral industry."

Fuel-agnostic design

Encouragingly, more technology providers are coming onto the market, to help drive the carbon capture option forward and invest in the necessary R&D. US-based Carbon Ridge has received design basis approval from DNV Maritime for its next-generation OCCS system. Called the 'Lone Ranger', the first unit was constructed in Houston, Texas, and the company has announced that it will soon be deployed on a commercial vessel for real-world testing.

This system is specifically designed for the maritime industry, can be utilised for both retrofit and newbuild applications, and is claimed to be a versatile solution for reducing emissions across a wide range of vessels, as it features a modular, scalable and fuel-agnostic design. According to Carbon Ridge, the system can be seamlessly integrated into existing and new vessel exhaust systems, offering an efficient path to meeting environmental standards without disrupting operations.

In Singapore, the Seatrium group recently launched SEARA as its own OCCS solution. According to the company, SEARA can be easily retrofitted to vessels of any size as its modular design makes it adaptable to different ship types, offering a "scalable solution and seamless integration into existing operations". SEARA recently received approval in principle (AiP) from ABS, confirming its compliance with marine vessel and carbon capture system standards. Incidentally, Seatrium has already gained considerable experience in carbon capture retrofits, with its shipyard in Singapore having been the chosen location for both the *Clipper Eris* and *Nexus Victoria* projects.

Capture rates

Also active in the market is the Finnish company Langh Tech, whose OCC system has been running in test mode on a vessel operating in the Baltic since spring 2024. According to the company, this pilot plant testing phase has demonstrated momentary peak capture rates of up to 90% of the exhaust gas flow entering the system.

Nevertheless, extensive vessel-specific case studies conducted during the testing period indicate that capture rates in the range of approximately 10-50% are technically and economically more feasible under practical operating conditions for many vessel types. Therefore, Langh Tech's OCC system has been optimised to capture around 50% of the CO_2 coming into the system, which can be tailored to a specific capture rate by treating only a part of the entire exhaust gas.

Langh Tech says that with its system, there is no need for solvent regeneration or CO_2 compression, which significantly reduces the additional energy consumption on board as well as the equipment and resources needed to operate the OCC system. In turn, the capture reagent, NaOH, can be produced by the electrolysis of sodium chloride using renewable energy. The reagent used is already widely used in the maritime industry, and the system can be adapted and scaled according to the specific needs of each vessel, states Langh Tech.

In another development, Mitsubishi Shipbuilding has acquired AiP from ClassNK for its new OCCS, which captures, liquefies and stores CO_2 after pre-treatment of vessel exhaust gas. Mitsubishi Shipbuilding says it developed the system by utilising CO_2 capture technologies from its parent, MHI, which has considerable experience with onshore facilities. Going forward, Mitsubishi Shipbuilding plans to accelerate the development of this system to bring it into market.

To support the development and introduction of related technologies, ClassNK recently published *Guidelines for Shipboard CO_2 Capture and Storage Systems*, which outlines safety requirements for OCCS and its installation on ships. ■

MED MARINE
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VOLTRA

BATTERY ELECTRIC TUG

ROBERT ALLAN

REPURPOSED FOR SURVEILLANCE

A vessel originally designed for crew transfer operations has been converted to protect subsea infrastructure in the Dutch EEZ, writes **David Foxwell**

Recent incidents in which pipelines and subsea cables have been deliberately damaged have highlighted the need for European countries to protect offshore infrastructure, and for a new type of survey and surveillance vessel dedicated to monitoring the underwater environment in areas of sovereign interest.

A notable example of this kind of vessel is *Proteus*, which acts as a mothership for ROVs and a suite of specialist capabilities, but others are entering service. In the Netherlands, like the UK, the government plans to invest further in offshore wind farms and to acquire new-generation vessels to protect these assets, but, in the near-term, a solution is to be provided by a converted offshore vessel, following the result of a recent tender won by a team comprising ship designer and builder Damen Shipyards Group and marine geodata specialist Fugro.

Underwater surveys

Earlier in 2025, the Dutch Ministry of Defence contracted the Damen-Fugro team to enhance maritime surveillance and security – above and below water – in the country's exclusive economic zone (EEZ). The solution proposed by the Dutch companies is based on the use of a Damen Fast Crew Supplier (FCS) 5009, a vessel acquired from the offshore market, which is being upgraded with a suite of surveillance technology and assets such as above- and below-water drones that will enable the Royal Netherlands Navy to monitor vessel activity in the North Sea and survey critical underwater infrastructure such as cables and pipelines.

In a project funded by the North Sea Infrastructure Protection Program (PBNI) coordinated by the Ministry of Infrastructure and Water Management, the Damen-Fugro joint venture has been awarded a two-year charter for the vessel, *DSS Galatea*, a contract that includes a pair of two-year options. The charter for the vessel, which is unarmed and non-lethal, was awarded following a public tender, and is set to begin shortly.

Speaking exclusively to *The Naval Architect*, Damen Financial Services commercial asset manager Laurens Romeyn, and commercial and operations director Erik van Sliedregt, say that acquiring the FCS 5009 enabled the joint venture to respond quickly to an "urgent requirement" from the Royal Netherlands Navy.

Romeyn describes the acquisition of the vessel and the charter contract as "the first step" in countering the growing threat to subsea infrastructure and quickly enhancing situational awareness. As Romeyn also explains, the FCS

The FCS 5009 design met the Royal Netherlands Navy's requirement for a survey and surveillance vessel

The Dutch government plans to build more offshore infrastructure, such as wind farms, that needs to be protected

5009 is an ideal platform for the new surveillance asset, combining as it does a stable, high-speed hullform capable of speeds of around 24knots with Damen's Sea Axe hull shape, that can be deployed rapidly, as required by the charterer, with a large deck that can accommodate containers containing specialised mission equipment required for the ship's role as a dedicated surveillance asset.

Sea Axe

The Sea Axe hullform arose as a result of research work that Damen did with Delft University of Technology to develop a design with improved seakeeping characteristics. That research concentrated on designing a ship that could maintain high speeds in strong winds and heavy seas.

The answer was the Enlarged Ship Concept, a concept that was the starting point for what became the 'Axe Bow' concept. The resulting hull shape had extremely good seakeeping characteristics and motion behaviour, and significantly lower resistance through the water, which translates into reduced fuel consumption and emissions. Based on the Axe Bow Concept, Damen developed the Sea Axe patrol vessels and the Fast Crew Suppliers now widely used in the offshore industry and in the new surveillance vessel.

"The Sea Axe hull shape ensures that the vessel can respond quickly as and when required," Romeyn explains. "It can do so while remaining fuel-efficient and provide a stable platform for those on board and for the deployment of uncrewed units. The hull shape reduces slamming and pitching, which makes for more uptime."

As highlighted above, one of the other benefits of the FCS 5009 is the size of its deck. At around 225m^2, allied to a high deck strength required of an offshore vessel, there is ample room and capacity for containers with project specific equipment. The size of the accommodation on board – for up to eight crew and 80 personnel – also make the ship type well-suited to meeting the charterer's requirements.

Growing theme

Now at one of Damen's shipyards, the seating installed on the vessel for offshore personnel that were transported by it has been removed, and upgrades required for the charter are being carried out, including the addition of more cabins and office spaces in order to meet the requirements of the charterer.

Work has also been carried out to meet classification requirements and those of the Dutch flag. *DSS Galatea* already has a deck crane, and will also be fitted with a davit to launch and recover a small workboat.

Romeyn says that the theme of maritime situational awareness was definitely a growing one, and one where the FCS 5009 and other platforms in the series could find similar applications. ■

FINE TURKISH SUPERYACHT CRAFTMANSHIP

Whether producing bespoke superyachts, or repairing and upgrading them via its Reviva Refit subsidiary, Turkey's Mengi Yay Yachting is experiencing growing demand

Founded in 1964 and based in Tuzla, Istanbul, Mengi Yay Yachting has earned its place among the world's most respected custom superyacht builders. With over six decades of legacy, the shipyard specialises in delivering bespoke superyachts tailored to each client's unique vision, balancing traditional craftsmanship with advanced technology.

Operating within a state-of-the-art facility spanning over 20,000m², Mengi Yay boasts six enclosed construction halls capable of accommodating yachts up to 105m in length and 30m in beam. The shipyard's portfolio includes a wide range of acclaimed models such as the Virtus series (39m, 44m, 47m) and the explorer-style Virtus XP line (52m, 65m). Beyond series production, Mengi Yay also offers fully custom yachts crafted in collaboration with world-renowned design studios.

One such standout collaboration is *Serenissima*, a fully custom 47m motor yacht designed and engineered by Nuvolari Lenard. *Serenissima* reflects the pinnacle of Mengi Yay's craftsmanship – harmonising classic exterior elegance with a contemporary interior tailored to the lifestyle of a discerning owner. The vessel showcases detailed joinery, innovative spatial planning and high-end technical features, earning recognition within international superyacht circles. Following the delivery of the first *Serenissima*, the second hull, *Serenissima II*, was launched in 2024, further reinforcing the shipyard's expertise in building complex, high-volume yachts for experienced global clientele.

Reviva Refit

With a growing demand for expert yacht maintenance and conversion solutions, Mengi Yay has expanded its operations through its dedicated refit division – Reviva Refit by Mengi Yay. This specialised brand offers comprehensive refit, repair and restoration services and operates across four strategic locations in Turkey: Tuzla, Didim, Kıyı Istanbul and Yalova.

Reviva Refit has completed more than 16 major refit projects, ranging from 17-65m in length, setting new benchmarks for quality and reliability in the refit industry. Each project is approached with the same level of care and precision as a new build. The brand leverages Mengi Yay's 60-year heritage and 40,000m² of advanced shipbuilding infrastructure to deliver tailored solutions that meet the evolving needs of yacht owners.

Core services provided by Reviva Refit include: exterior and interior painting, including advanced coating systems and high-gloss finishes for protection and visual impact; interior production and restoration, including use of custom carpentry, fine cabinetry and refurbishment using premium Italian materials; and metal fabrication and welding, involving structural enhancements in steel, stainless steel and aluminum.

The yard also provides services related to: piping and outfitting, such as system upgrades and installations for water, fuel, HVAC and grey/black water management; glass repair and replacement, including aesthetic and structural glass solutions for hulls and superstructures; and mechanical and hydraulic systems,

Mengi Yay's state-of-the-art facility in Tuzla spans over 20,000m²

Mengi Yay collaborated with Nuvolari Lenard on the fully custom 47m motor yacht *Serenissima*

including full servicing and modernisation of propulsion, stabilisation and steering systems.

At its core, Reviva Refit is driven by the same values that define Mengi Yay: attention to detail, solution-oriented teamwork and a passion for excellence. The brand's motto, 'Reviving Yachts, Renewing Experiences', reflects its commitment to extending the lifespan and enhancing the performance of each vessel it touches.

Whether delivering award-nominated newbuilds like *Serenissima* or transforming ageing yachts into modern masterpieces, Mengi Yay and Reviva Refit continue to raise the standards of Turkish yacht building on the global stage. ■

COMPETITIVE *SPIRIT*

Team Black Pearl of Bangladesh University of Engineering and Technology, victor in this year's Worldwide Ferry Safety Association student design contest, shares how it put together the design for the winning concept for Lagos waterways

This year, the Worldwide Ferry Safety Association (WFSA) concluded its 12th International Maritime Student Design Competition, an annual initiative hosted to encourage students to create designs for safe, stable and affordable domestic ferries – and particularly for rivers and regions within developing countries, or which are prone to higher-than-average rates of accidents.

Previous instalments of the contest have focused on ferry designs for operations on the Pasig River in Manila; the Singapore Strait; the Amazon in Brazil (notably coinciding with the COVID pandemic, necessitating additional design measures to ensure safe passenger distancing); and the Savu Sea region in Indonesia, to name just a few locations. Last year, the contest called for a design for a ro-pax ferry for the River Niger in Nigeria, which was won by Team Nawasena from ITS, Indonesia (covered in depth in *Ship & Boat International* September/October 2024, pages 28-31).

As reported in that article, the Nigerian Inland Water Authority, which regulates some 3,000 waterways, has been working to combat an unacceptably high death toll – with 1,000 fatalities attributed to domestic ferry accidents in 2023 – within this network. Resolving these safety issues is critical for Nigeria – and particularly for its capital – given that, over the past three years, Lagos State (in which nearly a tenth of the 2023 fatalities were recorded) is rapidly expanding its public ferry system to relieve urban congestion.

TECHNICAL PARTICULARS
NAIJA SPIRIT

Length	28m (oa)
	27.2m (bp)
	27m (wl)
Breadth	9m
	2.7m (demi hull breadth)
Depth	2.7m
Draught	1.2m
Displacement	91.6tonnes
Service speed	20knots
Passengers	200

Contest specs

Dr Roberta Weisbrod, executive director of the WFSA, explains that the appetite for modernisation is strong in Lagos: "The Lagos State Waterways Authority [LASWA] oversees a network of 250 daily trips, 27 routes, 12 terminals and 44 jetties," she comments. "In 2024, the state introduced 15 x 40-seater passenger waterbuses, built locally by Caverton Marine Limited, marking a milestone in Nigerian engineering and manufacturing." Additionally, at COP28, Lagos obtained a €410 million grant to enhance its infrastructure, including the construction of new terminals and electric ferries.

***Naija Spirit* would run on a mix of batteries and hydrogen, with supplementary solar panels and an underwater hydrokinetic turbine**

Interestingly, the 12th WFSA student design contest saw the association return to Nigeria, with David Okafor, a naval architect with the Nigerian Navy, once again assisting in drawing up the specifications for the design teams.

This year's challenge called for a 200-pax electric ferry capable of navigating Lagos' waterways, emphasising a 25km route linking Ikorodu, a northeastern business zone, to the CMS transport hub on Lagos Island. The student teams had to factor

Team Black Pearl, from Bangladesh University of Engineering and Technology (BUET), winners of the 12th WFSA International Maritime Student Design Competition

in constraints such as low-clearance bridges, shallow docking depths (2.5m is common, Okafor advised) and water hyacinths, the latter of which can block ferry channels and jetties and cause damage to boat propellers and engines.

Project challenges

This year's winning entry was *Naija Spirit*, a 28m, double-deck aluminium catamaran, designed by Team Black Pearl of the Bangladesh University of Engineering and Technology (BUET). Team Black Pearl was captained by final-year student Md. Safayet Hossain Shishir – who, incidentally, was part of the BUET team that secured second-place in last year's WFSA River Niger design competition.

Each WFSA student design contest brief presents unique challenges for teams. For Team Black Pearl, this year's contest involved overcoming a tight submission deadline and limited access to reliable, real-time data for the specified Lagos route.

Shishir tells *The Naval Architect*: "This edition of the competition allowed roughly three months to complete the entire project, which included everything from initial studies and literature reviews to developing preliminary plans, performing calculations, making critical design decisions and executing the final design. We overcame this challenge through effective coordination within the team, clearly assigning tasks with specific deadlines and managing our resources efficiently. Strong teamwork and structured planning were essential to delivering the project successfully within the limited timeframe."

Further, Shishir highlights, being based in Bangladesh made it difficult to obtain a comprehensive overview

MEET THE TEAM

Md. Safayet Hossain Shishir: a final-year naval architecture and marine engineering student at BUET, and team captain, Shishir kept Team Black Pearl on track, while contributing to the final principal particulars, trip time estimations, weight/scantlings calculations and the general arrangement.

Md. Abdul Kader: a postgraduate responsible for selecting the primary and auxiliary propulsion systems (including the battery system and hydrogen fuel cells) while overseeing renewable energy calculations, intact/damaged stability considerations and floodable length, seakeeping and manoeuvring analyses.

Abu Rasel: an undergraduate tasked with hull optimisation – ensuring high performance and low resistance – and *Naija Spirit*'s 3D-model visualisation, while also developing the ferry's aesthetics.

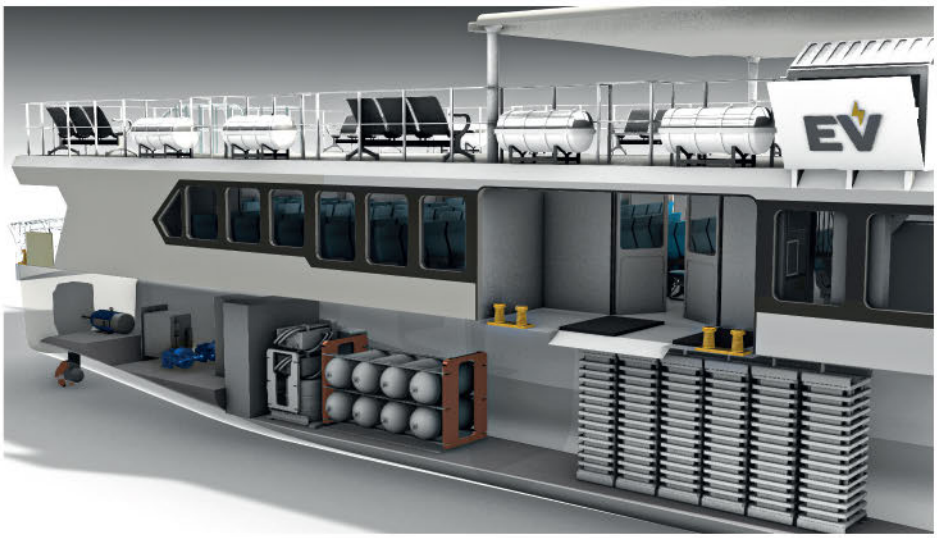
Mahmudul Hasan Shahed: an undergraduate managing the technical particulars and trip times, also responsible for cost analysis and estimations to ensure the ferry remained economically feasible.

Afif Bin Habib Omeo: an undergraduate specialising in CFD, who analysed the ferry's resistance, propeller performance and passenger evacuation procedures.

Md. Kawsar Mhamud Zidan: an undergraduate who handled most of the ferry's 2D plan drawings in AutoCAD, while developing the outboard profile and life-saving equipment calculations.

Md. Atiqur Rahaman: an undergraduate who made an in-depth literature review of resources for the project, sharing this valuable info with the team, while assisting with weight, power and propulsion calculations.

The team was supervised by *Dr. Zobair Ibn Awal*, professor of naval architecture and marine engineering at BUET, who provided guidance and feedback.



The machinery space was fine-tuned to optimise power and distribute weight

of Lagos' riverine conditions. "To address this, we conducted extensive online research and gathered relevant information to ensure our design would be suitable for the region and aligned with international standards," he says. "For instance, we paid special attention to ensuring the ferry's speed would be competitive with local road transportation. To estimate road travel times accurately, we performed a detailed traffic analysis, using Google Maps over an entire day.

"This provided valuable insight into typical journey durations by road. Accordingly, we optimised our vessel's speed." However, despite these hurdles, the WFSA has always guided student participants rather than leaving them to navigate every problem on their own, as Shishir explains: "Additionally, support and prompt responses from Dr Weisbrod to our inquiries were instrumental in helping us progress effectively."

Electric arrangement

One of the most critical challenges, though, Shishir highlights, was the design of the vessel's electric battery pack. "It had to provide sufficient capacity for a complete round trip, while remaining as lightweight as possible to maintain vessel efficiency," he says. "Another major focus was ensuring the ferry offered a clear travel time advantage over road transportation. This required identifying the optimal operating speed, minimising hydrodynamic resistance and targeting a one-way travel time of around 40 minutes.

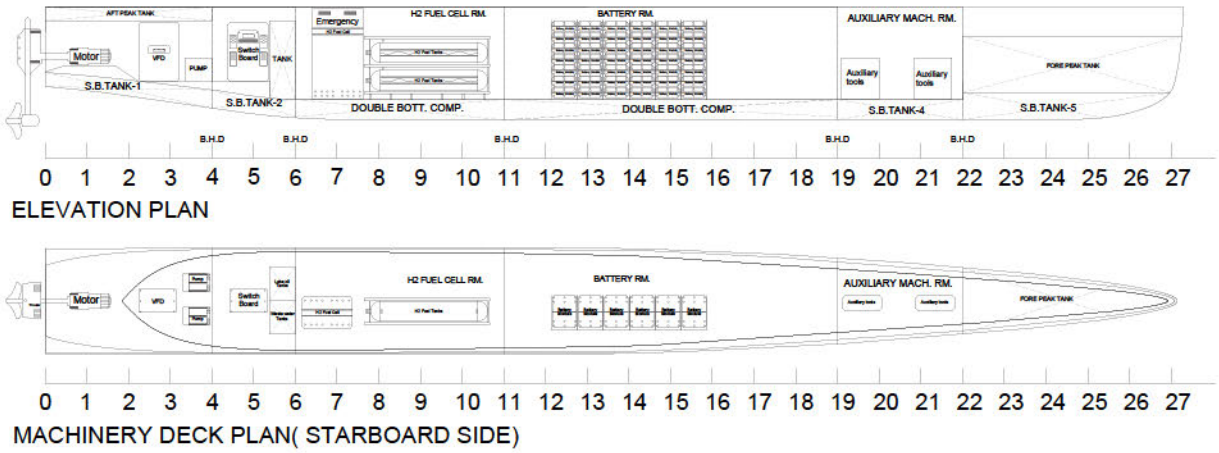
"Additionally, balancing charging time with battery weight posed a significant engineering challenge. Achieving the right trade-off was essential to ensure efficient turnaround, sustained performance and overall operational viability."

Naija Spirit would utilise an integrated electric propulsion system, comprising: two marine-grade, permanent magnet electric motors, rated 680kW at 1,200rpm apiece; a 584kW thruster with retractable, tiltable propellers; Sinus Penta 0457-series variable frequency drive inverters, with operating power bands spanning 1.3kW to 3,000kW; and switchboards provided by Stadt. The team also specified the use of ABB's marinised power cables.

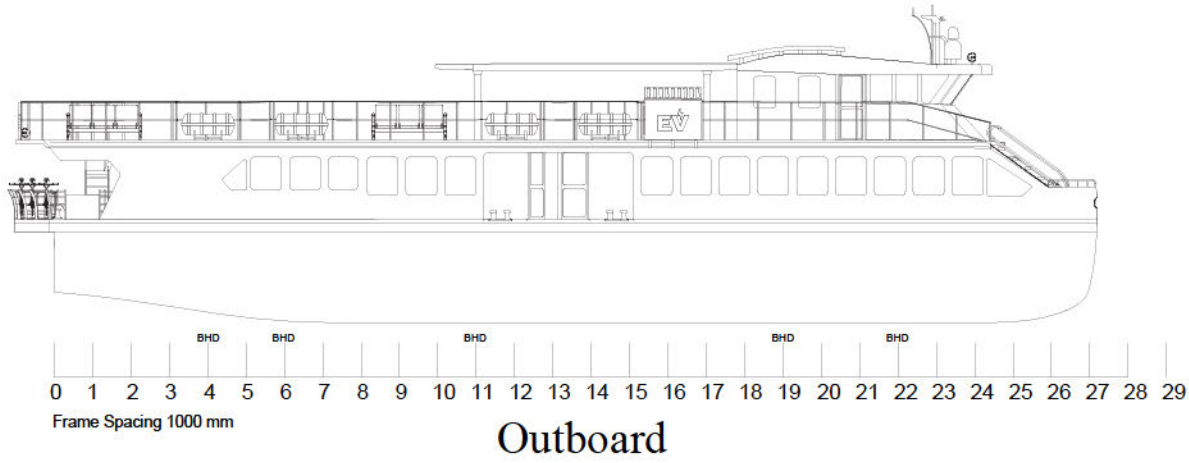
The set-up would also incorporate a hydrogen fuel cell system, to serve as an emergency power source while avoiding greenhouse gas (GHG) emissions. Shishir explains: "In the event of a failure in the main propulsion system, the ferry will rely on the hydrogen fuel cells to maintain a speed of up to 14knots, ensuring it can safely reach the nearest terminal."

For *Naija Spirit*, the team chose two 1tonne Ballard hydrogen fuel cells, placed under the main deck at the demi hull. These would be paired with four Mahytec RGV500 hydrogen tanks, each with a 6.5kg

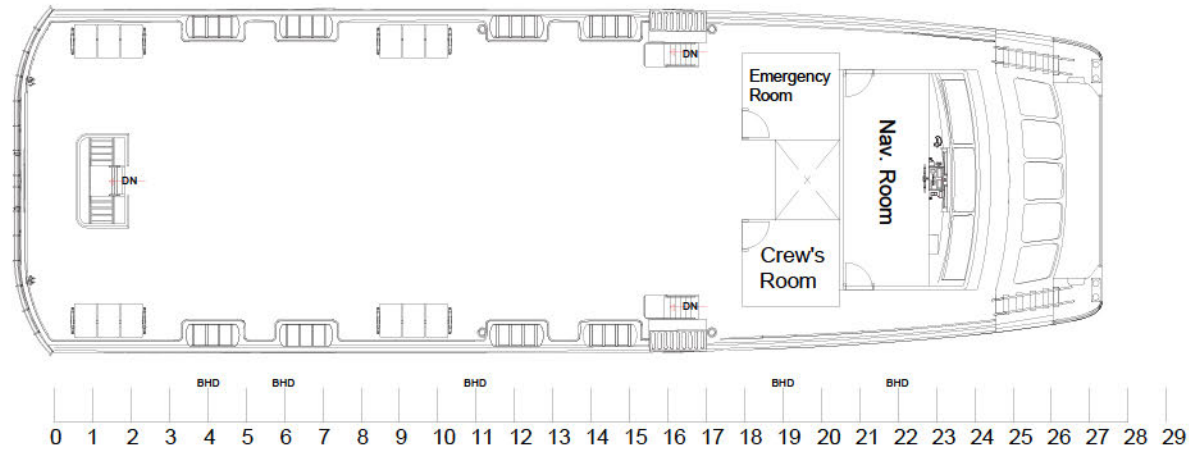
A diagram of the ferry's machinery space



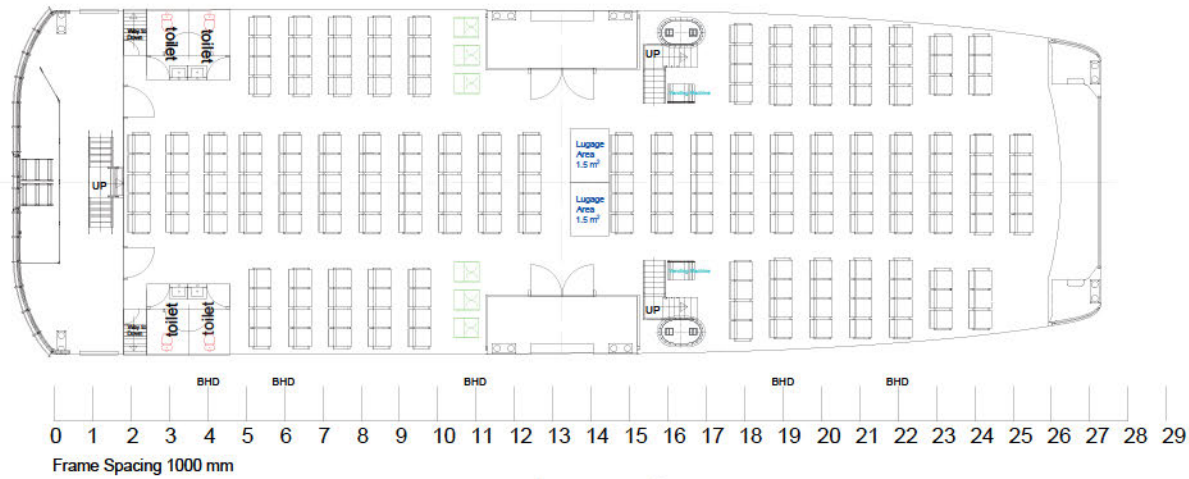
The general arrangement of *Naija Spirit*



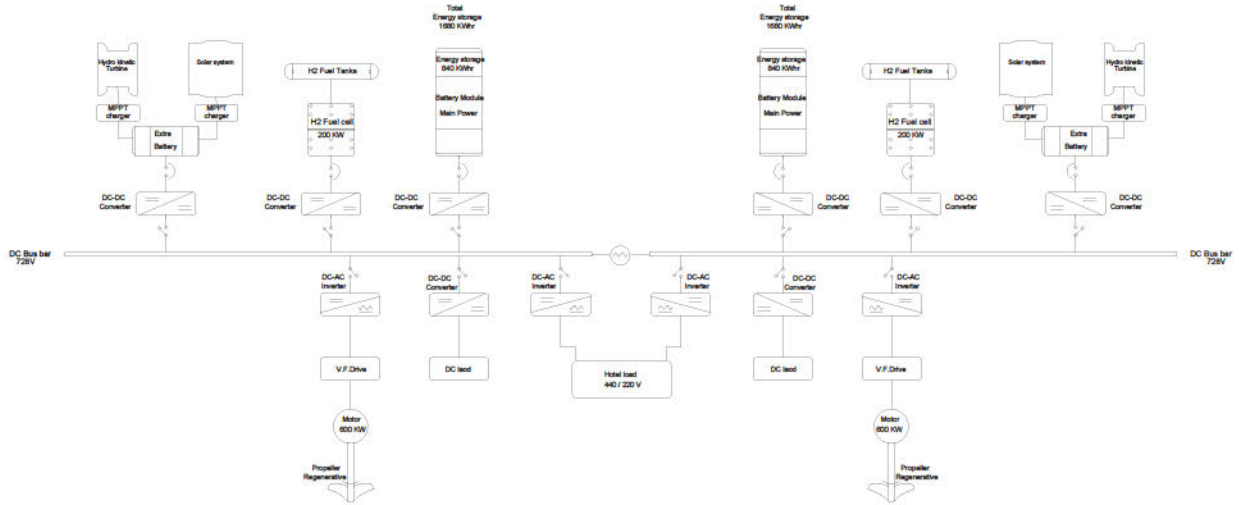
Outboard



Navigation Deck



Main Deck



A basic electric circuit diagram of the ferry, completed using IACS guidelines and drawing on ABS' 2022 DC power distribution systems for marine and offshore applications

capacity and weighing 0.185tonnes. Shishir adds: "Weight has always been a critical challenge...the main issue was finding a hydrogen fuel cell with a suitable height to fit within the under-deck space."

Team Black Pearl also calculated that 168 battery modules would be required, constituting a combined weight of 14.66tonnes. EST-Floattech's NMA-certified Octopus-branded batteries were selected. Shishir says: "The battery room is situated on the under deck." Due to the battery pack's weight, the room was "positioned around the midship, to ensure vessel stability", he explains, adding: "The battery spaces are isolated using watertight bulkheads, and designated in compartments in both demi hulls symmetrically, also maintaining structural integrity."

Speed and range

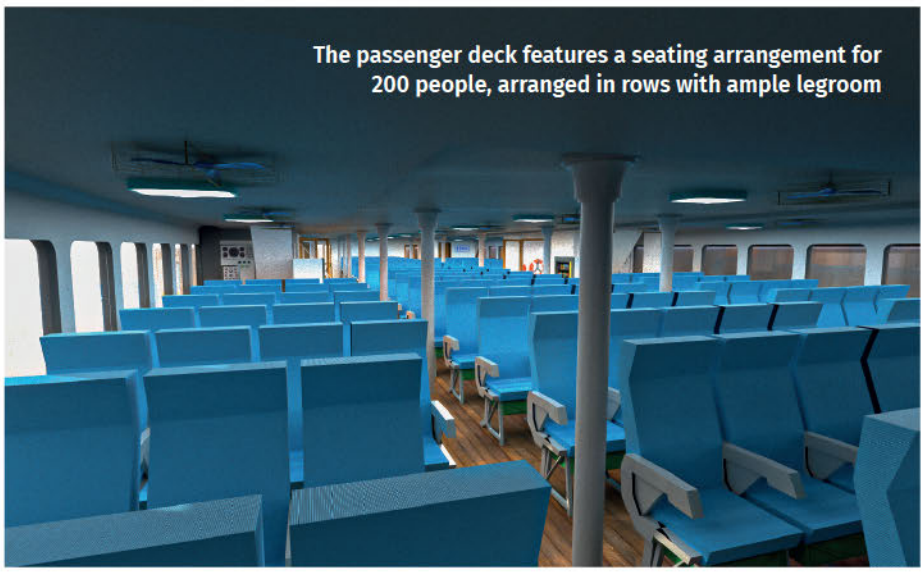
With the above propulsive arrangement, the team calculated that *Naija Spirit* would be capable of operating at a maximum speed of 20knots. "It can complete two trips – Ikorodu to CMS and back – covering 50km before requiring a recharge," Shishir says. "The ferry can complete up to 10 trips within the 12-hour operating window, from 6am to 6pm, covering approximately 250km in total."

Other clean energy features include a 55m^2 spread of Solbian flexible solar panels, mounted on the roof and at points around the ferry. Each panel is rated 0.216kW, Shishir says, adding: "Assuming six hours of effective sunshine, the panels can generate a total of 71.28kWh – enough energy to power the ferry's hotel loads on that day." An additional 154kW of power would be generated by an underwater hydrokinetic turbine "with a diameter equal to the ferry's draught, placed at the region of maximum flow velocity, identified by CFD analysis", Shishir adds.

The retractable propellers would feature a depth adjustment system, enabling the crew to adapt the propeller height in response to fluctuations in water depth or vessel load – while also hopefully reducing fuel consumption. Shishir says: "The fully retractable design, selected from an existing and proven configuration, protects the propeller even in the event of complete grounding, ensuring it remains undamaged. The entire propeller system operates hydraulically and is designed for ease of maintenance, featuring a user-friendly plug-and-play setup that allows the crew to service the system efficiently with minimal downtime."

Ferry stability

Naija Spirit's passenger deck features a seating arrangement for 200 people, arranged in rows with ample legroom. This deck would also feature vending machines, a luggage area and bicycle



The passenger deck features a seating arrangement for 200 people, arranged in rows with ample legroom

The team used Pathfinder software to simulate a full-ship evacuation

storage space at the aft. The navigation deck, meanwhile, would house the navigation room, a crew room and an emergency room. "The navigation deck is equipped with essential tools such as radar, GPS, electronic charts, VHF radios and signal lights, ensuring safe navigation and effective communication, even in adverse weather conditions," says Shishir.

Determining vessel stability was another important consideration, right down to the "careful arrangement of deck items", Shishir reveals, adding: "Even and symmetric general arrangement resulted in minimal vessel trim, and the number of watertight bulkheads was determined by floodable length analysis."

Intact stability analysis was conducted, taking into account severe wind and rolling. "Notably, the design passed the IMO rule [3.1.2.5] for passenger overcrowding criteria, which addresses one of the most critical safety concerns for passenger vessels," says Shishir. The team's damaged stability analysis was conducted in accordance with SOLAS 2009, specifically utilising MSC 216(82) guidelines for passenger ships. "A total of 129 damage scenarios were analysed, including full damage cases, cases with 50% damage and one immediate case," he says. "The vessel successfully met all immersion angle criteria across these scenarios, and the GZ [righting arm] curves were calculated without any computational errors.

"Additionally, the attained index [A] of probabilistic damage stability surpassed the required threshold, confirming a high level of safety assurance. The analysis covered full load departure, ballast and lightship conditions, with the vessel compartmentalised into six zones and two horizontal decks to ensure detailed and robust stability evaluation."

Although developed for Lagos waterways, the *Naija Spirit* concept could also benefit domestic operations in Bangladesh

To limit the draught to 1.2m, enabling the ferry to navigate Lagos' shallow waterways, the team optimised *Naija Spirit*'s hull design and weight distribution. "Its catamaran shape, with a wider beam, boosts buoyancy and stability without needing a deep draught," says Shishir. "Lightweight aluminium construction further reduces displacement."

Evacuation plan

And then, of course, there is the safety factor, the key driver of the WFSA contest. Shishir says that the team comprehensively drew up plans for potential pre-accident, accident and evacuation phases. *Naija Spirit* would be well-equipped with life-saving appliances, lifejackets (stowed under every passenger seat), a water sprinkler system, fire detectors and fire extinguishers. "Sufficient life rafts are positioned strategically near the entrance doors to help in the quick evacuation of passengers and crew," he says.

Team Black Pearl then used Pathfinder software to simulate a passenger evacuation. The simulation accounted for a full complement of 200 passengers, including 15 elderly persons and 20 children, plus five crew members guiding the evacuation.

"Two situations were tested," Shishir explains. "In the first, all exits were clear, and everyone evacuated in 6.41 minutes; in the second, a fire in the machinery space blocked the rear exits, and evacuation took 10.23 minutes. The ferry also has eight life rafts on the roof, each holding up to 25 people.

"These results meet the IMO safety rules, including the stricter evacuation time limits under MSC.123[75], and are well within the 25.07-minute limit set by the High-Speed Craft Code of 2000."

The ferry would also be fitted with directional sound beacon technology – a highly effective way of directing passengers to designated assembly areas, especially in conditions where visibility may be restricted by smoke, thus helping to prevent potentially fatal bottlenecks and overcrowding in particular onboard locations.

After the contest

So, having won the WFSA student design contest, could we see *Naija Spirit* come to fruition? One stumbling block at present is the lack of a suitable charging infrastructure at the Ikorodu and CMS terminals.

"Therefore, we analysed the existing power distribution companies in the vicinity of these terminals and identified some potential opportunities," says Shishir. "For example, the EKEDP [Lagos-based electricity provider] has large industrial capabilities to meet the energy demands of a shore-based charging station." He adds: "This presents a significant opportunity for the government and relevant stakeholders to explore further and make informed decisions to support this development. This step is crucial, not only for this project, but also for paving the way for a broader shift toward electric vessels."

To make it as simple as possible to build a physical version of *Naija Spirit*, the ferry would be assembled using pre-cut fabrication methods, making it easy to put together at local, established shipyards, such as Caverton Marine and Naval Dockyard Ltd.

Shishir concludes: "The Lagos government is prioritising a multimodal transportation system, which is expected to provide a solution to the country's heavy traffic congestion. As part of this initiative, they are promoting waterway ferry services and investing to offer a more sustainable solution.

"In many ways, this situation mirrors the challenges faced by our own country, Bangladesh, where similar traffic issues persist. We hope that, not only through this ferry design but also with the Nigerian government's vision and efforts to address these problems, we can draw valuable insights that could benefit Bangladesh as well. It is crucial that government officials step forward to engage in discussions and explore potential investment plans with relevant technical and economic stakeholders.

"We are eager to share our ideas with the Association of Naval Architects and Marine Engineers, Bangladesh and leading design firms, presenting our concepts and plans to help tackle this issue. We firmly believe that this is a fundamental challenge for most developing nations like Bangladesh, but we also see a glimmer of hope in utilising our riverine resources to create the most effective solution for the future of our nation."

In this way, rather than being a one-off, localised exercise, the WFSA student design contest has the capability to extend beyond borders, inspiring innovation and laying the foundations for what may prove to be the safe, energy-efficient domestic ferry designs of tomorrow. ■

WIND PROPULSION

The Key to Cutting Emissions?

As the maritime industry moves towards a greener future, wind-assisted propulsion is taking centre stage. In the last six months of 2024, the number of large vessels equipped with wind propulsion systems surged to 54, with a further seven ships constructed wind-ready. With over 80 wind-powered vessels set for delivery in 2025/26, the industry is on course to surpass 100 wind-assisted ships by the end of 2026—and this is just the beginning.

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The Wind Propulsion 2026 Conference is your opportunity to stay ahead of the curve. The agenda will bring you up to speed on the latest technological advancements, innovative ship designs, and policy shifts shaping the future of wind propulsion. Gain insights from leading experts and engage in discussions that will define the next generation of sustainable shipping.

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MIXING IT UP WITH CLEAN ENERGY

Finnish ro-pax *Aurora Botnia* is set to further boost its green credentials via the installation of a new battery energy storage system, combining two battery chemistries for optimal results

Launched in 2021, the 24,036gt ro-pax vessel *Aurora Botnia* was provisioned for green operations from its inception, having been produced with a hybrid diesel-electric arrangement that includes a battery system and a dual-fuel powerplant capable of burning both liquefied natural gas (LNG) and bio-LNG (LNG produced from organic waste).

As summer approaches, though, the 150m x 26m, 935-passenger vessel, operated by Finnish transport company Wasaline, is about to undergo a major battery upgrade. This retrofit will see a 10.4MWh battery energy storage system (BESS) installed on board and two distinct battery chemistries – nickel manganese cobalt (NMC) and lithium iron phosphate (LFP) – combined into a hybrid solution, a move expected to slash the ship's annual CO_2 emissions by up to 23%.

"Dual-battery approach"

The retrofit will be supported by naval architecture and design firm Foreship, whose head of new technologies, Joonatan Haukilehto, explains: "This is one of the most technically ambitious hybrid conversions yet attempted on a ro-pax ferry...to our knowledge, it is the first time this dual-battery approach has been realised in a maritime retrofit. By integrating high-power NMC batteries with energy-dense LFP batteries, we have enabled *Aurora Botnia* to draw on the unique strengths of both."

At the same time, Haukilehto adds, the retrofit will be achieved without any significant changes to the ferry's electrical infrastructure. The upgrade will result in a near-sixfold increase in the vessel's battery capacity, taking it from 2.2MWh to 12.6MWh.

The ferry is fitted with four Wärtsilä 8V31DF engines, which, typically, are only run simultaneously in the heaviest and most challenging ice conditions. "The majority of voyages have required two engines running, while the new BESS will make it possible to cover most of these needs running one dual-fuel/diesel generator [DF/DG] engine on constant high load, supported by the large battery pack," says Haukilehto.

So, why combine two battery types? Haukilehto tells *The Naval Architect*: "The newbuilding contract for *Aurora Botnia* was signed in January 2019, and, at that time, NMC battery technology was the most feasible option for the vessel.

"The vessel was fitted with 2.2MWh NMC batteries with high C-rates, which were able to supply over 6MW of power instantly to the vessel's electrical network. In principle, this is enough power to take over the complete load of one DF diesel generator should it shut down for any reason."

C-rates measure how fast a battery is charged or discharged relative to its capacity; for example, '1C' means the battery charges or discharges its full capacity in one hour, while 2C means it does so in half the time (30 minutes) and 0.5C means it takes two hours. While higher C-rates mean faster charging or discharging, they can compromise battery life and safety.

***Aurora Botnia*'s forthcoming BESS upgrade will boost its battery capacity from 2.2MWh to 12.6MWh**

Since 2019, however, battery technology has evolved significantly – "most notably in the breakthrough of LFP chemistry", Haukilehto says. He continues: "Foreship's feasibility study evaluated multiple BESS configurations and technologies and concluded that installing 10.4MWh LFP-type batteries offered Wasaline the most cost-effective way of enhancing vessel efficiency and increasing its use of renewable shoreside energy.

MODULAR OVERHAUL FOR *SUOMENLINNA II*

2004-built Finnish passenger ferry *Suomenlinna II* has upgraded its powertrain with the installation of a new propulsion drive from ABB. The 2004-built, 395-pax vessel, which makes multiple daily crossings between the coast of Helsinki and the Suomenlinna sea fortress – a UNESCO World Heritage site – was recently retrofitted with ABB's ACS880LC drive.

Still, the 38m vessel hasn't entirely scrapped its existing system. ABB explains: "The 329gt vessel was equipped with an ACS600 drive system, which had become obsolete. However, its existing cabinets, busbars and cables were suitable for repurposing, therefore helping to preserve resources. Instead of replacing the full system, ABB delivered a module-based retrofit, only replacing components as necessary. This transitioned the outdated onboard drives to ACS880LC with minimal impact on the ferry's operating schedule."

"LFP batteries have significantly lower C-rates than their NMC-type counterparts. By combining the two battery technologies the vessel can cover high power peaks with the NMC battery pack while maintaining long discharge cycles with the LFP batteries."

Clean electricity

The expanded battery set-up would supply up to 20% of the ferry's total energy demand, he says, adding: "This will deliver enhanced energy efficiency throughout its 1,000+ annual voyages by enabling the ship's LNG-fuelled powerplant to operate continuously at its highest efficiency, while using the minimum number of generating sets. DF engines are at their most efficient in the higher load range; at part-load, efficiency drops and methane slip tends to increase.

"By being able to maintain one engine at constant high load while covering the 'remaining load' with a large battery pack, fuel is burned with the highest possible efficiency while emissions are minimised. Battery charging using renewable energy during port stays is also maximised."

As an additional green bonus, the ferry will run on renewable shore electricity on its trips connecting Vaasa in Finland and Umeå in Sweden. Haukilehto notes: "Quayside power use is already 'zero emissions', thanks to the shore power infrastructure at both ports of call." It is also expected that this will help Wasaline to sell surplus emissions allowances, generating welcome additional revenue while assisting other companies to meet their emissions obligations.

Foreship's support also includes advising Wasaline on how to optimise the retrofit for commercial and regulatory impacts. "Using emissions modelling aligned with the EU Emissions Trading System and FuelEU Maritime, the consultancy demonstrated how combining the new battery capacity with existing LNG and bio-LNG fuel use could enable compliance through to the 2040s," Haukilehto explains.

Feasibility study

The new 10.4MWh BESS will be installed in an existing potable water tank, which will be extended slightly towards the side void space and converted into a battery room. Most of the modifications will involve some form of steelwork.

"Naturally, such a large battery pack needs a significant amount of wiring, and all of the auxiliary systems – such as firefighting and detection, cooling and ventilation systems – will need to be be modified," Haukilehto says. "In principle, we are reducing deadweight and increasing lightweight – but, as the power electronics remain largely unaltered and only batteries are being added, the increase in lightweight will be quite modest."

Foreship's input to the retrofit has included a feasibility study covering technical impact evaluation, emissions modelling and cost analysis. This is now being followed up with a more detailed look at factors such as supplier evaluation, classification design, engineering support and implementation assistance.

"The intention is to start the modifications during the vessel's normal operations in summer 2025 and to finalise the project during *Aurora Botnia*'s regular drydocking period at the beginning of 2026," Haukilehto says. "The BESS installation will be planned and executed so that there is no need to increase the duration of the regular five-year drydocking."

All of which should gift Wasaline a competitive edge in the run-up to 2030, and the overhaul may inspire similar moves in other pockets of the Scandinavian ferry sector. Peter Ståhlberg, Wasaline MD, describes the retrofit as representing "a significant leap toward our 2030 climate goals", and says: "By integrating advanced battery solutions and maximising our use of clean shore power, we are proving that sustainable ferry transport is wholly viable." Lauri Haavisto, Foreship CEO, echoes: "This project demonstrates what is possible when owners take a strategic approach to compliance and decarbonisation. With careful planning and the right partner, retrofit does not mean compromise: it can unlock lasting competitive advantage." ■

REVISE THE SIZE

Could Chartwell Marine's SOV daughter craft come to compete with, or complement, traditional CTVs in the field? **Stevie Knight** finds out

Despite some ambiguous signals from the market, overall wind industry growth looks set to continue. In fact, according to UK government statistics, by 2050 more than 2,325 CTVs and 423 SOVs will be needed to meet global offshore O&M.

However, CTV designs have long tended toward 'bigger is better', especially with the rise in sites' distance and scale. As a result, some of these big beasts are now almost 40m-long. This isn't news: back in 2019, Chartwell Marine recognised the market had to find an alternative. So, both Chartwell Marine's founder and managing director, Andy Page, and naval architect Robin Saunders pursued a capable service operations vessel (SOV) daughter craft design.

The result is a far cry from more typical daughter craft: instead, "they're effectively small crew transfer vessels [CTVs]", says Page. In fact, the company's latest models are just 12.2m in length with a 4.2m beam, but critically, he underlines, "all of the boats have to be less than 15tonnes... because that's the maximum for a single point lift".

It has been far from easy, though, Page admits. "It's really, really hard work to create a boat with 12 technician seats, two crew and all the modern creature comforts right down to USB ports for people to plug in their phones," he explains, "and then package all that in a robust, 15tonne unit."

However, arguably one of the most significant innovations is on the bow: Chartwell's daughter craft feature specialist, modular turbine-transfer fendering from Buoyant Works. "We can swap out some sections to meet the requirements of any wind farm site," says Saunders, "including those that don't have piles but push onto the monopile instead."

Two hullforms

The architecture itself is also interesting: there's both a catamaran and a monohull version of these daughter craft, with the same dimensions.

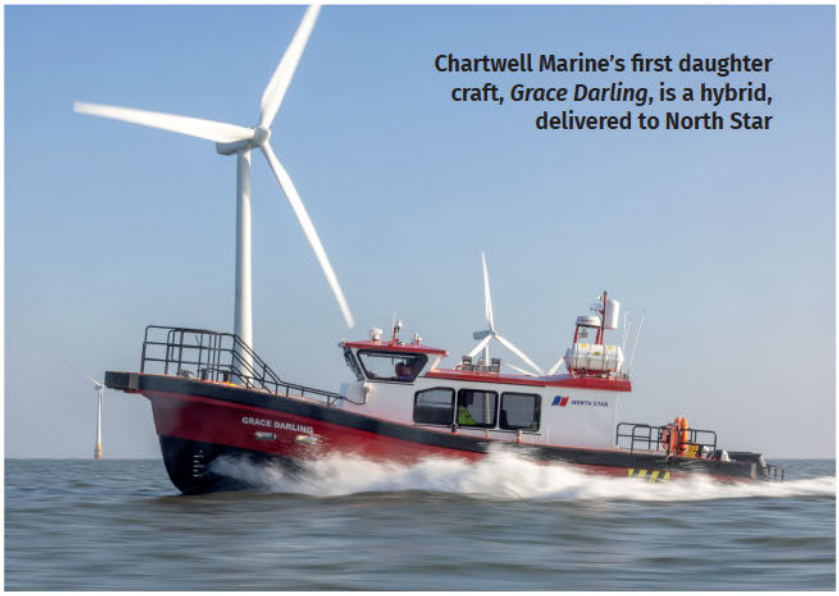
Taking the catamaran first, there's considerable divergence from more traditional forms. For example, other vessels of this size usually have a freeboard measuring under 1m. However, offshore passage and turbine transfers demand an elevated foredeck, almost doubling its usual height.

At the same time, the overall outline is constrained by the SOV's lifting gear and stowage. "We've had to focus on getting the wet deck as thin as possible to allow waves to pass through underneath," Saunders explains. "That's a key feature both architecturally and structurally."

The monohull's form also required attention: "We've had to flare the top sides to create enough surface for personnel to transfer," Saunders adds. "The shape almost looks like an aircraft carrier...the deck is far wider than the relatively slender hull underneath."

This isn't the only way these sisters significantly diverge. "When a catamaran approaches the wind farm and pushes on, there's natural roll stability, just by having two hulls in the water," says Page. By contrast, monohulls tend to heel over to far greater angles. As Saunders explains, a single hull pushing onto a tower can be more easily "twisted off" by this motion.

Chartwell Marine's 12.2m x 4.2m daughter craft are "effectively small CTVs", says Page



Chartwell Marine's first daughter craft, *Grace Darling*, is a hybrid, delivered to North Star

Chartwell's solution lies in some clever kit: the combination of a Seakeeper gyroscope, which lends stability and advanced fendering, allowing the vessel to yaw.

"When the boat is against the pylons, this fender stays still while the boat can rotate left and right," says Saunders. "That freedom means the boat can roll without releasing."

So, despite their modest size, both these Chartwell daughter craft can deliver technicians to the turbines in 1.5m Hs and transit at up to 28knots. "We've proven that capability at model scale, and then in operation," says Page, adding that it took many hours of CFD analysis and tank testing at QinetiQ's facility before the design was ready for production. The first, *Grace Darling*, was delivered to North Star in 2022.

Design evolution

Still, these daughter craft have evolved in the last few years: they now feature adaptable suspension seating and large windows for increased light and visibility, which in turn helps reduce seasickness and motion-induced fatigue. Thermal and sound insulation also creates a climate-controlled, low-noise environment.

It's an effective combination – so much so that if these 'compact CTVs' are deployed alongside an SOV with a walk-to-work gangway, technicians can reach multiple turbines at once, cutting down the typical three-day O&M cycle. It also helps that, on average, these daughter craft can be built in just six to eight months for around 25% of the cost of a typical CTV.

So, could these craft become a CTV competitor? Page explains that while it may look as if daughter craft could edge out traditional vessels, the real picture is more complex. "First and foremost, we will always – and should always – have CTVs in the logistic lifecycle of a project," Page says. "They are versatile, cost-effective assets: SOVs and daughter craft won't fulfil all the requirements."

Further, he adds, the big ships have other pragmatic, commercial considerations. "You have to ask, what's the value of carrying daughter craft for this project, compared to, say, containers holding spares or generators?" he says. Likewise, housing two sets of daughter craft crew could mean giving up eight bed spaces, otherwise used by technicians.

Therefore, daughter craft may not always fit the bill. "We're seeing customers buying a

***Boreas Worker*, another Chartwell daughter craft design, is operated by Edda Wind on the Dogger Bank Wind Farm**

Chartwell-designed daughter craft have adaptable fendering, which allows for international deployment – including the US

daughter craft and using it for a campaign or a construction mission, where it's highly effective," says Page. "But then the requirement changes, so they might take it off and employ it as a near-shore CTV or simply put it into storage, mobilising it again when necessary."

However, Saunders points out that given currently tight profit margins, these big, expensive SOVs need to be working to schedule. Therefore, a daughter craft could be valuably employed to, say, pick up or deliver spares. Further, if the mothership receives an urgent call moving it outside a two-hour recovery range, these boats can serve as emergency rescue vessels for the technicians left on the towers.

"It's not just about more turbines being serviced in one go," Saunders underlines. "It's more important that the main boat carries on doing its day job."

Power play

There is one more point to consider: power. On the back can be anything from Volvo IPS to diesel outboards and Hamilton waterjets. There are, notably, also hybrid versions: North Star have four currently in operation which pair 80kW of installed electric power with 300hp (224kW) diesel engines.

But there is no fully electric version, and to be frank, neither Page nor Saunders see that as commercially viable anytime soon. "For daughter craft operations, the passage to and from the tower isn't too difficult to accomplish electrically," says Page. "Transits don't consume that much energy. The real difficulty is pushing on: we use a huge amount of thrust, probably in the region of 90% of the available propulsive power, to hold station against the offshore structure, especially in higher sea states," he explains.

Also, as onsite charging won't likely be available on every tower, battery banks scaled for the heavy power draw would drive the design outside the 15tonne weight constraint.

But, as both Page and Saunders concur, these daughter craft intrinsically save fuel – and, importantly, cash. Firstly, efficiency is helped by simply ditching a number of passages from shore. Secondly, "it's physics", says Saunders: "A smaller, lighter vessel will burn less fuel than a heavier CTV. And, for fast deployment, it makes both environmental and commercial sense."

At this point, it's worth comparing the installed power: for example, the 25m Chartwell Ambitious CTV relies on 2,160hp (1,610kW) while these daughter craft operate efficiently with just 600-760hp (447-567kW) on board. Of course, each vessel has its place and its duty, but it is worth noting the impact this has on fuel burn and emissions, says Page, adding: "It's knowing when to say, actually, with this asset, we're better off focusing our efforts on bigger contributors."

In fact, interest in Chartwell's daughter craft appears to be growing: eight have been delivered, with a further seven currently in build, "so there will be 15 on the water pretty soon," says Page, adding that there's already an international client base that spans the UK, Denmark, the Netherlands and the US.

However, he believes that take-up should rise, and not just for Chartwell's benefit. In his view, as it stands, the yards cannot meet future CTV build demand. So, while Page underlines that daughter craft can't provide the entire solution, they will help – if their role as an integral addition to SOV equipment is recognised. ■

SHIP ENERGY EFFICIENCY

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THE ROYAL INSTITUTION OF NAVAL ARCHITECTS

TAILOR-MADE TRANSFERS

Tokyo Kisen's new CTV sisters have been designed and built as bespoke models for operations in Japanese waters, as the country's long-term offshore wind farm plans gradually come to fruition

Incat Crowther worked with ClassNK to ensure the TK-27 cats complied with strict local requirements

Japan's offshore wind farm sector is gaining momentum as part of the country's push for carbon neutrality by 2050. The country aims to install 10GW of offshore wind capacity by 2030, and as much as 30-40GW by 2040, with a focus on both fixed-bottom and floating turbines – the latter technology being particularly important due to the country's deep coastal waters.

There have been a few short-term setbacks over the past five years, mainly related to supply chain glitches, inflation and technical challenges. However, Japan's potential for an offshore wind infrastructure exceeding 9,000TWh per year has attracted numerous OEMs, suppliers, service providers – and, of course, boat operators and builders.

For example, this year saw Japanese operator Tokyo Kisen Co take delivery of the first of two bespoke aluminium crew transfer vessel (CTV) catamarans. The first in the new TK-27 class, designed exclusively for Tokyo Kisen by Australian naval architect Incat Crowther, completed its sea trials in late 2024, before being delivered to the operator in April 2025.

Local rules

This vessel and her in-build sister have been constructed by Cheoy Lee in Hong Kong and classed domestically by ClassNK, with Tokyo Kisen also providing input into the duo's design. This was particularly necessary in ensuring that the boats were suited to their working environments off the coast of Japan – and to meet recently revamped but stringent local rules.

Incat Crowther elaborates: "The design was developed in compliance with ClassNK rules for High-Speed Craft, while also incorporating its newly introduced rule addition: Part O (12) – Wind Farm Support Vessels, which had recently been appended to the Rules for the Survey and Construction of Steel Ships. This led to conflicts between the High-Speed Craft and Steel Ship rules, with the latter being naturally unsuitable for a 27m aluminium catamaran."

While resolving these conflicts proved somewhat challenging – not least with ClassNK being "relatively new to the CTV industry", Incat Crowther tells *The Naval Architect* – the debut cat has become the first vessel to adopt this new amendment, thereby opening the door for further builds of this type.

Future-proofed

The design of the cats has also been "future-proofed", Incat Crowther explains, in terms of both occupancy and propulsion. For example, while each TK-27 cat will begin its working life carrying 12 turbine technicians, it will retain the flexibility to boost this number to 24 "as Japan's regulatory

TECHNICAL PARTICULARS
TK-27 CATS

Length	26.4m (oa) 25.2m (wl)
Breadth (oa)	9m
Depth	3.85m
Draught (hull)	1.5m
Deck payload	35tonnes
Engines	2x Yanmar 12AYM-WET, 1,200k
Output of each	1,220kW@1,900rpm
Propulsion	2 x Servogear CPP
Generators	2x 35kW
Service speed	25knots
Max speed	28knots
Crew	4
Turbine technicians	12 (upgradeable to 24)
Classification society	ClassNK

The CTVs are future-proofed for larger technician complements and future fuels

framework evolves" and CTVs become more commonplace – and as the country's network of turbines expands, the designer points out.

Similarly, both cats have been prepped for future fuels. While each currently employs a pair of Yanmar 12AYM-WET main diesel engines, rated 1,220kW apiece and ensuring a top speed of 28knots, it will be possible to upgrade the boats to dual-fuel or even all-electric/pure-biofuel operations as these technologies gain pace. The Yanmar engines are matched with a controllable-pitch propeller (CPP) system supplied by Servogear.

Bow arrangement

Incat Crowther has designed nearly 50 CTVs over 25m, many of which operate in Europe's offshore wind farm sector. While Japan's offshore wind industry presents unique challenges, the designer notes that adapting vessels to Japanese weather and wave conditions was a manageable transition. "The conditions around the Japanese coastline were no more challenging than those typically encountered in European offshore wind farms," the group reveals.

Each TK-27 cat offers a 45m² useable foredeck cargo area and 18m² of aft deck, both strengthened to accommodate a combined maximum payload of 35tonnes. The TK-27's superstructure is resiliently mounted for lower noise and vibrations – an important design feature, because reducing the risk of seasickness is paramount for these offshore workers and their demanding schedules.

The TK-27 twins also incorporate Incat Crowther's Resilent Bow Technology, which has been developed to minimise impact loads at the wind turbine boat landings and to reduce onboard accelerations. Incat Crowther says: "This, combined with the high bollard pull, will provide a transfer wave height in excess of 2m" – thus extending the CTVs' operational windows.

Each cat's main deck houses a large mess area, two bathrooms and an internal storage and personnel change area. The upper deck features the elevated wheelhouse, a private mess and a pantry, while the lower decks offer two twin cabins, a workshop space and a utility room. Other onboard capacities include tankage for 25,400litres of fuel oil, 2,500litres of fresh water and 2,000litres of sullage.

NEW WINDFLEX CTV FOR BELGIAN SUPPORT

UK operator Tidal Transit has added another CTV, *Anthea Luna*, to its fleet. The vessel, built by Penguin International in Singapore, and delivered to Tidal Transit in March, will provide service and maintenance support to the 326MW Thorntonbank wind farm off the coast of Belgium, owned by C-Power.

Anthea Luna was built to the specs of the WindFlex 27 Quad IPS series, designed by Incat Crowther. Features include a length of 27m, a breadth of 9m, capacity for 24 technicians and four Volvo IPS30 pod drives for improved efficiency. This series is also future-proofed for electrification. Tidal Transit director Leo Hambro comments: "As the industry increasingly adopts more sustainable, low-carbon technologies, we're proud to deliver a vessel that not only offers the highest levels of fuel efficiency today, but one that's also ready to join the electric fleet of tomorrow."

***Anthea Luna* will service the Thorntonbank wind farm off Belgium**

AN INSTINCT FOR DETECTION

Cruise ship *Ambition* is testing a smart detection system, proven in offshore energy, to instantly spot and track man overboard incidents, boosting recovery rates while meeting US and ISO standards

Zelim's intelligent detection system, ZOE, has made a rather interesting journey, from remote offshore energy installations in the North Sea to a 1,200-pax cruise ship, in the space of a year.

The system, which has been fine-tuned to instantaneously detect and track man overboard (MOB) casualties in the water, was installed aboard Ambassador Cruise Lines' 216m x 28.8m, 1999-built *Ambition* earlier this year. It's quite the story arc, considering ZOE's origins – though, in technical terms, the system's life-saving principle remains the same.

ZOE was originally developed by Zelim as a solution for its uncrewed casualty recovery vessel, the Guardian, created to deliver emergency MOB response at offshore wind farms. With these turbine arrays increasingly moving further offshore and into deeper waters, the Guardian was intended to provide on-site assistance, being stored aboard, and deployed from, a nearby SOV (see Box, page 47).

Incident lifecycle

Instantaneous MOB recovery is as critical in the cruise industry as it is in offshore energy. Responding promptly to an MOB incident in the open ocean, particularly at night, can be extremely challenging: the casualty may drift far from the still-moving cruise ship, especially if the fall goes unnoticed and is reported hours later.

Sam Mayall, Zelim CEO, tells *The Naval Architect*: "MOB incidents are a huge concern for the cruise sector. They happen fairly frequently – on a global basis, there's an average of more than one a month – and a high percentage involve non-mariners. Unfortunately, people don't generally 'fall off' a cruise ship; they jump." The US has attempted to tackle this problem, with actions including the introduction of the Cruise Vessel Security and Safety Act (CVSSA) in 2010, which requires cruise ships "to integrate technology that can be used for detecting passengers who have fallen overboard".

Doug Lothian, Zelim CTO, explains: "Without continuous tracking, a drifting casualty can be quickly lost from view as the vessel moves, making a successful rescue far more challenging. ZOE...continuously tracks the MOB as they drift [and] provides precise geo-location data, enabling bridge teams to coordinate and accelerate the rescue effort with greater accuracy."

Mayall adds: "There have been incidents where somebody has gone over the side but nobody has noticed for several hours – the cruise ship could be several hours away by the time the alarm is raised. This makes the search area absolutely vast, and so the probability of detecting the MOB becomes pretty slim.

"Most of those incidents don't work out well for the casualty. However, if the crew could instantly know that someone has gone overboard, and has the technology to track the MOB throughout the whole incident lifecycle, you could potentially complete a rescue, from the MOB falling overboard to being returned on board the ship, in less than 20 minutes."

Type approval tests

As a result, ZOE has undergone independent testing aboard *Ambition* to meet the requirements of the CVSSA, as well as those of the ISO 21195 standard for the detection of persons falling overboard. Mayall continues: "The ISO has developed standards for MOB detection systems, requiring a 95% detection rate and no more than one false alarm per day."

Working alongside class society Lloyd's Register (LR), Zelim has put ZOE through its paces aboard *Ambition*, including LR Phase I and II type approval tests, involving a total of 130 mannequin drops. As a result, ZOE achieved an overall score of 98.2% for probability of detection.

"One key takeaway of the tests was that ZOE was able to detect and identify small mannequins," says Mayall. "The ISO standard only dictates that the system must pick up on larger children or adults,

Zelim's ZOE intelligent detection system has been undergoing LR type approval tests aboard the 216m cruise ship *Ambition*

COMPACT GUARDIAN

Zelim's Guardian unmanned recovery vessel (URV) was initially developed to provide safety coverage for offshore wind farm technicians, and particularly those working at remote, deepwater sites. As Zelim put it at the time: "The increasing distance of projects from shore renders traditional maritime support ineffective...rescue boats can take several hours to reach the emergency, and even rescue helicopters can take well over an hour." The Guardian's unmanned arrangement also removes the risk to first responders entering deepwater zones, especially in rough waves and bad weather.

Designed by Chartwell Marine, the first Guardian unit was launched by Coastal Workboats in 2024. Built in aluminium, the Guardian measures 8.4m x 2.55m, displaces 3.5tonnes and has a range of 200nm and a potential speed of 30knots+, thanks to a 400hp (298kW) Bukh diesel engine and an Alamarin-Jet AJ285 waterjet. Should it be deemed necessary, crew can step on board to take direct control.

The vessel is equipped with Zelim's patented Swift recovery conveyor, which can retrieve man overboard casualties even if they are unconscious, as well as the AI-enhanced ZOE system, providing enhanced situational awareness for the Guardian's remote operators, while distinguishing between human casualties and marine mammals, buoys and even floating junk, for example.

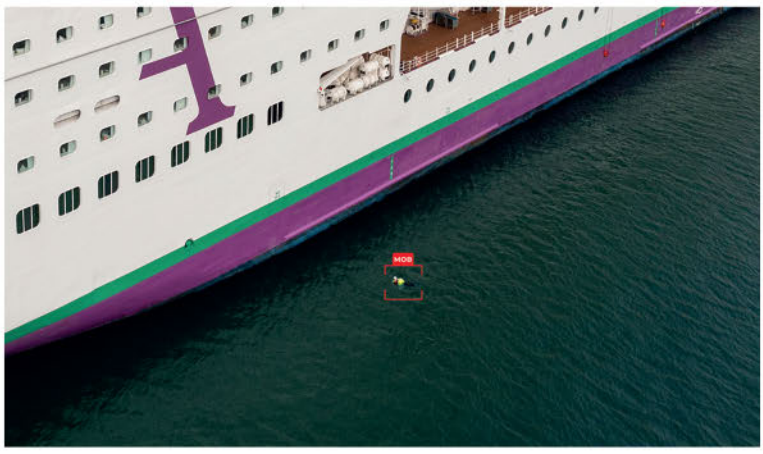
The Guardian's Swift conveyor, pictured with a mannequin, enables the quick retrieval of MOB casualties

but it's an unfortunate fact that children can fall overboard too. The validation trial showed that ZOE is as accurate detecting smaller MOB casualties as it is with larger people."

The ZOE set-up on *Ambition* includes multiple daylight and infrared cameras, including pan-tilt-zoom (PTZ) types, spread across 14 onboard locations – though up to 20 onboard locations are possible. "The ISO standard dictates that we have to provide 360° coverage around the vessel – a passenger can go overboard anywhere on the ship and the system will know about it," says Mayall.

In the event of a camera picking up a MOB incident, ZOE sends an instant alert to the bridge, and the cameras begin to track the MOB casualty in the water. The system also sends a looped 10-second video clip of the incident to the bridge (or to the relevant person in the vessel's CCTV room, depending on the ship's safety management plan). As soon as the alert is acknowledged by the responsible crew member, the system inputs and utilises data from the ship's radar and ECDIS to pinpoint the casualty's location in real time.

The relevant crew member then receives a prepopulated ERP checklist from the system, guiding them through the next steps, such as the exact wording/phrasing for a mayday call. Mayall adds: "Luckily, MOB incidents don't happen all the time, and the crew's training should kick in – but, when crew deal with this situation outside of training for the first time, they may feel nervous and unsure of what to do. The system guides them through exactly what to do and say, in line with the company's and industry's best practice."



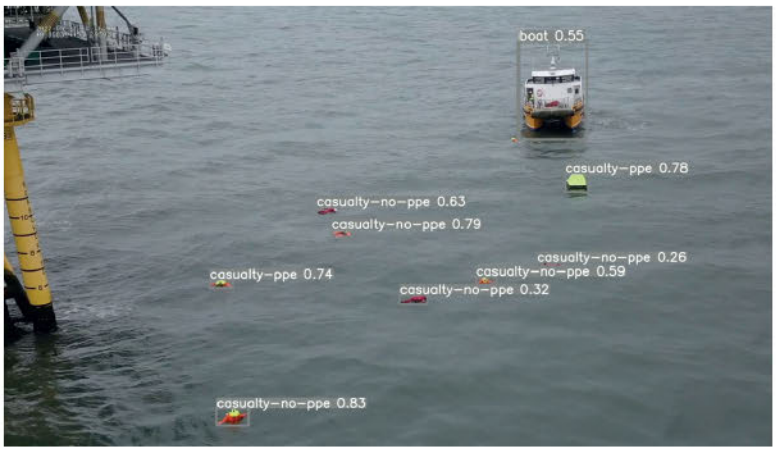
ZOE's cameras can detect and classify objects in the water – in this case, a mannequin correctly flagged as an 'MOB' – with 360° coverage around the vessel

Addressing false positives

As mentioned, ISO 21195 specifies no more than one false alarm daily. Mayall elaborates: "You don't want to be getting 30, 40, 50 false alarms a day, every time a movement triggers the cameras, to the point where the crew get fed up and ignore the system."

It is here that Zelim has had to train ZOE to overcome a perennial challenge that faces all visual detection systems: false positives. Mayall offers the example of a seagull dive-bombing a side of the ship. "If the seagull is on a downward trajectory at the same rate as a falling person, and is similar in size to a small child, that could trigger an alarm," he says. "A false positive could include anything that looks 'human-like' being thrown off the side off a ship. So, it's not just about detecting the presence of 'something there' but also classifying what it is. That's where ZOE's database comes in."

ZOE's database draws on millions of images to accurately distinguish between objects – though constant human input is necessary to avoid false positives



As well as granting the bridge team the opportunity to review the 10-second incident clip – to ensure that a suspected MOB casualty isn't actually a falling sunbed, for example – ZOE utilises an expansive dataset, comprising 7.5 million annotated pictures of people in the water, as a reference for object classification. Much of this data was sourced during the system's initial trials at offshore energy sites, where the system had to learn to differentiate between a half-submerged turbine technician casualty and a seal's head – though some of this data was also gathered through exercises hosted with the US Coast Guard (USCG), HM Coastguard and Canada's Civil Air Search and Rescue Association (CASARA).

While machine learning "makes up 20-25% of the overall ZOE package", Mayall says, the human-machine interface (HMI) remains vital; without constant refinement and input, the system runs a higher risk of misidentifying objects, which would lead to false positives. "You're always trying to teach the system experience," he says. "You're constantly providing it with images with different colours and different sizes and shapes, and images taken in daytime, night-time and different weather conditions. You have to teach the system all of this to ensure that it's accurate: the more data you feed it, the better it gets."

Situational awareness

ZOE can offer additional benefits beyond MOB detection and tracking, Zelim adds. For example, the camera and sensor network can identify potential navigational hazards – think other vessels and semi-submerged objects – meaning that it can also assist the crew as a tool for enhanced situational awareness, collision avoidance and detection of pirates, illegal migrants and hazards to navigation.

Asked about ZOE's potential to spot aerial drones in good time – whether piloted by paparazzi or more hostile actors – Mayall says this may be possible in future, though the system is currently not configured to deal with these. There may also be scope for the system to detect and log incidents involving containers, or other deck equipment, falling from the decks of container ships and bulkers, which could prove useful in resulting insurance claims.

And, naturally, a logical next step might be to include a Guardian (or a couple) aboard *Ambition*, which could then be instantly deployed to recover the MOB casualty as quickly as possibly – potentially effecting a successful rescue within minutes, and with minimum risk to the cruise ship's personnel.

For now, Zelim's *Ambition* trials have proved that "the technology required by the CVSSA is available", Mayall says. At the time of writing, Zelim and LR were progressing with Phase III of the certification process for ZOE, after which further adoption of the system within the cruise sector is the goal.

The system trials were also welcomed by Ambassador Cruise Lines COO Nick Hughes, who recently commented: "ZOE gives our passengers and crew piece of mind that in the rare event of a MOB incident, bridge teams are immediately alerted to a person falling overboard, with the person tracked until rescued. It allows us to direct an immediate and rapid rescue response. What we also like about the system is that it can be used to alert our watchkeepers to hard-to-see navigational hazards." And, as ZOE ventures into new territories, both in open seas and in/around cruise terminals and harbours, its database will continue to amass new images and information, increasing its overview of the objects, wave and weather conditions and safety risks commonly encountered within the maritime sector. ■

SAFEGUARDING AGAINST CYBER-STRIKES

As ships' systems become more digitalised, their vulnerability grows – and so, the number of cyberattacks on ships, plus the methods used, are expected to increase in the coming years, write **Tore Stensvold** and **May Chan**

Digitalisation is accelerating rapidly, partly driven by demands for decarbonisation and the need for CO_2 intensity and emissions monitoring and reporting. Still, this activity increases vulnerability to cyberattacks. Given how many shipboard systems are interconnected, this can cause major problems.

In 2024, 45 maritime companies were targeted by ransomware. However, according to Lars Benjamin Vold, CEO of non-profit the Nordic Maritime Cyber Resilience Centre (NORMA Cyber), this is likely an underestimation. "There's a significant number of unreported cases – we don't hear about all incidents," Vold says.

NORMA Cyber was established in 2021 by the Norwegian Shipowners' Association (NSA) and the Norwegian Shipowners' Mutual War Risks Insurance Association (DNK) to monitor, collect data on and analyse cyber-related threats. In 2024, the other Nordic countries were invited to join – and so, today, Norwegian, Finnish, Swedish and Danish shipping companies and maritime organisations are members, representing more than 2,600 vessels. NORMA Cyber is entirely funded by membership fees. "We don't rule out admitting members from other nations – that's up to our owners to decide," says Vold.

Digitalisation has also changed the day-to-day work of classification societies. As Jarle Coll Blomhoff, head of digital ship systems at DNV, recently put it during a shared presentation with NORMA Cyber in Oslo: "We now have access to all systems and data from shore – we don't need to go on board."

State-sponsored threats

Since its formation, NORMA Cyber has come to identify three types of threat, each involving different goals, methods and resources. These include: state-sponsored threats; criminal threats; and hacktivism.

Criminal groups are the most prevalent, and tend to be well-organised and well-resourced. About 90% of cyberattacks are carried out by such groups. Their goal is financial gain –whether through ransom demands for unlocking encrypted data, fraud or selling stolen information. Meanwhile, hacktivists – politically motivated activists who are generally organised (to different degrees) – are considered a lesser threat to the maritime sector. "Hacktivists aim to create attention but have limited resources and skills – and, in most cases, little to gain from breaching ship systems," says Vold.

State-sponsored actors, however, have become an increasing threat this decade due to growing international tensions and escalating conflicts across regions. States may seek to cause problems for other nations, institutions, companies and infrastructure, or to steal information, patents and military secrets. They either train and organise their own hackers or hire hacker groups to work for them.

In this regard, China and Russia are notable. In 2024, Russia was suspected of carrying out more than 40 sabotage operations in Europe, including both cyber-related and physical actions. Russia is also responsible for GPS/GNSS jamming, disrupting ships' and aircraft navigation systems. NORMA Cyber expects GNSS disruptions to remain a significant threat in 2025, especially in the Arctic and Baltic regions.

Vold notes that state actors have greater resources and capabilities at their disposal than do the other hacker categories. Also, as ships play a central role in both national and global economies and security, it is not surprising that they are increasingly being exposed to espionage and sabotage by state actors.

Vulnerable points

If malicious actors gain access to operational technology (OT) systems on board, the consequences could be severe. Unauthorised control of propulsion, navigation, energy and power management systems presents obvious cause for concern.

"If attackers take control of a vessel carrying gas, petroleum products or hazardous cargo, the

Lars Benjamin Vold, NORMA Cyber: "If attackers take control of a vessel carrying gas, petroleum products or hazardous cargo, the potential for damage is very high"

Jarle Coll Blomhoff, DNV: "We now have access to all systems and data from shore – we don't need to go on board"

potential for damage is very high," Vold warns. NORMA Cyber also notes that certain segments, like oil and gas, offshore wind and national prestige projects, are more exposed than others.

With more components that can be remotely updated or monitored by suppliers, the number of vulnerable onboard points increases. Visitors boarding the vessel – such as service technicians or equipment suppliers – could also pose a risk. Anyone with access to connected equipment could potentially compromise not just one component but entire systems if they are centrally networked. According to NORMA Cyber, the Russia-linked threat group Fancy Bear has used various tactics to infiltrate and maintain presence in targeted espionage operations, including password-spraying, phishing emails and exploiting internet-exposed edge devices and servers.

NORMA Cyber has discovered incidents where USB drives have spread malware and created backdoors into onboard IT systems. There's no evidence that all cases were deliberate, targeted attacks – some involved self-propagating malware. A service technician or repair worker could unknowingly use a USB drive containing malware, infecting one or more vessels.

Similarly, NORMA Cyber says, there is no evidence to support claims of deliberate sabotage by shipyards or subcontractors during ship construction.

The passenger angle

In 2024, NORMA Cyber recorded 237 distributed denial-of-service (DDoS) attacks. Of these, 153 were linked to the pro-Russian group NoName057. The actual number of attacks is likely much higher than publicly reported, though.

Currently, there are few autonomous or semi-autonomous vessels. NORMA Cyber says that companies working on autonomy, such as Kongsberg Maritime and Massterly, are much more focused on security, and are building in multiple safeguards from the outset.

Cruise ships are not considered particularly vulnerable to cyber threats by NORMA Cyber. However, the company points out one possible risk: among thousands of passengers, someone with malicious intent could find physical or wireless access points and look for security holes.

"Cruise ships have a third party on board – passengers – that cargo ships do not," says Vold. "That must be factored in when designing and configuring onboard systems and passenger areas." The csonsequences could be significant if someone disables the freshwater system, sanitation, HVAC, navigation, energy production or other critical systems on a vessel with thousands of passengers far out at sea.

Cyber-risk also applies to superyachts and megayachts, where high-profile, celebrity owners may be bugged by guests inside their onboard entourages – sometimes working in connivance with gossip sites and paparazzi.

Shoreside targets

Vold says there are few attempts to directly attack OT systems on board ships, but that attacks on the IT systems of shipping companies, charterers, ports and terminals are far more extensive.

Land-based IT systems are more vulnerable and can quickly cause significant damage, affecting numerous ships. If commercial operations like chartering, logistics, bunkering or invoicing are disrupted, ships may still sail, but the financial consequences can be severe – as experienced in 2017 with the Petya/NotPetya-variant ransomware attack.

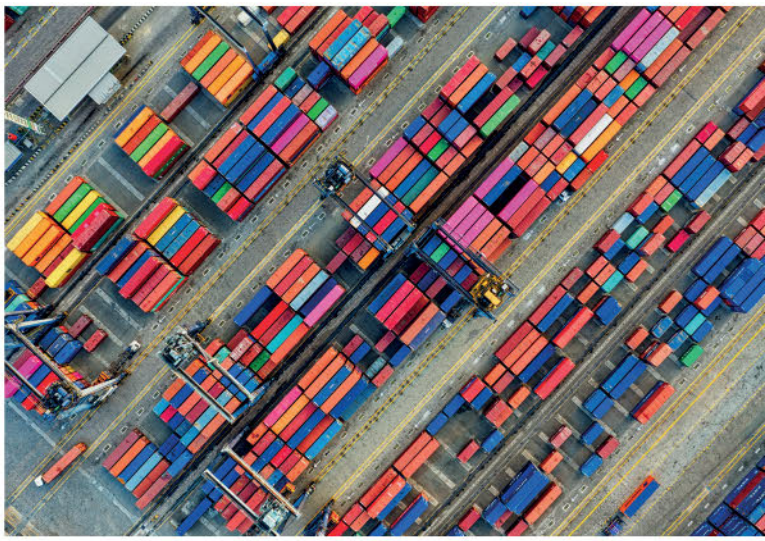
While several shipping companies were hit by NotPetya, the most publicised was possibly Maersk. NotPetya infected Maersk's IT infrastructure, locking PCs and servers across 600 sites, crippling terminal operations, container tracking and booking systems and preventing cargo handling at more than 70 ports worldwide. Maersk consequently reported losses of approximately US$300 million due to disrupted operations, lost revenue and recovery costs.

Ports can be just as vulnerable as ships, Vold points out: they operate critical IT systems that can affect vital logistics chains involving multiple stakeholders. As a result, ships may be unable to unload or dock, leading to prolonged anchoring times and, in some territories, food, medicine and fuel shortages.

AI and AiTM

Hackers and criminals are increasingly using AI, including for voice manipulation. They can create voice imitations of crew members or office staff to trick people into revealing passwords, log-in credentials or other sensitive account information.

In its 2025 intelligence report, NORMA Cyber states that attackers are using phishing tools capable



Ports can be just as vulnerable as ships to cyber-attacks (image: Logicalis UK&I)

of bypassing multi-factor authentication (MFA) to gain account access. These are known as 'Attacker-in-the-Middle' (AiTM) attacks, where the victim logs into their Office 365 account to view shared content. The attacker monitors the authentication process and steals the username, password and session cookie.

Cookies allow the attacker to log in as the user without triggering a new authentication process. In the last six months of 2024 alone, NORMA Cyber has reported over 80 user accounts compromised by AiTM phishing attacks. This type of phishing poses a serious threat of financial fraud, data theft and network compromise, both onshore and offshore.

NORMA Cyber is advising its members to prepare for worst-case scenarios and to be as resilient as possible. This means having redundant systems, barriers, back-up systems and solid routines in place. If an attack does occur, the company stresses, it's crucial to have protocols and systems ready to ensure a fast recovery – provided a back-up or reserve systems are available.

However, this planning should avoid devolving into undue paranoia. For example, Line Falkenberg Ollestad, advisor at the Norwegian Shipowners' Association (NSA), says the NSA often receives questions as to whether states could embed equipment to take control of specific vessels. She emphasises that there is no reason to stir up fear or warn against specific countries or shipyards, but rather base decisions on facts. Misinformation could be a bigger threat, Ollestad notes. ■

FRESH FIREFIGHTING TACTICS

The British Tugowners Association and partners have issued guidance to help tugs safely tackle a variety of at-sea fires, including blazes involving alt-fuels, requiring a distinct response

Updated guidance on tackling 'non-traditional' fires, including those involving batteries and alternative fuels, take prominence in the British Tugowners Association's (BTA's) recently published *Use of Tugs in Firefighting* e-doc, which offers industry-standard guidance for tug operators.

"In 2023, over 200 shipboard fires were reported globally, highlighting the urgent need for effective firefighting protocols," the BTA says. "Additionally, with the growing prevalence of alternatively fuelled vessels, such as those powered by lithium-ion batteries, methanol and ammonia, the guide addresses a critical gap in practical marine firefighting procedures."

The UK-specific guide (drawn up to comply with SOLAS and Merchant Shipping Act requirements) was developed with input from Lloyd's Register, UK Harbour Masters, Hampshire Fire & Rescue, REACT Emergency Response, Artemas Academy and Multraship Towage and Salvage, among others. Additionally, Society for Gas as a Marine Fuel (SGMF) and Shipowners P&I contributed to the document.

The contents include up-to-date information on areas such as: the legal obligation to assist persons in distress (as outlined in the abovementioned SOLAS/MSA requirements); the importance of establishing training standards and conducting regular firefighting drills; and the different categories of FiFi-rated vessel, plus the equipment, monitor types and discharge rates required for each.

Alt-fuels incoming

In his intro to *Use of Tugs in Firefighting*, Ruud Plomp, owner and founder of Artemas Academy, writes: "During my career, I have worked with a large variety of tugs, crews and equipment. Although it may look the same to a lay person – tugs spraying water over or against a burning ship – experts will immediately recognise the difference between a good, less good or poor deployment of the tug.

"The crew must be able to deploy their tug in the safest and most effective way under a wide range of circumstances. The tug itself must also be in good condition, both from a nautical and firefighting technical perspective. Besides maintaining the ship, [crew] must regularly test the equipment, go through the relevant procedures and checklists, and collaborate with other parties and organisations."

The guide notes: "As of May 2025, according to Clarkson's World Fleet Register, 2,224 vessels in the global fleet [2%] were alternative-fuel-capable." This is in addition to, the guide continues, "an orderbook of 1,991 vessels, representing 52% of the tonnage in the global orderbook".

As such, the techniques traditionally employed to combat hydrocarbon-based fires may prove obsolete when up against alt-fuels like battery packs, LNG, LPG, methanol, ethanol, HVO/FAME, ammonia, hydrogen and even nuclear energy.

Battery issues

For example, the guide explains that, while a lithium-ion (Li-ion) battery can store significant amounts of energy, it can be highly dangerous if it overheats and enters a state of thermal runaway, where it keeps producing more heat in a chain reaction. While Li-ion batteries are usually safe, problems can occur if the battery becomes damaged, either due to physical impact, overcharging, extreme heat or issues with the battery's control system.

"Thermal runaway generates large volumes of flammable gases that can catch fire very quickly and may also cause a vapour cloud explosion," the guide warns. "Gases of a Li-ion battery fire are extremely white and should not be confused with a steam cloud." When thermal runaway occurs, the battery can reach temperatures exceeding 1,600°C and violently release toxic gases, flames and pieces of the battery itself. This can spread to nearby batteries or flammable materials, rapidly making the fire more intense. The toxic gases form a vapour cloud that can easily explode if it builds up in a confined space. This emphasises the need for proper venting.

"Lithium-ion battery fires are extremely difficult to extinguish and boundary cooling of the affected area or vessel until the fire burns itself out is often the best course of action," the guide advises. "The use of fixed firefighting systems on board and water jets for boundary cooling is the most effective known method for control."

The guide recommends that tugs called in to assist casualty vessels in the event of a Li-ion battery fire consider three factors. Firstly, the internal location of the fire: "due to the intense heat, it is possible there will be structural damage or hull integrity compromised, which could be exasperated through thermal shocking from boundary cooling water", the guide notes. Secondly, vapour cloud venting: "the assisting vessel should remain upwind, and where possible on the weather side, of the area where the vapour cloud is being vented due to the potential

toxic gases and toxic soot", the guide explains. Thirdly: "the assisting vessel should remain a safe distance from the casualty vessel due to the explosion risk from the vapour cloud".

Li-ion battery fires are tricky because they can restart days after they seem to have been put out, due to leftover chemical energy in the battery. This means water needs to be applied for a considerable period, though too much water could affect a burning ship's stability. The water used to fight these fires can also become polluted with toxic metals, which can harm the environment and people's health, so protective gear is essential for anyone involved in its containment.

Ammonia risks

Liquid ammonia, meanwhile, is toxic when inhaled: high concentrations of ammonia vapour can cause immediate irritation to the eyes, nose, throat and respiratory system, and prolonged exposure can lead to death.

"A liquid ammonia leak or spill requires a larger exclusion zone than LNG or LPG due to ammonia's high relative density, which causes the ammonia vapour cloud to sink and pool on the deck or water surface," the guide says. "It is more persistent and takes longer to dissipate compared to LNG or LPG, requiring larger exclusion zones."

The most effective way to extinguish ammonia fires, the guide recommends, is "applying water via water spray". However, crew should be aware that "applying large quantities of water to an ammonia liquid pool will increase the evaporation rate, making the fire larger". The guide continues: "Water spray on ammonia vapour should be applied with caution, as it may result in the formation of ammonium hydroxide, a corrosive by-product. Recondensing ammonia vapour, in certain scenarios, can reduce the intensity of the release but must be carefully managed to avoid further liquid release.

"Firefighting tugs likely to attend an ammonia fire should have gas detector(s) which are calibrated to the safe exposure limits of the chemical."

Ammonia is less likely to catch fire than other gases, so sending tugboat crews into areas with hazardous ammonia vapour levels should be avoided unless absolutely necessary, the guide suggests. Responding to ammonia leaks requires the use of proper personal protective equipment (PPE), including full chemical suits with self-contained breathing apparatus (SCBA), especially when ammonia levels exceed 30ppm.

Methanol fires

Methanol has also attracted owners and operators keen to source alternatives to HFO/MDO, but has some fire safety-related drawbacks. These include a low flashpoint of 11°C, which makes it highly flammable and volatile, and the fact that it burns with a near-invisible blue flame and little smoke makes it extremely impossible to detect without the use of thermal imaging cameras – which the guide recommends as 'must-haves'.

The guide adds: "Aqueous film-forming foam [AFFF] is recommended for extinguishing a methanol fire. Water should be used only for boundary cooling, as methanol can continue to burn even when diluted 90% with water, which makes vessel stability a significant concern if only water is used to fight a methanol fire.

As more ships adopt green propulsion, firefighting tugs face new risks from battery and alt-fuel blazes, the British Tugowners Association advises (image: Robert Allan Ltd)

"Methanol's relatively slow evaporation rate means it can accumulate in a confined area, leading to an increased risk of toxicity. Firefighting tugs attending a methanol fire should be equipped with gas detectors calibrated to safe exposure limits of methanol, and personnel should wear appropriate PPE, such as chemical suits with SCBA to prevent exposure during firefighting operations."

As the maritime industry evolves, engaging with such resources may prove crucial for ensuring safety and preparedness in tackling fires involving alternative fuels – and could prove a useful stepping stone to developing an international framework for such firefighting operations. ■

SAFE SPACE

The reduced footprint offered by Survitec's Safehaven lifeboat system could give naval architects more onboard room to play with, helping to redefine cruise ship design, writes **David Foxwell**

Hit hard by the COVID-19 pandemic, the cruise ship industry has rebounded with a spate of orders for newbuilds, leading to an orderbook that now stands at around 70 vessels: a trend that could provide the first opportunities for a revolutionary change in lifeboat technology.

So says marine safety specialist Survitec, which is eyeing initial orders for its Seahaven system, the world's largest inflatable lifeboat.

Developed in the early 2020s, Survitec secured type approval for the Seahaven lifeboat system from Lloyd's Register (LR) in September 2022. It subsequently completed heavy weather sea trials, in line with SOLAS requirements for novel appliances. This required the test to be performed in conditions that do not drop below six on the Beaufort Scale, and the IMO A.520 physical tests as required by LR.

The Seahaven has also been the subject of a number of studies. A Brookes Bell report highlighted a 15-33% reduction in evacuation time compared to conventional lifeboats, and found that the Seahaven achieved a 100% success rate in optimal conditions, outperforming the 73% success rate of traditional lifeboats. The report concluded that the Seahaven reduces potential loss of life by nearly 50%.

A Lawes & Co report outlined operational efficiencies, including reduced onboard inspections and maintenance, from 150 hours per month for traditional lifeboat systems to just 8–10 hours per month. The reports also highlighted reduced training requirements, made possible by the use of controlled environments and simulators, removing the risks associated with lifeboat drills.

Foreship study

Now, says Survitec, another independent study has confirmed the Seahaven's ability to enhance safety and drive revenue growth. The study, published in April 2025 and undertaken by naval architecture and marine engineering consultancy Foreship, quantifies what Survitec describes as "substantial benefits" if the Seahaven is integrated into cruise ship designs.

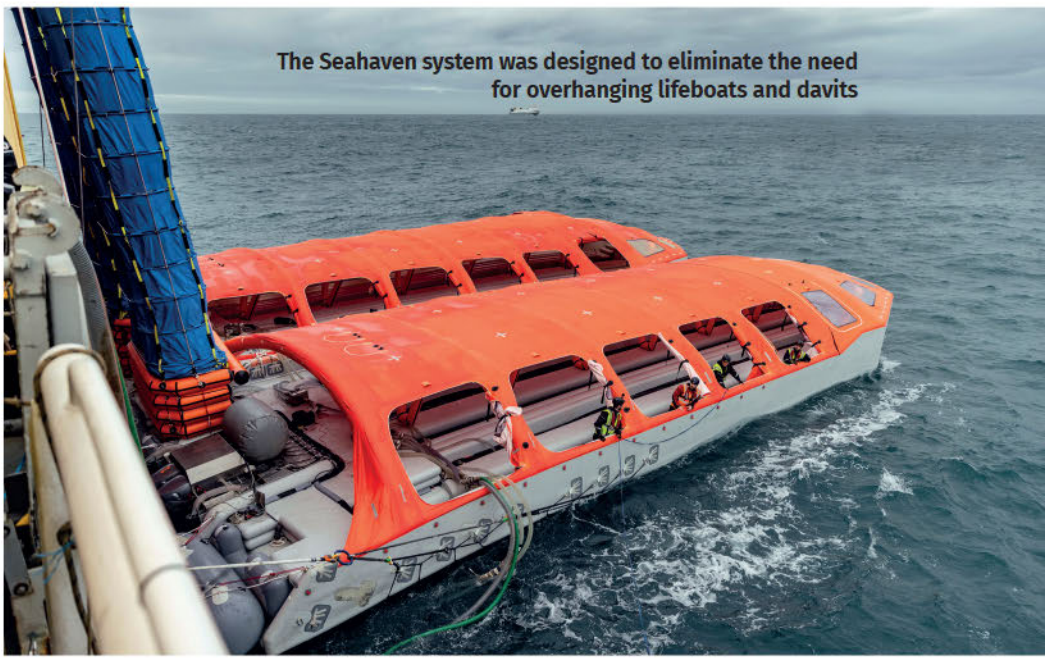
The Foreship study also notes that, if used in place of conventional lifeboats and davits, across different vessel sizes and arrangements, the Seahaven confers significant weight advantages and is suitable for both new designs and retrofitting on existing ships.

Speaking to *The Naval Architect* in May 2025, Survitec commercial director MES and AES Richard McCormick said the company appointed Foreship to independently review the application characteristics of the Seahaven design and to evaluate the integration of the Seahaven in place of conventional lifeboats. The study also assessed the impact on escape routes and muster station configurations, and quantified technical benefits, such as additional cabin and public space gains.

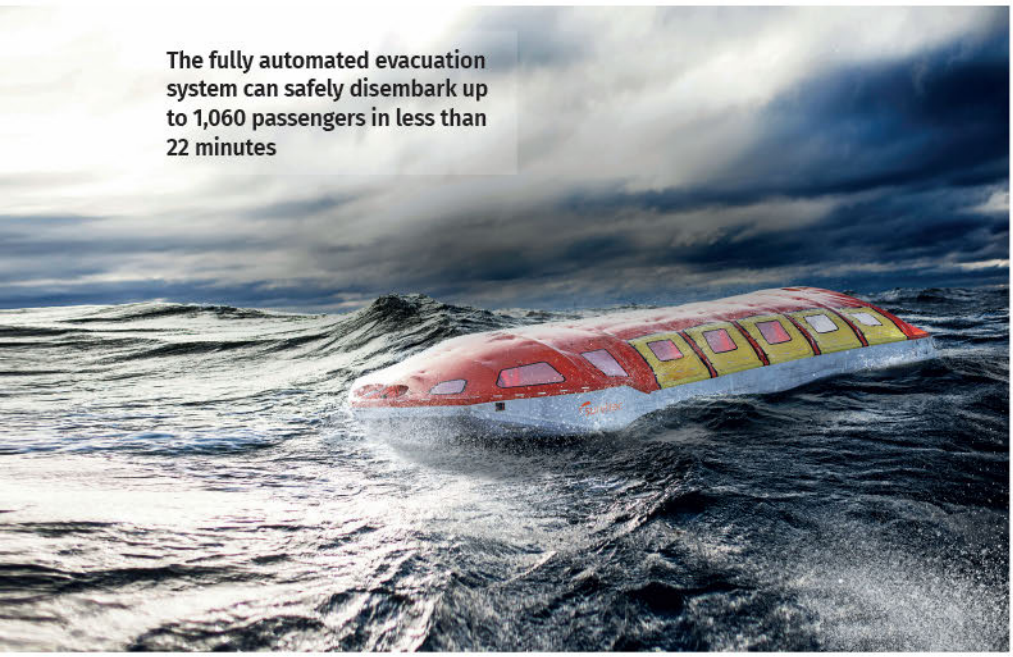
A whitepaper, *Seahaven Application Study*, outlines the study's findings and examines a number of potential configurations for integrating the Seahaven system. McCormick said the study "emphasises the Seahaven's ability to enhance cruise ship layout and functionality, optimising valuable deck space by eliminating bulky davit-launched lifeboats". He also highlighted the reduced number of crew associated with the deployment of the system compared to conventional arrangements.

Reduced footprint

McCormick noted that contracting for new cruise ships is running at a high level, and said that



The Seahaven system was designed to eliminate the need for overhanging lifeboats and davits



The fully automated evacuation system can safely disembark up to 1,060 passengers in less than 22 minutes

the company is closely engaged with the leading operators, designers and yards specialising in cruise vessel construction.

"There was a lull in construction during and immediately after the pandemic," he explained, "but that has changed. There are a number of new designs being developed that the Seahaven is being considered for, and we are hopeful of an order by the end of 2025."

"Our main target area is the market for medium-to-large-sized vessels," he said. "So, if we assume that conception of a new design to its introduction into service can take four to five years, we are confident that, by 2029/2030, the first newbuilds with the Seahaven will be entering service."

Apart from enabling rapid evacuation of large numbers of passengers, one of the advantages of the Seahaven is that it occupies reduced vertical and longitudinal space on a vessel, compared to conventional lifeboat designs, enhancing bridge visibility and minimising vessel overhang. This characteristic is particularly beneficial for vessels manoeuvring through the Panama Canal, said McCormick.

The system's reduced weight, compared to conventional lifeboat configurations, affords greater flexibility in ship design, which may lead to reduced construction costs for newbuilds and improved stability for retrofitted vessels.

"With this design flexibility, operators can repurpose prime space for additional passenger cabins, expanded public areas or upgraded leisure and entertainment facilities, ultimately enhancing revenue potential," McCormick explained. "The whitepaper outlines opportunities for mid-sized cruise ships, such as converting interior cabins into sought-after balcony cabins. Alternatively, larger vessels can utilise space savings to introduce additional leisure and entertainment facilities, ultimately enhancing the guest experience."

Capacity analysis

In the Foreship study, a capacity analysis was conducted to evaluate the alignment of the Seahaven lifeboat system with various vessel sizes and configurations. This measured how well the Seahaven system matches the maximum persons on board, including passengers and crew.

The study also compared the Seahaven's deployment characteristics with conventional lifeboats, focusing on SOLAS requirements for a 20° heel deployment. In the case of medium-sized cruise ships, the study found, the Seahaven integrates well, with no significant SOLAS deployment issues. Its minimum helical slide length suits most designs, allowing manageable deployment without major modifications.

As a fully automated evacuation system, the Seahaven can safely disembark up to 1,060 passengers in less than 22 minutes, eliminating the complexities associated with davit and release-hook mechanisms. By simplifying onboard lifesaving appliance (LSA) management, the Seahaven reduces maintenance costs and crew training requirements while ensuring compliance with SOLAS regulations.

The system – which Survitec believes can unlock up to 85% more deck space in some cases, compared to a conventional arrangement with lifeboats and davits – has a much smaller stowage footprint, and is launched at the push of a button. It can travel independently for 24 hours at speeds of up to 6knots, and contains SOLAS emergency packs.

The Foreship analysis also highlights Seahaven's adaptability across multiple deployment configurations, including hybrid solutions integrating marine evacuation systems (MES) and tender lifeboats. This flexibility ensures seamless integration into diverse vessel types, making the Seahaven a viable LSA solution for cruise lines looking to future-proof their fleets.

"This review outlines the Seahaven's innovative step forward in inflatable lifeboat design, offering enhanced passenger safety, flexibility, cost upsides and improvements to both onboard operations and passenger experience in suitable applications," the authors of the whitepaper concluded. "For any vessel, the Seahaven's deployment time will be a critical advantage in future real-life scenarios, with studies finding safer evacuations and evacuation time improved by up to 33%." ■

RELIABLE, REALISTIC WAVE FORCE ANALYSIS

Rob Melville and **Johan Daelman** of offshore technical solutions provider Kent explain how leveraging CFD in tandem with potential flow modelling can better capture critical wave conditions in relation to offshore wind turbine monopiles

Offshore wind turbines are subject to a variety of dynamic environmental forces, amongst which wave run-up on monopile foundations is of particular concern. This run-up can generate significant impact forces on secondary structures, such as external working platforms and access arrangements. Accurate prediction of these forces is crucial for designing robust and resilient secondary structures, particularly under extreme wave conditions.

Semi-empirical models use established wave theory, empirical correlations and simplified assumptions to estimate wave run-up heights. While they are computationally efficient and widely used in engineering practice, they lack the spatial resolution needed for complex geometries and therefore tend to be used in an overly conservative manner, which can result in costly over-engineering of structures.

Leveraging CFD

For many years, CFD has provided a possible alternative approach to modelling the forces resulting from wave run-up. CFD allows the 3D geometry of an offshore monopile to be accounted for (including features such as working platforms), calculates the transient interaction of the wave with the structure and allows the pressure loading across the structure to be extracted. The physics models employed also allow for features such as breaking waves to be modelled.

However, due to practical project budget and schedule constraints, CFD has typically been employed only for a few scenarios, and tends to be used to model regular waves. A variety of different regular wave profiles can be used, including linear and non-linear, which can be tied back to specific extreme sea states (for example, one in 50-year wave exceedances).

Although this can lead to excellent prediction of loading under certain modelled conditions, concern has been expressed as to whether such approaches may necessarily guarantee conservative or 'worst-case' results that can be applied to the structural design, because simulating only a few regular waves may not accurately represent the characteristics of the waves that generate the highest run-up forces on a structure. This is because real sea states are inherently irregular, and the non-linear interactions between the components of irregular waves can produce effects that idealised regular wave models cannot capture.

For instance, the local steepness of interacting irregular waves may exceed the breaking limit of regular waves. Since the forces from wave run-up on a structure depend, among other factors, on wave steepness, using an irregular wave model allows for a more accurate representation of these forces.

Irregular sea states

To address this concern, an alternative approach is required to model a more realistic series of waves.

One approach is to model a time series of irregular waves for an extended period of physical time (ie, several hours) over a large domain allowing non-linear interaction between irregular wave components to achieve irregular, non-linear waves representative of extreme sea conditions (see Figure 1). This would be an extremely costly and time-consuming endeavour with 3D CFD modelling. However, this can instead be achieved using less computationally expensive solvers, such as potential flow solvers (which assume inviscid, irrotational flow) or even 2D CFD simulations, and need not include the geometry of the monopile.

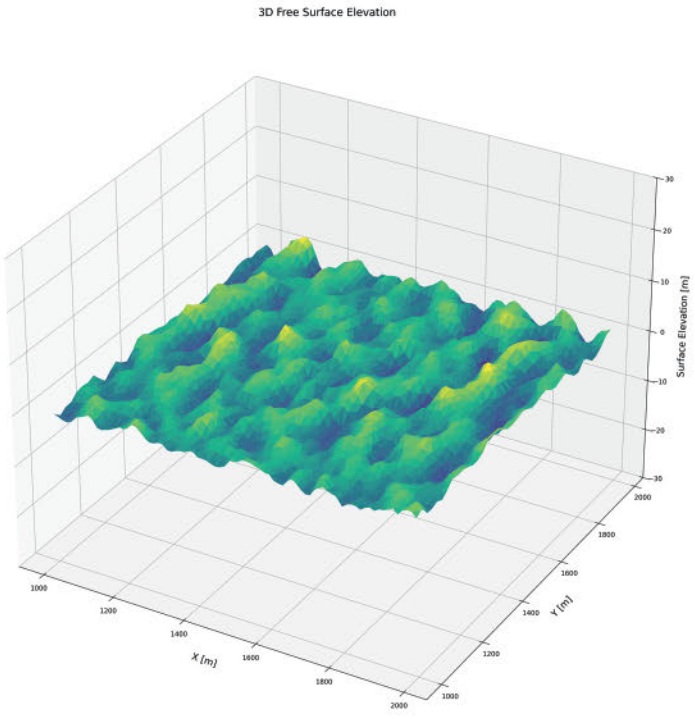


Figure 1: An example non-linear and irregular wave field, based on potential flow theory

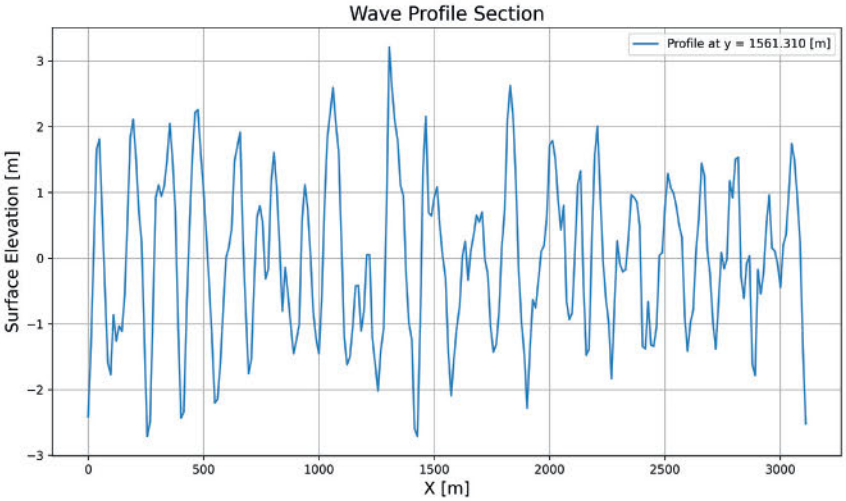


Figure 2: An example 2D cross-section of the non-linear and irregular wave field used to force the 3D CFD model

After running for a large period of physical time, thousands of waves are then produced, which can then be interrogated to capture critical wave scenarios, including the crest height, crest velocity, steepness, or the potential to plunge or spill, using, for example, semi-empirical models.

Following the identification of critical wave conditions, a 3D CFD model can be constructed over a smaller domain but including explicit representation of the monopile and associated secondary structures. The CFD model can then be initialised with, and driven by, the irregular sea state modelled in the 2D simulations at the times when the critical waves would be expected to impact upon the monopile (see Figure 2).

The 3D CFD phase focuses on accurately simulating the interaction between waves, the monopile and secondary structures, including run-up, breaking and the resulting pressure loads. Key outputs include time-varying wave shapes, spatial pressure distribution and force measurements on the platforms.

Benchmarking can be conducted to ensure the accuracy of the CFD outputs by comparing them with 2D results and available empirical data. This

hybrid approach allows the high accuracy of CFD to be employed but with increased confidence that the most critical wave cases have been captured.

Confidence in determining design loads for a wind farm would be expected to increase with the number of cases modelled, not just in terms of identifying candidate cases from the series of irregular waves. In addition, the physical scale of an offshore wind farm is such that several different environmental conditions may need to be considered, including seabed slope and bathymetry; this impacts the behaviour of the wave as it progresses towards the monopile. If the monopile sits on a sloped seabed, this can serve to increase wave run-up compared to a flat terrain.

Metocean data can also vary across the wind farm, so several different extreme wave conditions may need to be considered.

Cloud computing

In recent years the hardware available to CFD engineers has been transformational. Just a few years ago, CFD modelling might typically be carried out on high-performance computing (HPC) clusters on the premises, which, while easily capable of modelling wave simulations, are a significant financial investment, have limited capacity and are often in high demand. This usually meant that, although CFD was a theoretical option for wave run-up modelling, only a handful of scenarios might be able to be simulated before a project deadline was reached.

Cloud computing has changed this. Not only do simulations now run faster on the latest chipsets, but they can also be undertaken in parallel, allowing a step change in the number of cases that can be considered within a typical project time frame. However, while the schedule constraints have been mostly addressed by the practically unlimited availability of computing power, the financial constraints have not. HPC remains expensive, and so hybrid approaches such as that outlined here present a practical way forward, whereby full 3D CFD modelling is used in conjunction with long duration 2D background flow fields.

Realistic, reliable data

Wave run-up remains a critical design consideration for offshore wind turbine monopiles, especially given its potential to impose significant loads on secondary structures. While semi-empirical methods offer a fast and conservative estimate, they lack the fidelity required to capture complex interactions with realistic geometries and sea states. CFD offers a compelling alternative, delivering high-resolution insights into wave-structure interactions and the resulting pressure loads. However, modelling irregular seas in full 3D CFD remains computationally intensive.

The hybrid approach outlined here – using lower-cost 2D or potential flow solvers to identify critical wave conditions, followed by targeted 3D CFD simulations – offers a practical and robust solution. It combines the accuracy of CFD with the broader context of realistic sea states, improving confidence in the structural loads used for design. With advances in cloud computing, the feasibility of such high-fidelity modelling has improved dramatically, allowing more cases to be run in shorter time frames.

Ultimately, the adoption of hybrid modelling techniques enables more defensible and efficient structural designs, improving accuracy while maintaining safety. As computational power becomes ever more accessible, such approaches are likely to become standard practice in offshore wind foundation design. ■

Rob Melville is fluid mechanics team lead and Johan Daelman is senior naval architect at global engineering firm Kent, which specialises in innovative offshore structure designs, including floating wind technology, with over 40 years of industry experience.

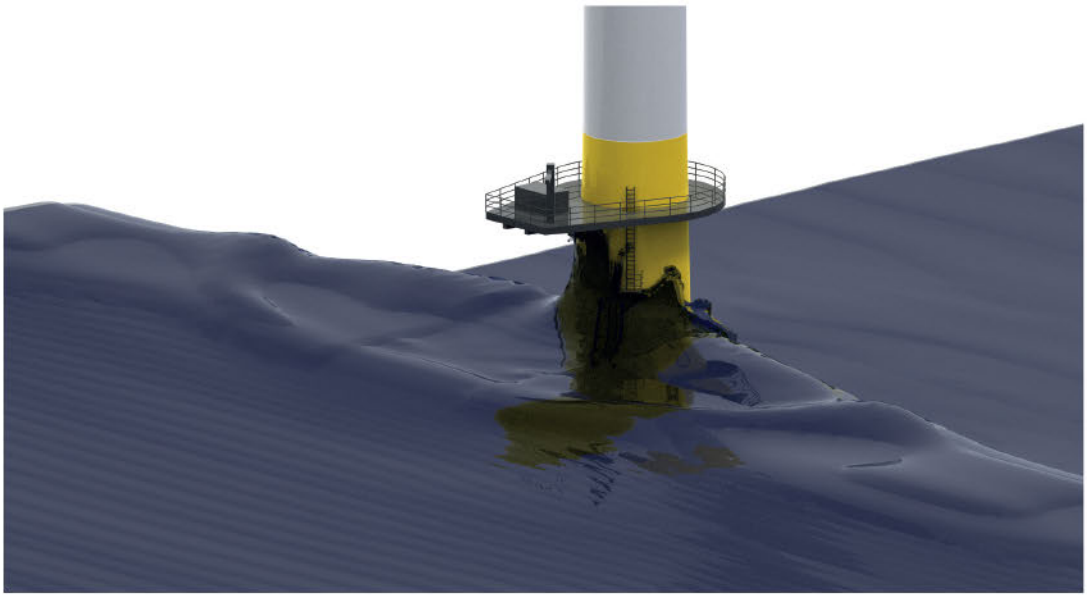


Figure 3: CFD modelling showing interaction of wave with monopile and secondary structures

LONG FUSE

A Norwegian project seeks to combine AI and hydrodynamics to assist the shift towards more energy-efficient operation, writes **David Foxwell**

A Norwegian project that started late last year will combine conventional hydrodynamics and artificial intelligence (AI) to reduce shipping's environmental impact. As Pauline Røstum Bellingmo, a research scientist, and Svein Peder Berge, a senior business developer at SINTEF, tell *The Naval Architect*, the partners in the FUSE project, which is funded by the Research Council of Norway and runs until 2028, want to expedite the shift towards energy-efficient operation through the development of enhanced ship performance models for voyage optimisation systems.

"On its own, conventional hydrodynamics has its limitations," says Berge. "So too does AI. We want to bring together two domains – ship hydrodynamics and AI – to rapidly reduce emissions from shipping.

"A purely data-driven approach to voyage optimisation can only take you so far. In this project we will explore ways to 'fuse' conventional ship hydrodynamics and AI to enhance ship performance estimations, with a particular focus on integrating operational data and AI with hydrodynamic models, to enable highly accurate models that can be applied to classes of vessel, rather than individual vessels.

"The idea is to develop theoretical approaches and methodology utilising the potential of using AI in combination with classical hydrodynamics, to develop more accurate numerical models for ship performance, including both energy and motion characteristics.

"Traditional hydrodynamic models are based on first-principles, reflecting physical laws. AI-based models which use operational data are used to establish a statistical relationship between inputs and outputs. Both approaches have their pros and cons, and we aim to fuse the best of both of them and develop hybrid models that will provide input to next-generation voyage planning and onboard decision support systems."

The partners in FUSE believe outcomes from the project could feed into voyage optimisation systems to reduce ship emissions (image: Einar Aslaksen)

Bellingmo notes that IMO wants to reduce greenhouse gas emissions from shipping by at least 40% by 2030, but vessel retrofits and transitioning to green fuels are unlikely to achieve the 2030 goal.

Energy-efficiency measures, on the other hand, can bring the industry closer to the 40% mark, she says.

"Voyage optimisation is one of the most promising operational measures to enhance energy efficiency," Bellingmo says. "It has the potential to reduce emissions, by between 10-30%. But, to achieve the most significant savings, accurate models for estimating ship energy consumption are required, and accurate predictions of fuel consumption in varying operating conditions are essential."

Bellingmo and the partners in the project – SINTEF Ocean, SINTEF Nordvest, NTNU, ferry operator Torghatten, G2 Ocean, Vard Electro and voyage optimisation company NAVTOR – believe FUSE can have a major impact on reducing emissions. Bellingmo and Berge note that, in 2018, global shipping emissions amounted to 1,076 million tonnes of CO_2, but that NAVTOR's voyage optimisation products are installed on 18,000 ships, accounting for around 30% of the global fleet. "Assuming the outcomes of the FUSE project can reduce emissions by 20% for each vessel, this would make a global emission reduction of 65 million tonnes of CO_2 when applied to vessels fitted with NAVTOR systems," they explain.

Ship motions

In addition to reducing energy consumption and emissions, the outcomes of the project will increase passenger and cargo safety through the development of enhanced models for predicting ship motions.

Bellingmo says: "This will reduce operating costs, enabling owners to avoid costs incurred as a result of damaged cargo and fatigue caused by excessive ship motion."

The outcomes from FUSE will benefit all of the participants in the project, says Bellingmo: "Vessel owners such as Torghatten and operators like G2 Ocean will be able to unlock the potential of operational data to optimise operations and reduce emissions. This will result in cost reductions from fuel savings, and increased competitiveness.

"NAVTOR and Vard Electro will benefit from the knowledge of how to fuse hydrodynamics and AI for enhanced voyage optimisation products that effectively leverage operational data. For Vard Design, enhanced ship performance estimation will provide insights from vessel operations that can improve ship design." ■

SHIP AESTHETICS: AN ENDANGERED ART?

Are naval architects losing the ability to produce 'beautiful' vessels and neglecting older but proven design concepts, asks **Maurice Napier**, C. Eng FRINA?

Picture 1: *Bulimba*, at Gravesend (image: George Garwood/World Ship Society)

Views on aesthetics vary greatly. For example, some ship enthusiasts shun a cruise company promoting its vessels as 'beautiful', thinking 'hideous' is more appropriate. Naval architectural training used to include making designs attractive but (with praiseworthy exceptions) how often is this considered nowadays?

Old ideas were that tempting appearance importantly created pride and encouraged other customers to use the designers, builders and owners – while encouraging crews to take more care of their vessel if she appealed to them. Surely these factors still apply. Also, attractive ships drew me and others interested in ships into the industry, giving a delightfully satisfying career in naval architecture, but few modern craft would have had that effect.

It is almost impossible to make some vessels attractive, but adopting fashionable features ignores the fact that fashion changes quickly and what it dictates today becomes unfashionable quite soon. That matters little with clothes or shoes, etc, which are replaced frequently, but ships should last much longer, and good styling principles remain constant indefinitely. Who wants their ship to look unattractive and/or outdated within several years?

There are reasons why conventional views evolved, and consistency should be paramount: for example, vertical bows look wrong with raked deckhouse fronts and vertical funnels cannot match raked bows or streamlined superstructures. Attractive design does not require complex curves or shapes, but proportions are critical (eg, Elder Dempster's *Eboe*/*Ebani* cargo liners appealed widely but the long, low superstructure aft on passenger liner *Windsor Castle* produced disparaging descriptions, as resembling a big tug). A report about a modern yacht said that her hull inspiration came from the hood of a cobra to give a menacing appearance, but would most people not prefer resemblance to a beautiful creature?

The 'golden ratio'

Many oldies regard the British India Bulimba-class cargo liners as representing a high point in aesthetics (see Picture 1). Built about 1960, they would not suit modern requirements, but some aesthetic aspects remain valid. Practicalities must naturally take priority – eg, superstructure aft is normal now for efficiency and cost, over-riding

opinions that the most attractive location is about 70% aft.

As Euclid commented, anything rectangular looks best if its length to depth matches the 'golden ratio' of about 1.618. When practical, this should therefore be the target for deckhouses, openings, windows, furniture, etc.

Funnel tops should be higher forward than aft, and should be shorter than their bases, with the fore end raked aft about 50% less than the aft end is raked forward. Black or coloured bands on a funnel with a sloped top should be angled and tapered (deeper forward), not horizontal or parallel to the top.

I recall an official notice stipulating curved deckhouse fronts instead of straight ones – albeit not for aesthetic reasons. Hopefully its motive is now unnecessary, since it was because a straight front greatly helped submariners to assess when they were abreast a ship before firing torpedoes – but curvature reduces windage effects and looks much nicer. If a straight front is necessary, radiused corners greatly improve appearance at little extra cost (see Picture 2). Even if sharp corners are adopted at wheelhouse fronts, appearance is enhanced considerably by radiusing corners of any eyebrow/sunshade overhead. If a sloped eyebrow is fitted above a wheelhouse, its depth at the centreline should be greater than at its sides, since perspective when viewed from forward makes a consistent depth appear undesirably as if the middle is shallower.

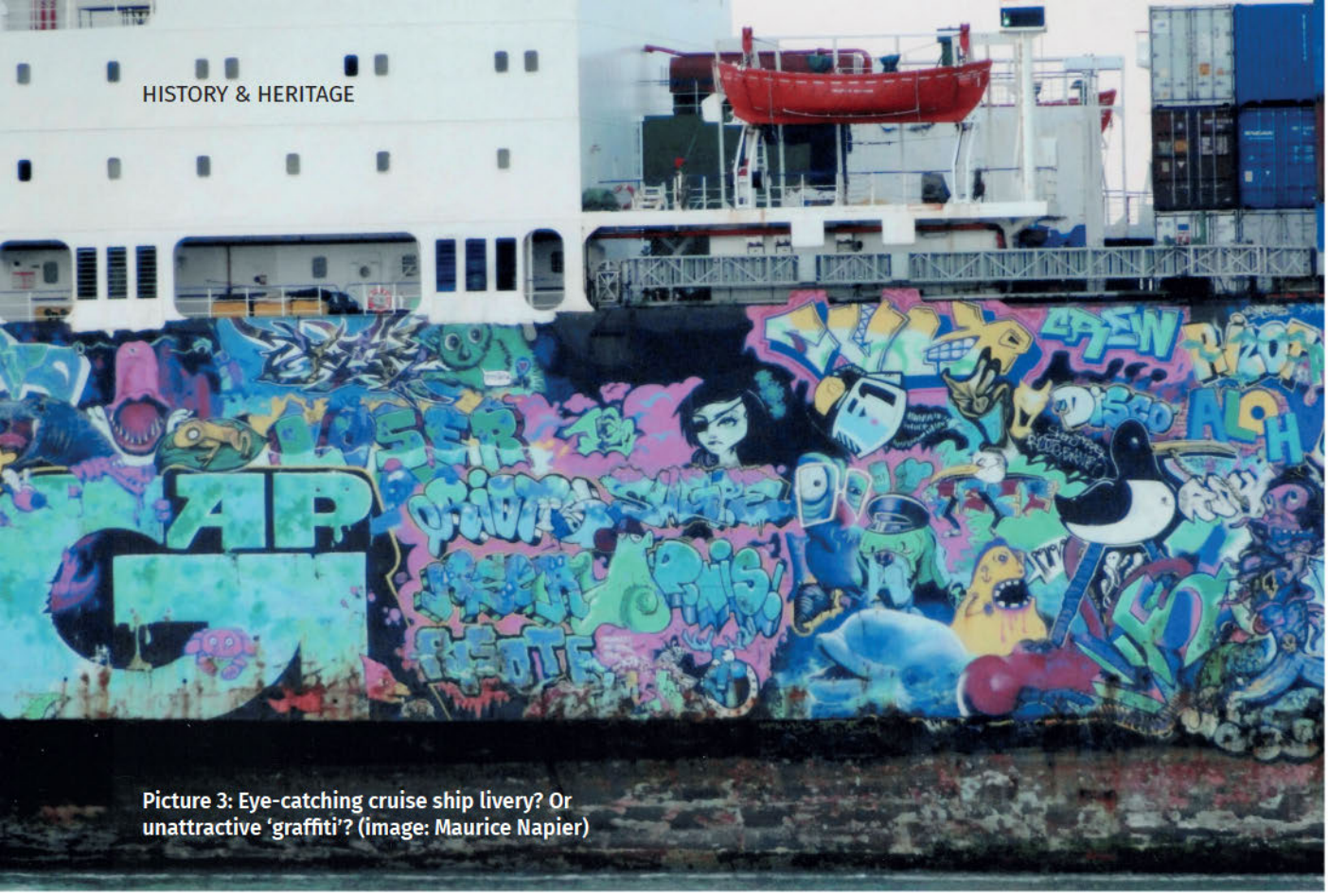
Modern ship aesthetics have a disadvantage due to smaller complements, since big accommodation blocks are more conducive to attractive design, as has been apparent for years – for example, when Watts, Watts & Co put much of the crew accommodation below deck, the superstructure appearance suffered. Graffiti was/is good fun on Moby ferries, but garish artwork on cruise ships can deter passengers from using them, and most people shudder at anything like Picture 3.

Considering windows

Windows greatly affect appearance – basically, the more the better, and pairs of them look better than singles, but spacing them equally on each deck is less attractive than staggering them. Rows of large windows look better if the foremost and aftermost ends are raked forward.

A coloured band painted across a deckhouse at window height can look good, but needs care to avoid the impression of no windows. Large circular windows resembling portlights are quite common in passengers' public spaces but rectangular, parallelogram or trapezoidal ones are more pleasing aesthetically.

Picture 2: The deckhouse of *Homeric* (image: Maurice Napier)



Picture 3: Eye-catching cruise ship livery? Or unattractive 'graffiti'? (image: Maurice Napier)

Rectangular windows on curved, sloped wheelhouse or deckhouse fronts often have tapered gaps between them, which look strange but arise when curvature is conical, defined by radii from the same fulcrum at deck and deckhead, creating different arc lengths at top and bottom. Having the same radii top and bottom avoids this (achieved by moving the fulcrum) – ie, making the front like part of a sloped cylinder instead of a partial cone.

Stanchions should be equally spaced and match each other unless good reasons arise for irregular spacing or design. Also, please take care when positioning pipes (see Picture 4).

Where stanchions or windows are raked and have radiused corners, the acute and obtuse radii should never be the same, since that creates a small arc at obtuse angles and a larger arc where acute, looking weird. Instead, radii at obtuse angles should exceed those at acute ones so that the tangent points where the curves meet the straight, sloped sections are at the same height.

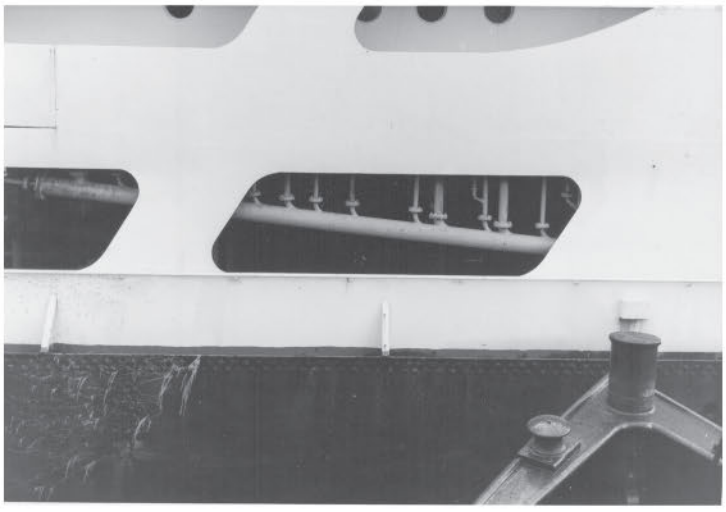
Promoting some ships as having the stem, aft end of funnel and superstructure stanchions parallel sounded good and looked fine on profile drawings, but the effect was lost because viewing a vessel from any angle except broadside-on made the slopes appear different.

Sheer joy

For those people old enough to remember when almost all ships had sheer (seldom as pronounced as in Picture 5), the best appearance was achieved when the lowest point was about one third of the vessel's length from aft. Zero or negative sheer (especially forward and even if just on a bulwark or paintline) can make a vessel's back appear to be broken, especially when the viewer is below it as is common.

Fo'c's'les and/or poops on ships with dark hulls look better if these areas are painted white.

If exhausts project above a funnel, they look best if ends are cut at an angle. Scrubber housings are generally repulsive



Picture 4: Watch out for unusual pipe locations (image: Maurice Napier)

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Picture 5: An example of very pronounced sheer (image: Maurice Napier)

to most people who like ships, but the industry has limited options, especially when converting existing craft. They could, however, often be improved by simply and cheaply sloping the top and/or end(s) or by suitable colouring – or painting imitation windows to make the structure appear as a deckhouse extension, as on *Sampogracht* (Picture 6; thank you, Spliethoff Group).

Aesthetic considerations are secondary if conflicting with major aspects – for example, builders made a mess of ogees on a superstructure, differing greatly from the drawings, but the owners accepted the terrible shapes when told that corrections would delay delivery. The costs of making ships look well can, however, be minimal, and bring great satisfaction. Streamlining has sometimes gone to extremes, with varying results, but often appealed, and modern production methods simplify procedures, reducing costs. Some shipowners spend considerable amounts on stylish buildings but economise on their vessels' aesthetics, which publicise their image widely.

The 1951-built passenger ship *Ocean Monarch* was awarded the American Academy of Design Gold Medal for "outstanding beauty and radical design features". How many modern vessels are beautiful? ■

Picture 6: *Sampogracht* on the Kiel Canal (image: Martin Lochte-Holtgreven)

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