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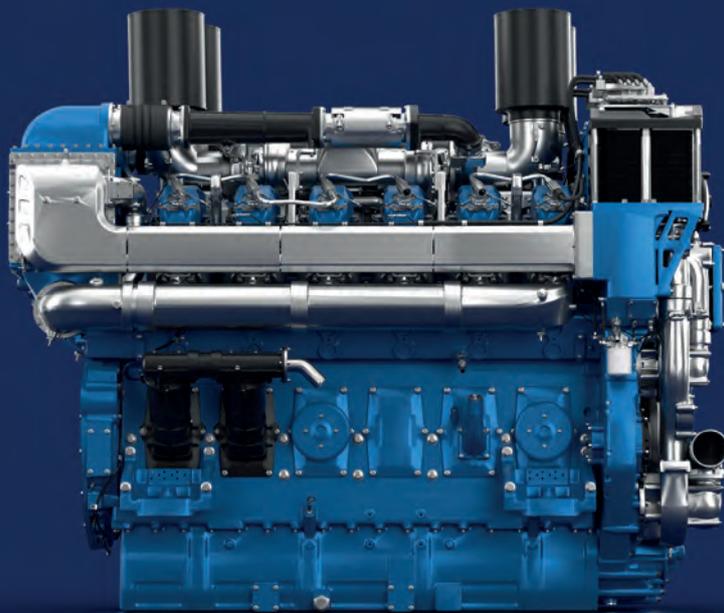


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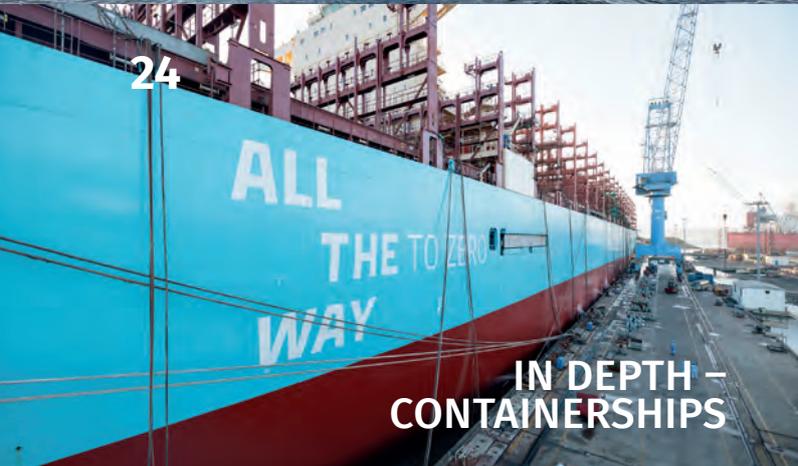
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A GOOD MONTH FOR AUTONOMY AND REMOTE CONTROL



Pioneer is the UK's first ROUV certified under Workboat Code 3, Annex 2

In the July 2025 issue of *The Naval Architect*, we covered the ups and downs of uncrewed surface vessel (USV) manufacture in the UK, in both our Uncrewed Vessels feature and the Editorial Comment. At that time, Matthew Ratsey, MD of Plymouth-based Zero USV, expressed his concerns that a mixture of outdated regulations and politics may be hampering the UK USV sector's ability to properly thrive. As Ratsey put it, when reflecting on the December 2023 publication of the Maritime & Coastguard Agency's (MCA's) Workboat Code 3 (WBC3, which specifically addresses safety and operational standards for remotely operated vessels in UK waters): "Why, after 18 months, has nobody got a USV through WBC3, Annex 2?"

It's good to see, then, that one uncrewed vessel has made the grade, with the announcement that ACUA Ocean's remotely operated and unmanned vessel (ROUV) *Pioneer* has received the relevant certification, assisted by classification society Lloyd's Register (see *Drone Tech*, page 16). Hopefully, this will set a precedent for future certifications, demonstrating that compliance with these rigorous standards is achievable and encouraging UK developers to innovate in autonomous and uncrewed maritime technologies while ensuring safety (not to mention decarbonisation).

Elsewhere this month, we take a look at Wind-Assisted Propulsion, which is emerging as one of the fastest-growing 'green tech' solutions of the

past five years. As tech giant Kongsberg points out (see page 38), it's not just a case of installing sails on vessels, be they fishing craft or oceangoing bulkers and tankers: how these sails interact with the onboard engines and propulsive systems is crucial if shipowners are to optimise their overall energy savings. Utilising AI and real-time data, Kongsberg's K-Sail system, officially launched in summer, is being fine-tuned to manage vessel route and speed in the most efficient manner possible, through a series of engine and sail energy trade-offs – while, as a bonus, reducing crew workloads.

Unsurprisingly, uncrewed vessels were also on the agenda at RINA's Warship 2025 conference, hosted in Glasgow in June. Professor David Andrews of University College London (UCL) provides a summary of the event and some of the papers and keynotes (see pages 18-20), which included a presentation by Captain Mohayed Magzoub, R.N., head of force development in the UK MoD. Magzoub told attendees that he foresees a blend of crewed and uncrewed warships on the horizon – and had some interesting comparisons to make between naval vessel design and that childhood staple, Lego. We hope to bring more you in-depth coverage of some of the individual papers presented at the conference in future issues of *The Naval Architect*. ■

Martin Conway,
Managing Editor

FERRIES

CEMRE LAUNCHES HEBRIDES FERRY #1

Turkish shipbuilder Cemre has launched the first of two new ro-ro vehicle and passenger ferries for operations in the Outer Hebrides, Scotland. Due for delivery to owner CMAL in 2026, the newbuild, *MV Lochmor*, will be operated by CalMac Ferries on routes linking Uig on Skye, Tarbert and Lochmaddy. The ferry will work alongside a forthcoming sister, *MV Claymore*, which is also under construction at Cemre.

The duo has been funded by Transport Scotland, which pledged £115 million to the project in 2022, “with some of the budget allocated to minor port improvements to reflect the design of these vessels”, CMAL comments. The company, which is owned by the Scottish government, adds: “*MV Lochmor* is the third of four standardised vessels being built at the



The 750dwt *MV Lochmor* can accommodate up to 450 passengers

Turkish yard for CMAL as part of a significant investment in Scotland’s ferry network.”

MV Lochmor features a length of 94.8m, a breadth of 18.7m and a draught of 4m. The 750dwt ferry can accommodate up to 450 passengers and 100 cars, or 14 commercial vehicles, “bringing

a major boost to capacity and resilience for the communities it will serve”, CMAL states. Following its launch, the ferry will now undergo outfitting and systems installations, in advance of sea trials, before entering service next year, with *MV Claymore* slated for delivery several months later. ■

AQUACULTURE SUPPORT

DAMEN FOLLA TO FEED AQUACULTURE SEGMENT

Damen Shipyards Group and Folla Maritime have launched their new joint boatbuilding venture, Damen Folla, which will focus on building and delivering vessels for the aquaculture support sector. The Damen Folla facility is based in Flatanger, Norway.

Damen, which primarily builds in steel, became the majority shareholder in aluminium vessel



specialist Folla Maritime earlier this year. Jeroen van den Berg, Damen product director for aquaculture and fishing, says the partnership “enables us to provide tailor-made solutions, from agile aluminium workboats to larger service vessels operating in rough offshore conditions”. Otto Sjølien, Folla Maritime CEO, adds: “Partnering with Damen opens new opportunities for larger, more complex projects, something we’re seeing growing demand for.”

The first fruit of the partnership will be the hybrid-powered Aquaculture Service Vessel (AOSV) 2813 class. Power-rated 2-3MWh, the AOSV 2813 will feature a 160m² deck equipped with three cranes, “making it ideal for a wide range of aquaculture and offshore operations, from net handling and anchor installation to ROV deployment, transport and towing”, Damen suggests. Other features will include dynamic positioning (DP) capability and a bollard pull of 280kN. ■

The Damen Folla site will focus on producing aquaculture support boats

TUGS

PURE BATTERY PULLING POWER FOR JAPAN

Tokyo maritime companies Tokyo Kisen and Marindows have launched what they claim to be Japan's first pure battery-powered electric harbour tugboat development project. The plans for the vessel, scheduled to service the ports of Yokohama and Kawasaki, were drawn up in accordance with the Carbon Neutral Port (CNP) policy, an initiative by Japan's Ministry of Land, Infrastructure, Transport and Tourism to achieve net-zero greenhouse gas emissions in domestic port operations by 2050.



The partners aim to commence construction of the tug in 2028 and to put it into commercial service by 2030. The vessel is set to feature two 1,500kW propulsion units and an onboard battery capacity of 6.66MWh, which should enable a maximum bollard pull (bp) of 53tonnes and a speed of approximately 14knots. The vessel has also been designed to work with a pair of 1,000kW-class shore-to-ship fast chargers.

This set-up improves significantly on the hybrid-electric tugboat *Taiga*, which Tokyo Kisen put into service in January 2023, and which featured a 2,486kWh-capacity battery. "Building on two and a half years of operating experience with electric-powered tugs, this project advances to the next stage – enabling truly zero-CO₂ operations – by developing and constructing a pure battery-powered EV tugboat," Tokyo Kisen comments.

Tokyo Kisen offers maritime safety, tugboat, passenger ship and logistics services in Tokyo Bay and beyond, while Marindows was founded in 2021 by e5 Lab to push maritime environmental sustainability through electrification and autonomous operations. ■

Tokyo Kisen's co-developed all-electric tug will enter service in Japan in 2030

PASSENGER VESSELS

YEAR-ROUND LINKS TO AUSTRALIAN RESORTS

Austral Vietnam has been contracted to build a passenger vessel for Australian tourism operator Cruise Whitsundays, part of the Journey Beyond group, to provide a year-round connection service between Airlie Beach, the resorts of Daydream Island and Hamilton Island and Cruise Whitsundays' Reef World pontoons, located 39nm from shore at Hardy Reef.

The aluminium vessel, which has been designed by Incat Crowther and is scheduled for completion next year, will measure 36.45m x 11.2m overall, and will feature a depth of 3.6m and a draught of 1.35m. The boat will accommodate 10 crew and up to 390 guests, with the layout incorporating 10 wheelchair-accessible spaces and various outdoor and indoor seating options, including a 36-pax first-class lounge, a 64-pax

premium lounge and an 80-pax undercover outdoor seating area, with seating arranged for 160 persons on the main deck.

The newbuild will be powered by twin Mitsubishi S16 T2MPTK engines, each delivering 1,499kW

at 1,800rpm, and will feature Naiad active ride control systems for enhanced comfort in wave heights of up to 2.5m. The engines will feed a pair of five-bladed, fixed-pitch propellers via ZF 5055 gearboxes, enabling a service speed of 25knots. ■

Austral Vietnam will construct the 390-pax vessel in 2026



SHIPBUILDING SUPPORT

UK NAVAL SUPPORT BARGE UNDER BUILD

Navantia UK has commenced fabrication of a 1,400tonne transport barge at its Methil facility in Scotland. Valued at £8 million, the barge will be custom-built to transport ship blocks between Navantia UK's Appledore and Belfast facilities, "facilitating construction of the [Royal Navy's] Fleet Solid Support [FSS] ships across multiple sites", the company says.

The barge's dimensions of 85m x 25m will gift it "a surface area equivalent to 10 tennis courts", Navantia UK says, enabling bow sections of the FSS ships to be built on board the barge, at the Appledore yard, before being transported to Belfast for final integration. Navantia UK expects the barge project to create 35 new jobs, including 14 apprenticeship positions, and for it to play a role in shipbuilding projects beyond the FSS contract.



Navantia UK says the naval support barge project will create 35 new jobs

Navantia UK was established in 2022, with the aim of partnering with UK industries to support the UK's National Shipbuilding Strategy and Net Zero goals. In January this year, the company completed the acquisition of Harland & Wolff and its four historic facilities in Belfast, Appledore, Methil and Arnish. ■

EDUCATION AND TRAINING

BMS TACKLES SCOTTISH SKILLS SHORTAGE

British Marine Scotland (BMS) has launched a national training and workforce study, to address Scotland's marine skills shortage. The scoping exercise, funded by Crown Estate Scotland, will focus on the leisure sector and small-to-medium-sized vessels, and will cover areas such as boatbuilding, marine engineering

and electronics, composite materials, supply chain services and marina, mooring and small harbour operations.

According to BMS, more than 80% of Scottish marine businesses have reported skills shortages, and nearly 60% expect staff to retire within the next five years. Only 12% of these

companies employ apprentices, BMS adds.

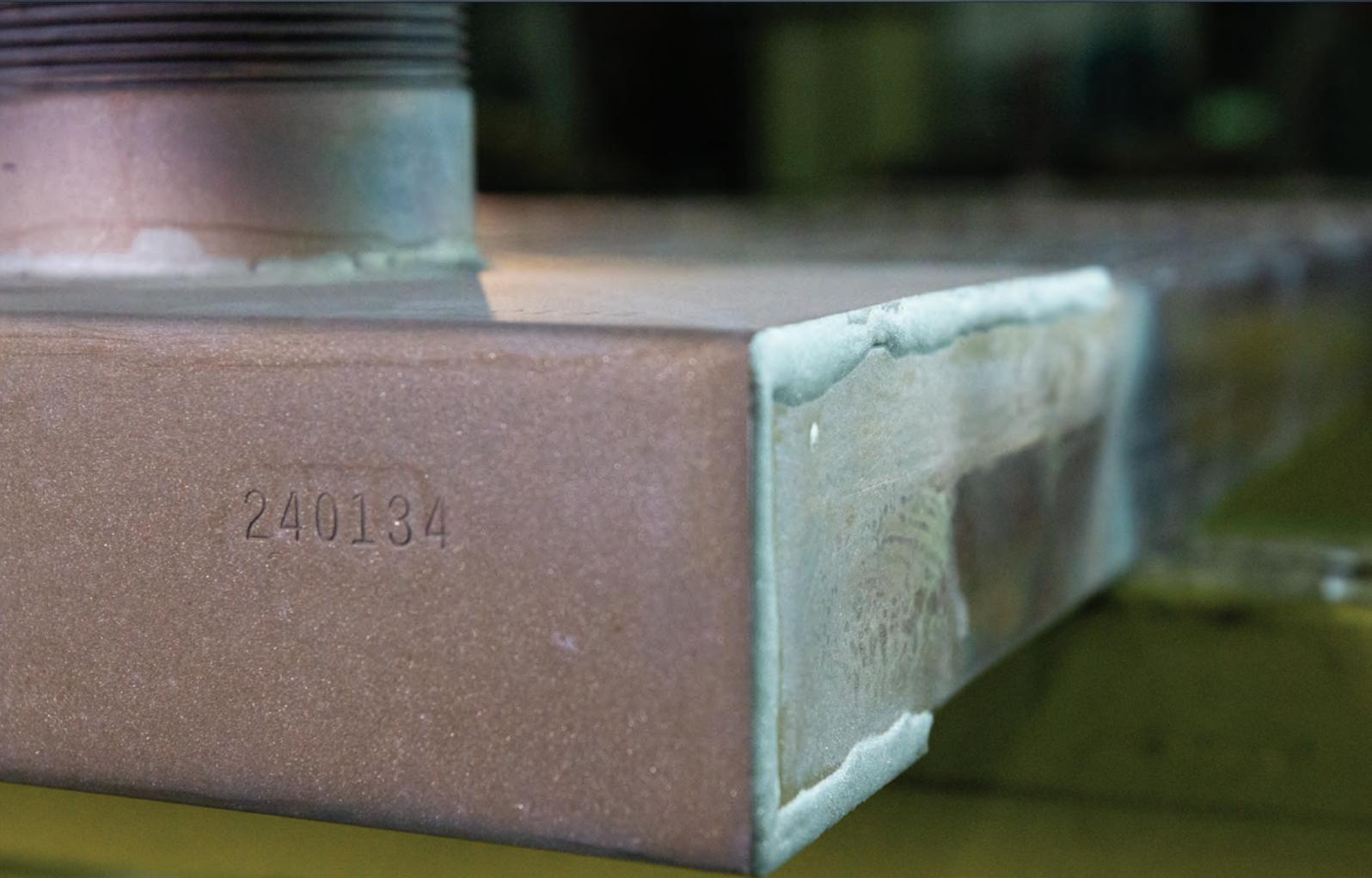
In a statement issued in August, BMS wrote: "There is a clear crossover with the marine technical skills required for the aquaculture, workboat and fishing sectors, but Scotland's marine tourism sector alone generates £633 million GVA and supports 31,000 jobs – 44% of all marine sector employment. Boating tourism contributes £84 million GVA and 3,100 full-time equivalent jobs. These technical skills are crucial not only for Scotland's economy but for the well-being and sustainability of our coastal communities."

The research will be delivered by workforce development specialist Margaret McCole and marine skills specialist David Tournay, under the direction of BMS. Patrick Flockhart, vice chair of BMS, states: "Without urgent action to train, attract and retain skilled people, Scotland's marine sector will face serious challenges. We're calling on everyone in the industry to get involved." ■

More than 80% of Scottish marine businesses have reported skills shortages, says BMS



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TANKERS

ELECTRIC-HYBRID TANKER ON THE RHINE

Concordia Damen has delivered another vessel in its CDS Tanker 110 class to Dutch inland shipping operator VOF Generation. The newcomer, christened *mts Generation*, will be used to transport mineral oils on the Rhine River.

Eight onboard tanks permit a combined cargo volume of 3,040m³, and tankage is provided for 1,320m³ of ballast water and 16m³ of fresh water.

mts Generation has been fitted with a hybrid propulsion system,

which includes a battery pack, supplied by EST-Floattech, and electrically driven Equadrives, manufactured by Verhaar Omega. Concordia Damen says: "This configuration ensures quieter, cleaner and more efficient operation, with peak loads being smartly managed by the battery capacity." The vessel has a speed of 18km/hour, or just under 10knots. ■

The CDS Tanker 110 is a stock Damen design, measuring 110m x 11.45m and featuring a depth of 4.9m and draughts of 1.2m (minimum) and 3.3m (fully loaded). The vessel class has a cargo capacity of 2,868tonnes – which, Concordia Damen claims, is some 200tonnes more than that offered by comparable ship types on the market.

The CDS Tanker 110 has a cargo capacity of 2,868tonnes



SUPERYACHTS AND MEGAYACHTS

AL REEM AT HOME IN THE AEGEAN

The 80m loa *Al Reem*, launched earlier this year by Turkish yacht construction specialist Bilgin Yachts, has commenced her maiden season in the Aegean, and is currently operational around the bays of Bodrum. Described by the yard as "the third and final yacht in Bilgin's 80m trilogy", the steel-hulled, aluminium-bodied vessel was

designed by naval architecture firm Unique Yacht Design, and features interiors by H2 Yacht Design.

Technical particulars include a breadth overall of 12.25m and a gross tonnage of 1,758gt. At full load, *Al Reem* draws approximately 3.5m and displaces 1,510tonnes. The yacht is powered by two MTU 16V

4000M73 engines, each rated 2,560kW at 1,970rpm, which enable a cruise speed of 15knots, increasing to 19knots max. The vessel's range, at half-load, exceeds 5,000nm, partly enabled by an onboard fuel capacity of 168,000litres and a water capacity of 48,000litres.

Other onboard features include "an owner's suite with panoramic 300° views, and extended outdoor living spaces", Bilgin Yachts states, adding: "Seeing *Al Reem* in Bodrum is a proud moment for the shipyard...it's the perfect backdrop for her design, because we see *Al Reem* as a yacht made to connect with nature and the sea, yet deliver the highest standards of luxury." ■



***Al Reem* is the "third and final yacht in Bilgin's 80m trilogy"**

ENGINES

EVERLLENCE ON A ROLL IN INDIA

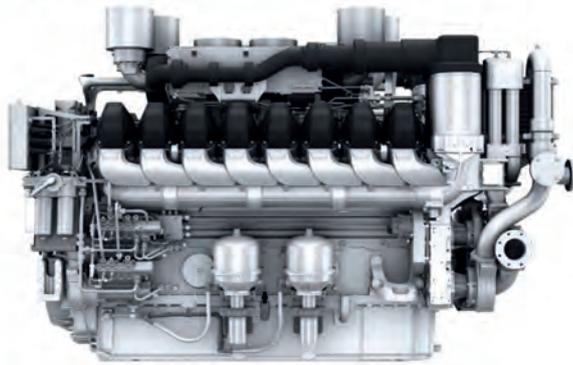
Mumbai-based Mazagon Dock Shipbuilders has placed a substantial engine order for 14 fast patrol vessels (FPVs) on its blocks, under construction for the Indian Coast Guard. Each newbuild will be fitted with three Everllence 16V175D-MM high-speed engines, rated 2,960kW apiece.

Intended for coastal surveillance, search and rescue, fisheries protection and coastal convoy escort work in India's exclusive economic zone, the FPVs will be fitted with waterjet propulsion systems, enabling them to reach speeds exceeding 33knots, and with deployable multipurpose drone systems and smaller, high-

speed boats for shallow-water rescues. The FPVs will also be utilised by the Indian Navy in times of crisis.

The 175D is designed for future-fuel adoption, including biofuels such as FAME and HVO. All 42 engines will be delivered to Mazagon Dock between December 2025 and December 2027, and deliveries of the FPVs to the Indian Coast Guard are expected to commence in March 2026.

Everllence



This is the second big Indian order scooped by Everllence (formerly MAN Energy Solutions) this year; April saw the company contracted to supply complete propulsion packages for five newbuild fleet support ships at Hindustan Shipyard in Visakhapatnam, each package containing two 20V32/44CR-branded engines. ■

Each FPV newbuild at Mazagon Dock will be fitted with three Everllence 16V175D-MM engines

MAPPING AND IMAGING

ECHOPILOT LAUNCHES 3D FORWARD LOOKING SONAR

EchoPilot has launched its new 3D Forward Looking Sonar (FLS 3D), designed to provide the helm with a 3D visualisation of the seabed up to 200m forward and 100m downwards. The sonar is primarily aimed at boats sized between 25-60m, supporting both leisure and commercial vessel skippers who are "entering areas where maybe the charts don't exist or haven't been updated", comments Andrew Scott, MD at distributor Marine Components International.

The company claims that, by offering an easy-to-read, colour-coded picture of what lies within its 30°-wide and 90° vertical beam, the FLS 3D can offer substantial advantages over 2D imaging. The sonar also calculates the average depth ahead, "plus you can see 100m forward in just 5m of water", says Scott.

The retail price point sits around £5,000 – about half the price of EchoPilot's previous iteration, closing what has been seen as an unfeasible gap between the cost of 2D and 3D systems. Scott adds: "There's a lot more security if you're certain you're not going to ground the boat...and it's also useful for knowing where you're dropping your anchor." ■



The FLS 3D sonar (shown on a Raymarine display) provides a colour-coded picture of what lies within its beam

PROPELLERS AND THRUSTERS

CARBON FIBRE BLADE OPTION FROM TEIGNBRIDGE

Teignbridge Propellers has launched a carbon fibre blade version of its Clamp on Blade (CoB) range of marine propellers. The new type, developed as part of a 12-month Clean Maritime Demonstration Competition (CMDC) project, is designed for use with a 10m electric-powered vessel, and can generate an efficiency gain of 3-4% over an equivalent metallic prop, Teignbridge reports.

The carbon fibre blade version of Teignbridge's CoB propeller range reduces noise and vibrations



“The carbon fibre composite blade option produces a lightweight and efficient propeller, which, due to the composite material characteristics, yields lower driveline vibrations combined with substantial noise reduction compared to conventional metallic propellers,” Teignbridge adds. “This is extremely beneficial when coupled with an electric drive.” The use of carbon also allows flex to be designed into the blades, which can be used to enhance the pitch for various vessel conditions and speeds.

The CoB propeller technology is available in diameter sizes ranging from 0.75m to 5.5m, with keyed or hydraulic shaft fitting. “In the unfortunate event that propeller blades become damaged, the individual blades can be replaced rather than having to remove and replace the whole propeller,” the company adds. “As CoB parts can be stored on board, there is no wait for replacement parts to be manufactured or repaired, reducing costly vessel downtime.” ■

SAFETY AND SECURITY

NEW CYBERSECURITY PACKAGE FROM WALLEM GROUP

Wallem Group has launched a suite of support and consultancy services to safeguard IT systems on board its clients' vessels. Dubbed Vessel IT Security and Management Services (VITS), the suite aims to offer “comprehensive support to enable smooth, secure and efficient IT at sea”, Wallem Group states.

The service aims to cover “the ship's entire digital ecosystem”, including all onboard Internet of Things (IoT) systems, and to provide its ‘Remote Vessel Infra Support’ service to customers, enabling diagnoses from IT experts on shore. For more complex IT issues, Wallem Group will deploy engineers directly to the ship, to oversee any system upgrades, IT system health checks and troubleshooting measures.

Steve Whitby, group IT and technology director at Wallem Group, says: “Modern vessel operations demand connected IT infrastructure, but this can expose outdated onboard systems and virus signatures, hardware performance issues and deficiencies in data back-up and IT support. Owners must secure networks, onboard systems and data against ransomware, phishing and unauthorised access.” VITS' ‘Vulnerability Management’ service enables Wallem's team to scan shipboard computers annually, to identify vulnerabilities and then apply patches remotely, while the ‘Advanced Endpoint Protection’ service uses machine learning

and behavioural analysis to defend systems against zero-day attacks and evolving threats. ■

Wallem Group's VITS services include the deployment of engineers to ships for hands-on IT check-ups



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RULES AND REGULATIONS

WORKBOAT CODE 3 BREAKTHROUGH FOR PIONEER

Class society Lloyd’s Register (LR) has issued the UK’s first certification for a remotely operated and unmanned vessel (ROUV) under the Maritime & Coastguard Agency’s (MCA’s) Workboat Code Edition 3 (WBC3),

Annex 2 – a much-anticipated development by USV and ROV developers in the UK, some of whom have seen restrictive MCA rules as hindering this certification process somewhat (see *The Naval Architect* July 2025).

The recipient is ACUA Ocean’s hydrogen fuel cell-powered USV *Pioneer*, a 14.2m x 9.m long-endurance monohull, designed for offshore surveillance and inspection. Officially launched in December 2024, the modular *Pioneer* has a mast height of 8.1m and a maximum payload capacity of 6.5tonnes, and has a service speed of 4knots, increasing to 6.5knots max.

Pioneer is the UK’s first ROUV to have been certified under Workboat Code 3, Annex 2 (image: ACUA Ocean)



Anderson Chaplow, principal specialist at LR, comments: “This certification represents a major step forward – not just for ACUA Ocean or LR, but for the wider UK maritime industry. It proves that certification of small, complex ROUVs under Annex 2 is achievable and sets a precedent for others in the industry to follow. It also shows what’s possible when developers, regulators and classification societies collaborate to bring emerging technologies safely into operation.” LR hints that it expects to issue further WBC3 Annex 2 certifications for UK USVs in the coming months. ■

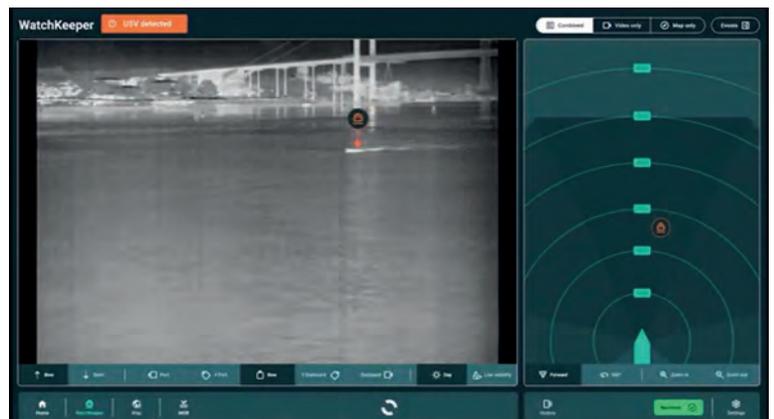
MARITIME SURVEILLANCE

ZOE RAISES SHIELD FOR US NAVY DEMO

Zelimo has trialled its ZOE solution, previously used to detect and track offshore wind farm and cruise ship man overboard (MOB) casualties (see *The Naval Architect* July 2025) to detect USVs off the coast of Newport, Rhode Island, as part of a Cooperative Research and Development Agreement (CRADA) with the US Navy’s Naval Undersea Warfare Center (NUWC).

The demo saw Zelimo unveil its ZOE Shield application, powered by the same AI engine used for its ZOE MOB solution. ZOE Shield can detect and classify small USVs operating without AIS, to safeguard critical subsea infrastructure, and is reportedly “immune” to GPS denial and radar jamming attacks, Zelimo adds.

The CRADA came about through Zelimo’s participation in the BlueTIDE 2025 tech demo event, hosted by 401 Tech Bridge, NavalX and the Northeast Tech Bridge. Speaking shortly before the August demo, Zelimo explained: “[Our] role in the scenario involves detecting small remotely operated surface vessels operating covertly in sensitive areas, which may pose a precursor threat to subsurface sabotage.” ■



ZOE Shield has been used to detect and classify USVs

NAVAL AND MILITARY

DEFIANT HIGHLIGHTS NOMARS EVOLUTION

August saw the US Defense Advanced Research Projects Agency (DARPA) hold the naming ceremony for USX-1 *Defiant*, an autonomous USV, at Everett Ship Repair, Washington. As the demonstrator for DARPA's 'No Manning Required Ship' (NOMARS) programme, *Defiant* was designed for no humans on board from the outset, unlike 'hybrid' units that can accommodate human operators if required.

"By eliminating constraints and requirements associated with humans, NOMARS opens up the design space to novel ship configurations that could never be considered for crewed vessels," DARPA says. "The NOMARS platform is designed to significantly reduce 'cost per mission hour' via reduced platform size, zero onboard manning and its ability to remain on mission for long periods of time."

Defiant has a simplified hull design to allow rapid production and maintenance at facilities or Tier III shipyards that traditionally support yacht, tug



***Defiant* was designed purely for zero-human-crew operations**

and workboat customers. The 55m, 240tonne USV will now undergo systems testing in preparation for an extended at-sea demonstration, after which it will be turned over to the US Navy's Unmanned Maritime Systems Program Office.

NOMARS programme manager Greg Avicola says: "While relatively small, *Defiant*...can handle operations in sea state 5 with no degradation and survive much higher seas, continuing operations once a storm passes. She is no wider than she must be to fit the largest piece of hardware onboard and we have no human passageways to worry about." ■

ENVIRONMENTAL MONITORING

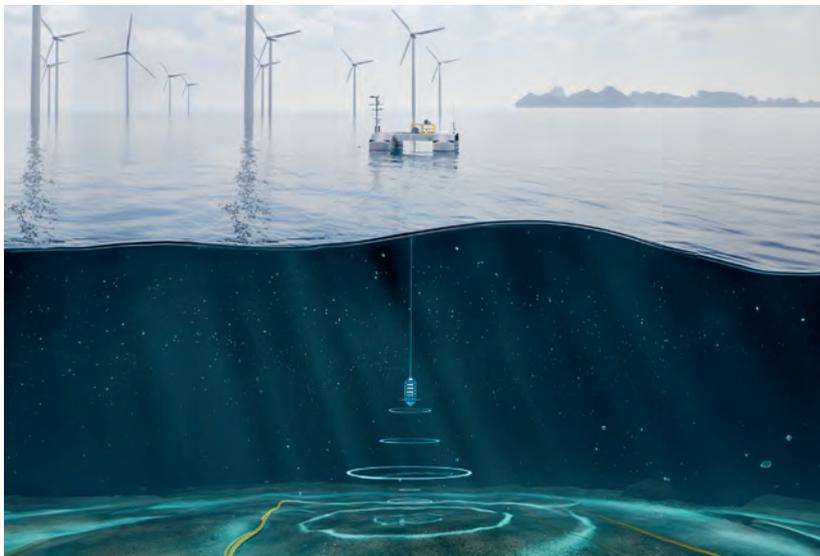
USV TO STREAMLINE WIND FARM APPROVALS

A UK initiative, Project ORACLES, aims to streamline the environmental approval process at up-and-coming offshore wind farms. The Project ORACLES consortium, which is headed by Robosys Automation

and includes Plymouth Marine Laboratories, ACUA Ocean, MSEIS and the ORE Catapult as partners, has secured funding from the UK Research and Innovation (UKRI)'s Innovate UK Launchpad programme.

Robosys states: "Currently, the data collection process for environmental monitoring at proposed offshore wind farm sites is labour-intensive, with separate providers handling aspects such as bird monitoring and sea conditions. Data is collected manually and analysed after it reaches shore, slowing down the decision-making process." Instead, Project ORACLES aims to "leverage advanced marine robotics" and autonomous systems to accelerate data transfer and analysis.

Project ORACLES aims to streamline environmental approvals at offshore wind farm sites



The project will see ACUA Ocean's USV *Pioneer* (see page 16) equipped with sensors (including ADCP and acoustics) and used to collect real-time data on water quality, marine life and environmental changes. The consortium also plans to develop a DP system and a beyond-visual-line-of-sight (BVLOS) winch profiling system for water column data collection. ■

WARSHIPS AND THE WAY FORWARD

Professor David Andrews of University College London (UCL), reports on this year's RINA Warship 2025 conference, which covered areas such as autonomy, sustainability and effective work processes

The annual RINA Warship conference took place in two days (16th and 17th June) in Glasgow at Strathclyde University's Enterprise Centre in the heart of Glasgow. There were 137 attendees, and 25 papers were presented and discussed with each day's session commencing with a dynamic keynote presentation.

The conference was welcomed by RINA president Cat Savage, and she thanked the three conference sponsors: BMT, ANSYS and SSI. Angus Watt of BMT drew attention to the UK's Strategic Defence Review and the technological challenges, while Richard Harding of ANSYS emphasised its expanding role in modelling and simulation beyond its Finite Element Analysis origins to cope with an increasingly complex battle space, not least the threat of swarms of drones.

Keynote presentations

Each of the two conference days commenced the paper presentations with a keynote presentation. Day 1's was given by Annabel Ransome-Williams, programme director for SSN AUKUS, who started by saying that much of her career in the UK Ministry of Defence (MoD) had been managing British naval decline, but we were entering

a changed era (due to the attack by Russia on the Ukraine in 2022) with a focus on the recapitalisation of the future fleet.

This notably included the advent of large language models (LLMs, like Chat GPT, for example), thus foreseeing: "remote everything"; AI being highly present; the need for resilience; and reacting to climate change. So, we are looking towards a single integrated force through the European, Atlantic and Australian project of AUKUS. Ransome-Williams saw programme outcomes for AUKUS as having the following emphases: "simplify"; ensure delivery is not late; and design for maintenance. The latter would lead to longer lifecycles with upgradeability and adaptability. Her final call was to ensure that "the human is at the centre of design".

Day 2 commenced with a presentation by Captain Mohayed Magzoub, R.N., head of force development in the UK MoD, who did not just talk about future naval force options but gave a vision of a possible future fleet composition. In calling for a 'system of systems' approach to capability development, he took the example of the Lego toy concept, launched in 1932. In 1947, the plastic connection was developed with the key being precise tolerances that controlled



RINA's Warship 2025 conference, hosted in June, attracted 137 attendees



Annabel Ransome-Williams, programme director for SSN AUKUS, stressed that “the human is at the centre of design”

the interfaces and made any new components backward-compatible. This conceptually provided an inspirational and successful model to follow. Naval forces would be developed in the light of:

- State level competition
- Technological proliferation
- Affordability, noting Norman Augustine’s statement, “Change is linear, cost is exponential”
- Climate change and its likely impact on world stability
- Demographic changes.

All of these would affect producing a ‘system of systems’ future force mix, where the funded force must cost less and the crew-able element of the force must be reduced. One proposed concept is a blend of crewed and uncrewed ships, where the advantages of several uncrewed units, fulfilling specific roles, could be commanded by a command vessel. This will present challenges in terms of local and shore control versus autonomy. The Lego concept, with a catalogue of parts with built-in adaptability (the connections), offers the vision of simpler, cheaper warships. A lively discussion ensued, thanks to Captain Mo’s intriguing example fleet studies.

Presentations overview

There now follows: the name of each lead presenter of 12 of the conference papers; each paper’s broad topic; and a brief summary of each presentation. This is reproduced below to encourage readers to read the full 25 papers in the conference proceedings. This report concludes by summarising the remaining activities that ended the last session of a successful conference.

1. **David Manley** (MoD and UCL) – *Support to Concept Analysis and Requirement Development Through Wargaming*: An outline of using wargaming to assist in the early concept design of warships as a design tool, rather than a fleet tactical study, emphasised that there was a lot of human interaction, giving insights as a “bird’s eye view”. This approach has now been introduced into teaching early-stage ship design at UCL.
2. **Jakub Orłowski** (Damen Naval Systems) – *Validating Operational Scenarios Through*
3. **Daniel Boyce** with **Claire Earlie** (main author) (BMT) – *A global view of the implications of climate extremes on sustainable ship design and operability*. With more energy in the oceans, the conclusion was there would be more stormy weather in combination with “stormy” politics.
4. **Dan Patten** (BMT) – *Balance of Survivability for Large Uncrewed Surface Vessels: Elucidating the requirements and possibilities*: The layout of an example 65m, 15knot-vessel was found to give improved survivability, but recoverability could then be problematic with accessibility still needing to be provided.
5. **Matt Toon** with **Rodrigo Fernandes Perez** (main author) (Siemens Digital Industries Software) – *Advancing Smart, Sustainable, and Autonomous Fleets with Digital Innovation Tools*: The authors concluded that the design spiral representation of the ship design process should be dispensed with. Digital twin technology “must age through life [TL]” and next-generation machinery will be developed using a TL “digital thread”.
6. **Alex Barber** and **Ian Groom** (Safeguard Engineering) – *A Functional Safety Assessment Approach to Support Level 4 Autonomy*: Level 4 autonomy removes humans directly in the loop, so was seen to be unrealistic for naval deployment. The issue of low-probability, high-impact safety assessment remains problematic in safety practice due to its inherent lack of data.
7. **Teresa Magoga** (DSTL) – *Advanced numerical simulation of hydro-elastic vessel structural response to assist sustainability assessments*: A hydro-elastic structural assessment should be part of any maintenance plan as a ship ages, with the need to predict stresses in harsh seaways – noting that strength is the only ship characteristic that only the naval architect cares about – until the hull breaks!
8. **Harriet Morley** (BAES), *Submarine Crewing – Getting the balance right - how Future Digital Tools can Support the Generation and Validation of Submarine Crewing*: This paper proposed scientific rigour versus practical engineering and raised the issue of governance over personal data. It was seen as an issue of naval culture. Submarine crews will only be reduced when designers show the crewing authority that this will really save money if the fleet is to counter the impact of crew numbers on submarine size and cost.
9. **Nick Danese** (SSI) – *Model-Based Sustainment: Digital Solutions for Improving Asset Availability*: From experience with RCN/USN/RAN, 55% to 70% of warship lifetime costs are in service, so the author concluded that naval ship acquisition, in common with a digital future, must emphasise user-friendliness.
10. **Micha Stam** (TUDelft) – *Modular naval vessels and the impact on the design and effectiveness*: Modularity can be based on geometric

Captain Mohayed Magzoub, R.N., head of force development in the UK MoD, proposed a blend of crewed and uncrewed vessels

considerations, whether payload-based, mission-based or software-based, and raise the question of including TL costing.

11. **Liam Nugent** (University of Strathclyde) – *Multi-Attribute Decision Making For The Design Of A Naval Surface Combatant*: Scoring for AAW missions using SBD/NADM/TOPIC was said to comprise: RCS; R&P; seakeeping; and survivability. However, the paper added that it was difficult to apply this to the complexity of naval acquisition (see Hockberger (1993) on COEA).
12. **Rachel Pawling** (UCL) – *Every frigate a squadron: Studies of Large Uncrewed Surface Vessels*: Design studies were presented, which put some detail on the vision by the R.N. head of force development (the Day 2 keynote) using “hidden UK industry” (rather than the main warship supply base) for rapid conversion to autonomous assets.

The last session started with a presentation by Chris McNair and Chris Baker (MoD) as chair and vice-chair of the RINA Developing Careers Committee. This new committee addresses what could be said (despite all the media noise on AI) to be the biggest problem for the engineering profession, as a whole. This issue applies, in particular, to the domain of naval architecture/maritime engineering, where there is urgency in recruiting anything like the numbers required of young people into the profession, as our demographics are already worryingly impacting on the maritime capability.

Whose responsibility?

The last formal presentation was by David Andrews, entitled *How important is it that stakeholders should better understand naval ship design?* with the added answer: “Do so through (recognising) the sophistication of ESSD: design ships INSIDE-OUT”.

The latter addition was the answer to the presented “stakeholder” paper by emphasising, to a warship design audience, that which the Council of RINA had stated in 2019: *“It was considered that this paper (the special edition of IJME in October 2018), which was a synthesis of his (DA) previously published research on ship design, was a seminal paper which sets the benchmark for ship designers looking to exploit new technology and techniques. As such, the paper was considered to be essential reading for all naval architects and marine engineers, and not just those working in concept design.”* So, in his concluding remarks at Warship 2025, Andrews asked the audience how many of them had followed the Council’s strong recommendation to read the 2018 exposition. Very few said they had. Consequently, Andrews felt the question raised in the conference’s concluding paper, on a lack of stakeholders’ understanding of ship design, was in the end the fault of the



ship design fraternity for not addressing the 2018 exposition, which the Council had urged the profession to read and respond to.

So, what briefly had the Warship 2025 paper said regarding the “stakeholders”? It had commenced with several examples (including the use of the inappropriate term “platform”) which showed how poorly the stakeholders, including the naval staff, politicians, journalists and academics, have understood the nature of naval ship design. An extensive appendix summarised some 10 books by naval historians giving “history’s view” of the performance of the Royal Navy’s warships in World War II (arguably, the last full “test”). Only one of these publications actually addressed the pivotal role of Sir Stanley Goodall, who was the DNC from 1936-44, and so the paper pays tribute in particular to the design of the fleet for which he was ultimately responsible and also to the scholarship of David K Brown, RCNC, whose several books detail technically Goodall and his Corps’ role and the performance of the British Fleet as a basis of a better understanding of what constitutes naval ship design.

From an extended argument (including the performance of the subsequent British designs in the Falklands Campaign and an analysis of the design decisions on the more recent Type 23 Frigates), the paper concludes that, in particular, stakeholders should not just take better notice of ship designers but realise competence in ship design largely resides with the naval architect. Finally, naval architects should see their role as leading on this demanding task – and read the Special Edition of 2018, as the RINA Council called upon them to do – so they can better articulate why this is an important question for all involved in naval practice. ■

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The President's Invitation Lecture (PIL) will take place on the first evening, featuring a keynote presentation, panel discussion, and networking dinner.

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AUS DEFENCE, MADE IN JAPAN

An upgraded version of MHI's Mogami-class vessel design has been described as "the best frigate for Australia" – but delivering on the deal will not be without challenges, writes **David Foxwell**



The upgraded Mogami-class frigate will significantly enhance the Royal Australian Navy's missile-launching capability (image: RAN)

In a major departure from convention, the Australian Department of Defence has selected a Japanese rather than a European design for its next frigate class. The decision – which is Japan's first-ever foreign sale of a major newbuild weapons platform – will boost Australian naval capabilities and Japan's defence-export track record, furthering close ties between the two nations.

In early August 2025, Australia's deputy prime minister and minister for defence, Richard Marles, announced that the Albanese government was accelerating the delivery of its next surface combatant fleet with the selection of an upgraded Mogami-class frigate design proposed by Mitsubishi Heavy Industries (MHI) as the preferred platform for the Royal Australian Navy's (RAN's) future fleet of general-purpose frigates. The new frigates will replace the RAN's Anzac-class frigates, and will be equipped for undersea warfare and air defence. Alongside the Hunter-class frigates and upgraded Hobart-class destroyers and advanced missile investments, the general-purpose frigates will be an essential part of the Albanese government's plan to more than double the size of country's fleet of surface combatants.

Marles said the Japanese design had been selected "following a rigorous and competitive tender process in which an upgraded version of the Mogami-class frigate was assessed as best able to quickly meet the capability requirements and strategic needs of the Australian Defence Force". The minister said the Australian government also

acknowledged a competitive, high-quality proposal submitted by Thyssenkrupp Marine Systems, based on the MEKO A-200 design.

Missile strike range

The Mogami-class design being built by MHI for the Japanese Maritime Self-Defence Force (JMSDF) is a 3,900tonne standard (5,500tonne full load) displacement vessel with a length of 133m, a beam of 16.5m and a draught of 9m. It has combined diesel and gas (CODAG) propulsion based on a single Roll-Royce MT30 gas turbine and two MAN diesel engines.

The frigates have an active electronically scanned array radar, towed array, variable depth and hull-mounted sonars and electro-optic and infra-red detection systems. The ships have a flight deck and hangar for an SH-60 helicopter and an 11-round Rolling Airframe Missile launcher for air defence, and carry the Japanese-developed Type 17 anti-ship cruise missiles. They are also fitted for, but not with, 16-cell Mk41 vertical launch systems for various missile types.

The upgraded Mogami-class frigate has a standard displacement of 4,880tonnes (6,200tonnes full load) and will have a range of up to 10,000nm and a 32-cell vertical launch system, and will be equipped with surface-to-air missiles and anti-ship missiles. The new stealth frigates will have the ability to fire SM-2 and SM-6 missiles, the most advanced air and missile defence weapons of their type, weapons that are also being deployed on the RAN's Hobart-

class destroyers and on future Hunter-class frigates. The Mogami-class frigate will also be able to fire Tomahawk cruise missiles, enhancing the RAN's ability to strike targets from its frigates from a range of 275km to 2,500km, an almost tenfold increase.

Minister for defence industry Pat Conroy said the decision would also take the RAN's general-purpose frigates from being able to fire 32 air defence missiles to a total of 128 missiles, and provide "cutting edge weapons and combat systems". He described the upgraded Mogami-class frigate as "the best frigate for Australia" and a "stealthy next-generation vessel", with highly capable radar and sonar. Conroy also noted that the Japanese design has a crew capacity of only 90 compared to the ANZAC-class frigates it will replace. "It's a much bigger ship, but it is able to operate with a much smaller crew," he told a news conference. "That's a reflection of how modern this ship is. It's going to be really important in terms of giving our Navy the capability to project power," he said, noting that the 10,000nm range of the upgraded Mogami-class is much greater than the ANZAC-class frigates' range of around 6,000nm.

Conroy highlighted the fact that the Mogami-class frigate "is in production right now" and "was the only option to meet the Government's timeline of the first frigate being delivered in 2029 for service in 2030". He added that the Mogami-class frigate was also the most interoperable with other Australian Defence Force assets of any of the designs proposed.

"Not risk-free"

MHI has been developing, designing and constructing the Mogami-class frigate since 2018. The first two ships in the class were ordered in 2018, and in July 2025, MHI launched the 11th ship of what is expected to be a class of 12 vessels for the JMSDF. Now that

the upgraded Mogami-class has been identified as the preferred design, the Japanese company will continue to work with the Japanese government and companies involved in frigate construction to respond to the Australian government's selection process, and present a proactive proposal for the final selection. It anticipates that there will be "broad-based participation of industries from both Japan and Australia" in the programme.

The first three frigates for Australia will be built by MHI in Japan, with the remaining eight planned upgraded Mogami-class units built at Henderson Marine Precinct in Australia, in which the Australian government is investing heavily, and for which it recently signed a strategic shipbuilding agreement with Austal Limited. The first of the three Japanese-built frigates is due to be delivered in 2029 and enter service in 2030, with the third in service by 2034.

Responding to selection of the Japanese design, International Institute for Strategic Studies analysts Nick Childs and Ben Schreer said the decision "is not risk-free", because Australia risks taking on a still relatively novice partner. "While Tokyo has an enviable pedigree for building warships efficiently, it has no experience exporting such systems," the analysts said. "That said, bigger risks may exist in Australia's ability to deliver on its side of the arrangement and to absorb the opportunity costs for its overall defence-capability development.

"Australia will also have to break its habit as a warship customer of asking for multiple design changes, which has caused delays and ballooning costs. Moreover, the development of shipbuilding facilities at Henderson needs to be delivered if the programme is to remain on schedule, on budget and for the Royal Australian Navy to receive all 11 ships." ■

Australia's first three upgraded Mogami-class frigates will be built by MHI in Japan (image: RAN)



ALT-FUEL INSIGHTS

Practical experience of operating the world’s first containership to be retrofitted to run in dual-fuel methanol mode is proving invaluable to owner/operator AP Moller-Maersk, writes **Clive Woodbridge**

Container vessel owner and operator AP Moller-Maersk is committed to achieving net zero by 2040. One of the most important levers anticipated for achieving this ambitious goal is the conversion of existing vessels to run on alternative fuels, including methanol.

In this context, the conversion of the 15,000teu, 350m-long *Maersk Halifax* represents an important initiative that will play a key role in guiding the way forward; not only for Maersk, but for other container shipping lines that will be monitoring the practical experience of this project with considerable interest, no doubt.

The retrofit operation was conducted at the Zhoushan Xinya Shipyard in China over the course of 88 days and completed at the end of October 2024. One of the most complex engineering aspects involved cutting the vessel into two sections to insert a new hull segment. This newly added section houses the methanol fuel tanks, fuel-handling and advanced safety systems.

Another major undertaking was converting the main engine to run on methanol. In addition to replacing

key components, the project team integrated an entirely new system to manage the fuel combustion. The engine’s control and safety systems were also upgraded to the latest industry standards.

Additional capacity

Ole Graa Jakobsen, head of fleet technology at Maersk, reflects: “Converting the engine to run on methanol was of course a significant achievement, but the most complex part was cutting the vessel in two and inserting the new segment. It was critical to have perfect alignment for the structural members, and the piping, and ensure the vessel was able to be fit back together.”

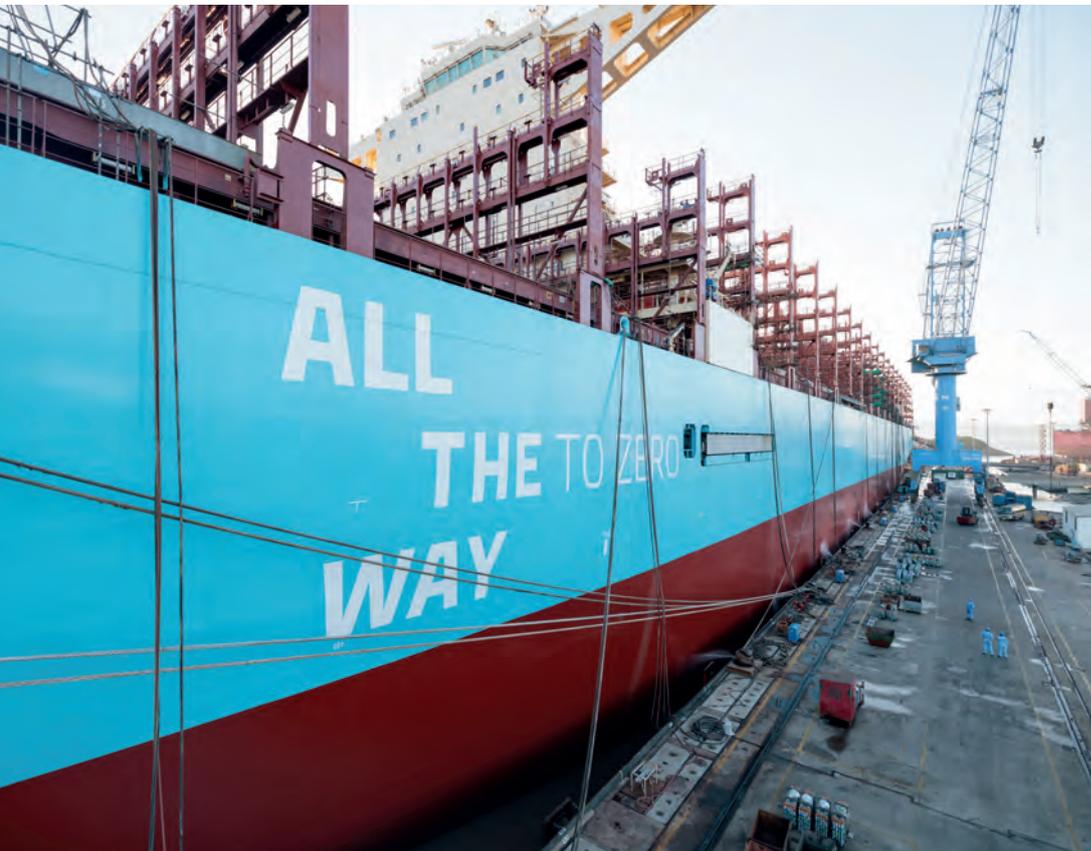
As well as the ability to run on methanol, there were other benefits from the conversion. For example, as a result of the elongation of the vessel, Maersk gained a small amount of cargo-carrying capacity on top of the methanol and fuel supply systems.

Maersk’s plan is to undertake further dual-fuel retrofits on other vessels of similar size, but the precise timescale has not yet been determined. Jakobsen says: “Currently, we are gathering valuable

insights from this pilot project. These learnings will play a pivotal role in shaping the retrofit strategy for the remaining sister vessels as we expect this methanol retrofitting technology to be an important part of transitioning parts of the fleet from fossil to low-emission fuels.”

The experience of operating the retrofitted vessel since its redelivery in November 2024 has been generally positive, Maersk reports. “The

***Maersk Halifax*, pictured during its conversion in China last year, has now been operating using methanol and conventional fuels for nearly a year (image: Everlence)**



vessel has overall operated reliably since departing the yard and resuming service, but, as with any pioneering exercise, something unforeseen will always turn up,” observes Jakobsen. “These minor issues have not been anything more than the crew has been able to solve with support from the shore team and key suppliers.

“As we have larger supplies of e- and bio-methanol coming online next year, we see *Maersk Halifax* as an important contributor to our methanol operating capacity.”

Global regulation “key”

Retrofitting containerships to run on methanol is a capital-intensive process, and Maersk believes it is important that the industry has a higher level of regulation to incentivise such investments.

“Global regulation is key for shipping’s decarbonisation efforts and we are eagerly awaiting the critical IMO MEPC meeting in October [2025], where we are hopeful that member states will adopt the IMO Net Zero Framework which was approved in April,” says Jakobsen. “Finally adopting the framework would mark a turning point. It sets a global direction for decarbonisation and provides the legal certainty the shipping industry has long asked for.”

Maersk Halifax is, at the time of writing, the world’s only large container vessel to have been retrofitted to use methanol as fuel. However, it will shortly be joined by a second vessel, the 20,000teu-capacity *COSCO Shipping Libra*, which is nearing the end of a conversion to dual-fuel methanol at a shipyard in Shanghai.

Everllence, formerly MAN Energy Solutions, was heavily involved in both these projects and is stepping up its efforts to respond to industry demand for such retrofits. Recently, the company has announced a strategic partnership with German shipyard group Meyer Re to advance methanol retrofit solutions. The collaboration will focus on retrofitting existing Everllence four-stroke engines, aiming to offer customers an economically attractive opportunity to convert older engines to a future-proof engine type.

The two companies plan to develop a comprehensive roadmap outlining the technical and operational steps required for the transition to methanol as a primary fuel source. This includes vessel retrofitting, infrastructure development for methanol fuelling and the establishment of industry-wide safety standards and best practices. ■

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KEEPING THE NOISE DOWN

Reducing underwater radiated noise from operations is a task best managed at the vessel design stage, writes **Jukka Suvanto**, senior sales manager at engineering and consulting firm Elomatic

Environmental accountability is a fundamental priority in the maritime industry’s agenda. Alongside the need to reduce shipping’s carbon emissions, shipbuilders and operators are increasingly expected to minimise their impact below the waterline. One of the most widespread yet underregulated issues caused by maritime operations is underwater radiated noise (URN), a persistent, human-induced low-frequency noise that affects 91% of European oceans, due to continuous noise from commercial shipping.

While the International Maritime Organization (IMO) released non-mandatory Revised Guidelines for the Reduction of URN in 2023, legally binding global regulation is still lagging behind the science. However, effective methods have been developed to support the mitigation of URN emitted from ships. Through proactive investment in noise-reduction technologies at the design phase, owners and operators are able to future-proof their vessels to ensure compliance with evolving regulatory frameworks.

The impact of URN

URN is primarily generated from a ship’s propellers and engines, as well as from sonar, seismic surveys and construction activities such as piling and dredging. The creation of continuous low-frequency noise disrupts the surrounding marine ecosystem, particularly mammals, where prolonged exposure to URN can result in immense discomfort, impacting their ability to communicate. The effects of underwater noise in marine mammals range from chronic stress to changes in mating, hunting and migration behaviour, triggering consequences that can cascade throughout entire ecosystems.

Despite the detailed understanding of the impacts that URN has on the surrounding environment, most of the global fleet continues to operate without significant mitigation strategies. IMO’s 2023 revision of its URN guidelines represents a step forward; however, without mandatory enforcement, the incentive for widespread change remains low.

Jukka Suvanto, Elomatic: “Reducing vessel speed, applying wind-assisted propulsion or installing air lubrication systems can all help reduce underwater noise”



“Without binding international regulations, industry progress remains uneven”

With regards to regional regulation, the EU addresses URN mitigation as part of its Marine Strategy Framework Directive (MSFD), which establishes that no more than 20% of a marine area can be exposed to continuous underwater noise, which is categorised under both impulsive noise (piling and seismic surveys) and continuous noise (vessel operations).

However, as detailed global regulation continues to develop, industry organisations are seizing the initiative through the introduction of positive measures to help address this issue. Incentive programs, such as port fee reductions in Vancouver and Prince Rupert, Canada, are encouraging operators to address noise pollution from their vessels. For example, these ports offer tax reductions for vessels that meet noise reduction criteria, with large containerships able to earn up to CAD4,000 (€2,700) per call.

Uneven progress

Further showcasing this growing momentum, in June 2025, following the 3rd UN Ocean Conference, leaders from 35 countries launched the High Ambition Coalition for a Quiet Ocean, the first global political alliance dedicated to tackling underwater URN.

Although these initiatives highlight a growing awareness of the need to introduce meaningful mitigation measures without binding international regulations, industry progress remains uneven. The lack of enforceable requirements continues to add a significant barrier to fleet-wide mitigation and long-term ecological protection.

To support the industry’s efforts, Elomatic has partnered with Aalto University in Finland to develop concepts that can predict the level of underwater noise a vessel will generate during the design phase, thereby negating the need for expensive retrofits through the use of smarter design methods. This predictive noise simulation framework can be applied early in the ship design phase, allowing naval architects and shipowners to minimise acoustic impact before a single plate is cut.

URN's impact on mammals includes chronic stress and changes in migration behaviour (image: Talia Cohen, Unsplash)

CFD predictions

CFD applications can help identify potential noise sources by modelling cavitation, turbulence and pressure pulses, and simulate how sound propagates through water to detect frequency-specific hotspots. These tools also support design optimisation efforts aimed at improving flow characteristics and reducing resistance. Additionally, CFD can be used to explore how operational factors such as speed, trim and loading influence noise output.

Elomatic's approach combines three key elements: Detached Eddy Simulation (DES), a hybrid CFD model that combines the Reynolds-average Navier-Stokes (RANS) equation and Large Eddy Simulation (LES) to balance the accuracy and efficiency of simulating complex turbulent flow around hulls and appendages; and the Schnerr-Sauer model, which is a numerical approach that uses CFD to simulate cavitation in order to calculate vapour fraction using bubble dynamics and mass transfer rates. This method enables accurate predictions of cavitation effects in ship's propellers or pumps. Lastly, the Williams-Hawkins (W-H) equation – a mathematical model used to predict noise generated by moving or vibrating bodies, and more specifically fluid flow – is used to simulate how sound radiates from ship structures into the surrounding marine environment.

Together, these simulations provide detailed insight regarding the likely URN emissions a vessel will generate during the design phase, supporting data-driven decisions related to hull design, propeller geometry, machinery placement and the integration of energy-saving systems.

Incorporating these considerations early in the design process can reduce the need for retrofits and help ensure that vessels are better prepared for emerging acoustic regulations.

Mitigation and efficiency

Several strategies for reducing URN also contribute to improved energy efficiency. Measures such as



reducing vessel speed, applying wind-assisted propulsion or installing air lubrication systems can all help reduce underwater noise while simultaneously lowering fuel consumption. Notably, these solutions are not limited to the design phase of newbuilds; they can also be applied as retrofits to existing ships, broadening their potential impact across the fleet.

These intersections suggest that addressing URN does not necessarily require trade-offs with other performance goals, and can in fact support broader environmental compliance efforts.

According to BIMCO, such energy efficiency measures are expected to account for up to 32% of the industry's decarbonisation gains by 2050, while also supporting a 5dB reduction in URN, with some estimates reaching as high as 10dB.

With regional limits on underwater noise exposure and voluntary frameworks gaining traction, the momentum toward global regulation is building. The longer shipowners delay in addressing URN, the more expensive and disruptive the transition is likely to become. By acting now, stakeholders can gain operational flexibility, access incentives and future-proof their assets. ■

IMO: MORE URN DATA REQUIRED

Roel Hoenders, IMO Secretariat head of climate action and clean air, has called on the shipping sector to work towards establishing "a true baseline on URN" to identify "knowledge gaps" when addressing the problem.

Welcoming moves to curb URN as a synergistic complement to efforts to meet IMO's 2050 decarbonisation targets, Hoenders recently commented: "We have strong data at a local level covering smaller ship types, and insights on global URN impacts; what we need is more data from large ocean-going vessels. There are also ships that we know have energy-saving devices, but the impact on noise is not reported, so it is not possible to estimate how many ships in service merit credit for 'low noise'."

CARBON CAPTURE 'MILESTONE' FOR SCORPIO

Beşiktaş Shipyard has retrofitted a tanker with innovative carbon capture technology, writes **Clive Woodbridge**

In July, Scorpio Tankers' *STI Spiga*, a 2015-built crude oil tanker, called at Beşiktaş Shipyard in Turkey for the installation of a modular onboard carbon capture system (OCCS). The main scope of works included: structural modifications; the installation of the OCCS foundations and CO₂ storage tank; extensive glass-reinforced epoxy (GRE) and steel piping installations, covering seawater, exhaust, steam, air and freshwater pipes; and the final integration with existing vessel systems.

Beşiktaş Shipyard was responsible for executing all of the onboard works, based on engineering documentation and 3D scanning data provided by the owner and its engineering partner. The vessel stayed in the yard for around 50 days for the retrofit, as well as for work connected with the vessel's second special survey and exhaust gas scrubber-related modification work.

The carbon capture system installed on board was a containerised OCCS unit developed by US-based Carbon Ridge. The modular container-based design allowed for installation on deck with minimal intrusion into internal spaces and for direct connection to the existing auxiliary engine and boiler exhaust systems, via a common manifold.

Other features include a seawater-cooled absorption process and onboard CO₂ liquefaction and storage capability; an interface with steam, compressed air and freshwater utility systems; and integration with existing fire detection, alarm and automation systems.

"Complex retrofit"

According to Beşiktaş Shipyard marketing manager Roberto Sergio: "This approach offers several advantages in retrofit scenarios, including its ease of installation due to having a self-contained design and a reduced need for major vessel redesign or long off-hire periods. In addition, it offers scope for future scalability and removal, depending on operational needs."

Sergio continues: "The main challenge of this project lay in executing a complex retrofit within an existing vessel layout, while adapting to spatial limitations and ensuring seamless integration with legacy systems. Since the engineering and 3D scanning items of work were provided by the owner, Beşiktaş Shipyard's role was to translate these plans into onboard execution."

Some of the key challenges included navigating tight space constraints during routing and installation and

implementing hull penetrations, support structures and foundations without impacting vessel strength. The yard also had to ensure alignment and fitting accuracy with prefabricated components, especially GRE piping and exhaust manifolds.

Sergio adds: "We overcame these challenges through careful coordination with the owner's technical team and on-site representatives. We were also able to take advantage of our in-house fabrication capacity for GRE piping and steel structures."

Compact design

The project was something of a milestone in terms of the retrofit of carbon capture systems onboard ocean-going tonnage, as this represented the first ever deployment of a centrifugal OCCS. The captured CO₂ is compressed, liquefied and stored safely for the duration of the voyage.

Chase Dwyer, CEO and founder of Carbon Ridge, says: "Unlike other OCCS solutions, which are designed to be deployed on land and then adapted

Scorpio Tankers' *STI Spira* entered dock at Beşiktaş Shipyard for the installation of the Carbon Ridge onboard carbon capture system





The modular design of the OCCS limited the need for intrusive structural work during the retrofit

for ocean operation, we have specifically designed and developed this technology for the maritime industry.” The technology's compact design means that space requirements are reduced by up to 75% compared to conventional OCCS designs, and its flexible installation options – vertical or horizontal, depending on vessel constraints – allow it to accommodate a variety of vessel types.

Beşiktaş Shipyard believes that the project demonstrated the Carbon Ridge OCCS system to be well-suited for retrofit projects, especially when supported by detailed upfront engineering from the owner. As well as the minimal structural impact due to its containerised format, system components and piping could be pre-fabricated, reducing onboard welding and hot work, the yard points out.

In addition to the OCCS system, several supporting environmental enhancements were executed during *STI Spira's* docking at the Turkish yard. These included upgrades to steam and freshwater systems, optimising the efficiency of the OCCS unit; modifications to insulation and drainage systems in way of the new installations; and updates to fire control plans and safety equipment in accordance with new system locations. Sergio concludes: “This project demonstrated that collaboration is key in advanced retrofit projects.” ■

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YACHTS, KNOTS AND LEGAL SHOTS

Robert Hodge, director and general manager of ITIC, addresses the often-thorny topic of design errors on yachts

In my previous article for *The Naval Architect* May 2025, I explored the legal intricacies of intellectual property and how they intersect with the work of naval architects. This time, I turn to a more immediate and tangible concern: negligence. While intellectual property disputes often unfold in the abstract realm of ownership and rights, negligence claims strike at the very core of professional responsibilities: designing vessels that are not only beautiful but safe, functional and compliant.

ITIC insures naval architects working across the full spectrum of vessel types, from passenger ships and bulk carriers to tankers and offshore support vessels. However, this article focuses specifically on yachts, where the blend of aesthetics, performance and customisation introduces unique risks and legal exposures. These real-world cases, defended or paid by ITIC, are not merely cautionary tales; they offer practical insights into risk management, documentation and professional accountability.

The swan-necked exhaust

This, one of the more complex and instructive cases, involved a naval architect commissioned to design a series of motor yachts for a yard. As part of the contract, the naval architect was required to provide a drawing showing the down-flooding points of the yacht on an 'as built' basis. This drawing was never delivered.

Subsequently, one of the yachts suffered water ingress through the engine inlet during heavy weather, causing significant engine damage. The yard alleged that they were unaware the water inlet

was a critical down-flooding point and claimed that, had they known, they would have used stronger materials.

They submitted a claim of €180,000 against the naval architect for engine damage and rectification costs.

ITIC defended the naval architect, pointing out that the yard's own 3D

model showed a swan-neck fitting on the engine inlet pipe, a design feature that only made sense if the yard understood the inlet's vulnerability. Moreover, the naval architect was not responsible for the material used, which was found to be weak and non-compliant with class regulations.

Despite having a strong defence, ITIC acknowledged that the naval architect had breached the design contract by failing to provide the required drawing. This introduced litigation risk. A settlement of €55,000 was proposed and accepted, covering unrecoverable costs and mitigating further exposure. This case underscores a critical lesson: even when the technical fault lies elsewhere, contractual obligations, especially those related to documentation, can expose naval architects to liability.

Cracked keels

Another case involved a yacht whose keel developed cracks shortly after delivery. The naval architect had miscalculated the structural loads, leading to a design that could not withstand operational stresses. The owner initiated a claim, and the dispute escalated into a lengthy legal battle.

The naval architect's defence centred on the argument that the calculations were based on data provided by the client and that the design met the agreed specifications. However, expert analysis revealed that the structural integrity had been compromised due to errors in load distribution and material selection.

The legal costs mounted, and although the case was eventually resolved, it highlighted the high stakes involved in even seemingly minor miscalculations. In yacht design, precision is paramount and the margin for error is slim. This case serves as a reminder that naval architects must not only rely on client data but also verify it independently and document their assumptions thoroughly.

The importance of rule clarity

In another instance, a yacht experienced motor failures shortly after launch. The owner blamed the naval architect, alleging that the design had contributed to the malfunction. However, ITIC's investigation revealed that the architect had no involvement in the selection or installation of the motor systems.

The claim was dismissed, but not before the architect incurred significant defence costs.



Robert Hodge, ITIC: "Even the best designs can become liabilities if not backed by rigorous documentation"

This case illustrates the importance of clearly defining roles and responsibilities in contracts and communications. Naval architects must ensure that their scope of work is explicitly stated and that any third-party components or systems are clearly excluded from their liability.

The cost of ambiguity

A particularly costly example involved a naval architect accused of failing to comply with a design agreement, resulting in a claim exceeding US\$500,000. The dispute centred on whether the architect had exercised due care in their calculations and whether the final design met contractual expectations.

ITIC's defence focused on the naval architect's adherence to industry standards and the limitations of the original brief. However, the lack of clarity in the contract and the absence of documented design decisions made the

defence more difficult. The case was eventually resolved, but it highlighted the financial and reputational risks of ambiguous agreements and undocumented assumptions.

Loss prevention: five practical steps

These claims provide guidance for avoiding negligence claims:

1. Document everything: from specifications to communications, detailed records are your best defence.
2. Verify client data: never assume that client-provided information is accurate. Conduct independent assessments.
3. Clarify scope: define your responsibilities clearly in contracts and avoid scope creep.
4. Communicate risks: warn clients about potential design limitations or trade-offs in writing.
5. Insure wisely: professional indemnity insurance is not just a safety net, it's a strategic asset.

As naval architects, you are trained to balance form and function, innovation and regulation. But you must also balance creativity with caution. The claims discussed here show that even the best designs can become liabilities if not backed by rigorous documentation and clear communication. ■

“...even when the technical fault lies elsewhere, contractual obligations, especially those related to documentation, can expose naval architects to liability”



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A HELPING HAND FROM DRONE TECH

The US Navy plans to utilise long-range USVs to support its conventionally crewed battleship fleet, writes **David Foxwell**

The US Navy has issued a solicitation for a new class of long-range uncrewed surface vessels (USVs) that could help it operate in 'high-threat' areas far from shore, supporting manned vessels with additional firepower.

The new class of USV – the Modular Attack Surface Craft (MASC) – would be able to operate alongside manned vessels, increasing the US Navy's ability to conduct anti-surface vessel and strike warfare while providing conventional vessels and their crews with intelligence that will enhance their capability.

A solicitation issued by the US Navy on 28 July 2025 invited industry partners to submit solutions for the MASC programme, which will utilise an innovative acquisition approach known as 'Other Transaction Agreements' (OTAs), enabling it to streamline acquisition of the new class of USVs and rapidly deploy them.

The solicitation said utilising existing commercial designs and production capabilities "will enable the US Navy to rapidly deploy a formidable and cost-effective USV force". Adopting the OTA approach "will accelerate the design, development and demonstration of new USVs, for which contracts will be awarded for prototype projects –

which may include not only commercially available technology – alongside concept demonstrations and pilot projects".

Of high importance is the readiness and ability to construct and field a vessel rapidly, in less than 18 months from prototype award. "Submissions should include information on current and projected production facilities," the solicitation states. The US Navy's unmanned maritime systems programme office, PMS 406, will work alongside the MASC programme addressing the requirement for containerised payload solutions for the USVs.

Three solutions

The purpose of the USVs is to provide autonomous carrying capacity for a range of payloads. Three 'vessels solutions' are highlighted in the solicitation.

In the first, Vessel Solution 1, a fast, high-capacity embarked payload platform is being sought that integrates ISO containerised payloads. This vessel solution should carry a minimum of two 40' equivalent unit (FEU) containerised payloads that weigh 36.3tonnes each and consume up to 75kW of electrical power. The vessel should achieve a minimum range of 2,500nm while maintaining at least 25knots at all times, in NATO Sea State 4.

The US Navy wants to use uncrewed vessels with containers to beef up its firepower (image: US Navy)





Recent months have seen several USVs brought to market that could theoretically be adapted for the MASC programme (image: Zero USV)

accommodation onboard for eight personnel for up to 14 days when required, although this attribute is not applicable to Vessel Solution 3.

Battlespace awareness

US Navy unmanned maritime systems programme manager Captain Matthew Lewis says the MASC programme “represents a

significant step forward in the US Navy’s pursuit of a robust and adaptable uncrewed surface fleet.” This innovative approach to acquisition, coupled with a modular design philosophy, “will provide the fleet with cost-effective and highly capable platforms to address the challenges of the 21st-century maritime environment,” he said.

Melissa Kirkendall, programme executive officer for unmanned and small combatants, explains that the MASC “combines essential capabilities from the US Navy’s Medium and Large Unmanned Surface Vessel programmes, merging them into a flexible, modular platform designed for multi-mission operations.” She adds: “By uniting advanced modular design with rapid, cost-effective acquisition strategies, MASC will transform our surface fleet’s capabilities, enabling distributed lethality and enhanced battlespace awareness across multiple mission domains.

“We encourage industry partners to engage with this transformative initiative and collaborate with us to shape the future of unmanned maritime operations.” ■

In Vessel Solution 2, the US Navy is seeking to address the need for a high-endurance, high-capacity, embarked payloads platform, which also integrates ISO containerised payloads. This USV should have the ability to carry a minimum of four FEU containerised payloads that weigh 36.3tonnes each and consume up to 50kW each. The solicitation said this solution “should maximise speed and range to the extent practicable”.

In Vessel Solution 3, the USV should have the ability to carry a minimum payload of one 20’ equivalent unit (TEU) containerised payload that weighs 24tonnes and consumes up to 75kW. The TEU payload should have no obstructions aft of the payload to the transom. This solution should also maximise speed and range to the extent practicable.

The US Navy wants the USVs to be able to avoid collisions autonomously and safely, including during low-visibility conditions and in scenarios where radio frequency emissions are not permitted. The vessels should also be able to safely continue their mission if communications with the control unit are lost.

Payloads are to be unobstructed from the topside of the containerised payload to the port, starboard, aft and overhead. The vessels are constructed to ABS standards and their interiors should include a climate-controlled and secure space for future electronics.

The requirement for open-ocean performance states that they should be capable of autonomously operating in sea state 5 at a wide range of speeds and headings. They should also provide



Uncrewed vessels (similar to the Royal Australian Navy’s USV Ranger, pictured) have been tested by the US Navy for several years (image: RAN)



The new OPVs will reinforce Montenegro's ability to patrol waters at the gateway to the Adriatic

DEFENCE DUO FOR MONTENEGRO

The Montenegrin Navy is to receive a much-needed boost to its fleet with two state-of-the-art newbuilds, planned for delivery in 2027, writes **David Foxwell**

Kership, the joint venture between French shipbuilder Piriou and Naval Group, has commenced construction of the first of two new offshore patrol vessels (OPVs) for the armed forces of Montenegro. Construction of the OPV follows a 2024 intergovernmental agreement between the French Ministry of Defence and the Montenegrin Ministry of Defence relating to defence cooperation.

Following the agreement, which was confirmed at the 2024 Euronaval exhibition, Montenegro signed a contract for the acquisition of two OPV 60s from Kership, to be built at the Piriou facility in Concarneau.

Acquisition of two modern OPVs will significantly enhance the country's naval capability. The Montenegrin Navy – which was established in 2006, following the secession of Montenegro from the State Union of Serbia and Montenegro – has few vessels and only a little equipment inherited from the armed forces of the State Union, but the country has an extensive coastline.

Updated design

Based on an existing design that Piriou built for the Senegalese Navy, the OPV 60 provides a combination of endurance, good seakeeping, robust construction and firepower. It was originally designed to undertake surveillance in coastal waters and within the exclusive economic zone. The third and final example of the design was delivered to Senegal in April 2025.

The OPV 60 is a 60m patrol vessel that Kership has updated to enable the Montenegrin Navy to carry out a range of missions, including protecting infrastructure, border control, anti-piracy operations, search and rescue, pollution response and humanitarian aid. Addition of the vessels will reinforce Montenegro's ability to patrol waters at the gateway to the Adriatic, better protect its national interests at

the sea and enhance its ability to contribute to NATO's collective efforts in the region. The new vessels will also enable the Montenegrin Navy to deploy special forces, in a significant upgrade to the country's armed forces, and above-water drones.

With a length overall of 62.95m and a beam of 9.5m, the OPV 60 has a draught of 2.7m. Constructed with a steel hull and aluminium superstructure, it will provide accommodation for 24 crew and up to 16 special forces personnel. The OPV will have a diesel-electric propulsion system with MAN engines, two fixed-pitch propellers, two rudders and a bow thruster. The OPV 60s will have a range of 9,700nm, a maximum speed of 21knots and a displacement of 550tonnes, and each will make use of an active stabilisation system.

Guns and drones

In a statement, Kership said the OPV 60s will also be equipped with a 7.5tonne-capacity crane and will be capable of embarking two 20' containers. Special forces personnel will be deployed using a pair of 6.8m rigid hull inflatable boats (RHIBs), which will be launched and recovered using a stern-mounted ramp. The newbuilds will be armed with a remotely operated 40mm gun and two remotely operated 12.7mm machine guns. They will also embark unmanned aerial vehicles (UAVs) and have diver/special forces facilities.

The design has also been modified to include a hull-mounted sonar and a nuclear, biological and chemical 'cell' to provide protection to the crew in the event of an attack. Naval Group will supply a Polaris combat management system for the new OPVs.

Kership says the first vessel, to be named *Petar 1*, will be delivered to the Montenegrin Navy in the first half of 2027, with the second, *Petar II*, due to be delivered six months after the first. ■



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IN THE FOLD

A funding injection from the UK Clean Maritime Demonstration Competition is enabling WAPS developer Anemoui to develop a new folding system for its 3.5m sails, and to optimise its sails for greater vessel fuel efficiency

Wind-assisted propulsion systems (WAPS) have gained significant traction in the maritime industry in the first half of the 2020s, driven by rising fuel costs, stricter environmental regulations and the push for decarbonisation.

In Q1 this year, a whitepaper produced by classification society DNV noted a sharp uptake in WAPS adoption since 2021, with 54 large ships now equipped with WAPS, and seven more designated as 'wind-ready'. Looking to the future, the WAPS-assisted ship orderbook includes 80 vessels, with 30-40 more planned for 2026-2027, DNV states.

Naturally, this uptake has spurred a good deal of investment into this green technology. In August, UK WAPS developer Anemoui announced that it had secured £1.2 million in funding, under the sixth round of the Clean Maritime Demonstration Competition (CMDC6), to realise a next-generation folding sail system for its Rotor Sails, tailored to Kamsarmax and Panamax bulk carriers (featuring

typical deadweight tonnage of 80,000-83,000dwt and 60,000-80,000dwt respectively).

The folding system will enable the Rotor Sails to be lowered to a horizontal position for passage under bridges, or to avoid cargo interference. In addition to the folding system, the project includes design tweaks to enhance the aerodynamic performance of the Rotor Sails, for greater fuel savings and emissions reductions.

The CMDC was established by the UK Department of Transport (DoT) and Innovate UK to develop green technologies for ships and ports, and funding is provided by the UK Shipping Office for Reducing Emissions (UK SHORE) programme. To date, the CMDC has funnelled £136 million of funding into maritime decarbonisation projects. According to Clare Urmston, Anemoui CEO: "This funding will support Anemoui in advancing the next generation of Rotor Sail technology. Ongoing innovation is essential to unlock further efficiency gains, adapt to evolving vessel designs and meet increasingly ambitious environmental targets."

"Continuous R&D"

Set to run for seven months, the CMDC6 project will see Anemoui design, build and test a prototype of a new folding system for its 3.5m-diameter Rotor Sail – a move the company hails as "an industry-first for Rotor Sails of this size, as folding systems have previously only been used on larger 5m sails". The ability to fold the sails makes them more practical for vessels operating on routes with restricted air draught or during port operations.

Ben Shaw, Anemoui R&D engineer, tells *The Naval Architect*: "The new folding system includes new design concepts that will improve structural efficiency, allowing for smaller components relative to the size of the sail, and fitting a taller Rotor Sail within the width of the ship when folded, reducing cost and increasing performance." These new design concepts, Shaw adds, will also "improve functionality for crew and additional protection of components from corrosion", to ensure optimal



Pictured: Anemoui's production base of existing 5m-diameter folding Rotor Sails; the UK CMDC funding will be used to develop a folding system for Anemoui's smaller, 3.5m-diameter Rotor Sails

Clare Urmston, CEO, Anemoi: “Ongoing innovation is essential to unlock further efficiency gains”

performance and reliability while reducing the need for maintenance.

“Continuous R&D is essential to maximise performance across a wide range of operating conditions,” Shaw continues. “Anemoi has a number of concepts for improving aerodynamic efficiency, which will allow the Rotor Sails to perform even better, especially in headwinds, primarily by reducing the aerodynamic drag. These concepts will be trialled using CFD and wind tunnel measurements, and a cost benefit analysis will be undertaken to assess the viability of introducing these to our product range.”

UK-based Pressure Design Hydraulics Engineers will manufacture the test rig for the new system, and the aerodynamic enhancements will be fleshed out with Cape Horn Engineering, supported by Stehr Consulting. Meanwhile, UK shipbroker Victoria Steamship will provide feedback from its fleet of nine bulk carriers, which Anemoi identifies as “a primary market for folding Rotor Sails”, while UK innovation accelerator Connected Places Catapult will conduct market research and a port and vessel integration study on behalf of the partners.

Shaw adds: “The prototype folding system will act as a proof of concept for the new designs. Anemoi will conduct trial folds with survival loads [ie, loads far beyond the actual weight of the Rotor Sail] applied.” He continues: “Thorough inspections will be made to confirm the integrity of the structure following testing and assessments of the practicality of operating the system aboard a vessel. Successful demonstration of the new designs will give confidence for implementation aboard a vessel.”

The folding system will require minimal crew input, with operations completed in approximately 10-15 minutes, for seamless integration into vessel workflows.

Challenges and feedback

Reflecting on potential technical hurdles, Shaw says: “The challenges arise from introducing fundamental changes in the configuration, which must be physically prototyped to ensure they are safe and effective. Proof of concept in this project will pave the way for upscaling the concepts to our 5m range to bring the same cost and operational benefits.” It will also be important to ensure that the system does not impact on cargo loading and unloading procedures, for a seamless transition between sailing and port operations.

The pay-off for overcoming these challenges is significant, though: Shaw estimates that a Kamsarmax equipped with four folding 3.5m-diameter Rotor Sails could slash emissions by 3,600tonnes CO₂e per year, saving vessels “over £500,000 in fuel and EU emissions trading system costs”.



In Q2 2025, Anemoi and Lloyd’s Register Advisory shared the results from the 2023 installation of three 5m-diameter, 24m-tall Rotor Sails aboard the 82,000dwt Kamsarmax *TR Lady*, following a year-long, multi-voyage testing period, in which the vessel sailed the Indian Ocean, the South Atlantic, the North and South Pacific and the Strait of Malacca, to name but a few locations.

Within that timeframe, the ship recorded average savings of 1.9tonnes of fuel and 7tonnes of CO₂e per day – equating to an average of 9.1% net propulsion fuel and emissions savings. However, Anemoi adds, these savings are liable to significant fluctuations, given that *TR Lady* does not follow a fixed route – which also applies to other vessels of this type. For example, Anemoi notes that “on a 22-day voyage across the North Pacific, average route savings of 21% net propulsion fuel reduction were calculated”. ■

THE MAGNUS EFFECT

Anemoi’s Rotor Sails work by using the Magnus Effect to generate thrust for ships. The Rotor Sails comprise tall, vertical cylinders mounted on the ship’s deck, and these spin, powered by electric motors. When wind blows across a spinning rotor, it creates a pressure difference, with low pressure on one side and high pressure on the other. This generates forward thrust, pushing the ship. Sensors are used to automatically adjust the rotor’s spin speed and direction, without the need for crew interaction, to optimise this thrust.

BRINGING IT ALL TOGETHER

Kongsberg's K-Sail solution aims to integrate WAP technology with other onboard propulsive and electronic components, to create a seamless, self-adjusting onboard ecosystem for optimal efficiency

Installing wind-assist propulsion (WAP) technology could help shipowners to reduce energy consumption and fuel costs – but, it's important to note, getting the best out of WAP systems (WAPS) necessitates integrating them with the other onboard propulsive components, rather than installing and utilising these WAPS in relative isolation.

As Henrik Alpo Sjöblom, VP for business concepts at Kongsberg Maritime, puts it: "Shipowners can choose their preferred type of wind-assist technology: there are several available and they all have their own attributes. However, to date, these technologies, whether incorporated in a newbuild or retrofitted, are essentially an add-on technology." He adds: "We believe they can be used in a much more effective way."

To pursue that aim, June saw Kongsberg Maritime officially launch its K-Sail service, an offering intended to help shipowners select and integrate WAP technology more effectively. Sjöblom, who is also the driving force behind K-Sail, tells *The Naval Architect*: "It's taking the same approach as you would with a yacht; determining how you manage all systems on board when you factor in the additional thrust from the sails. You really need to analyse how the sails work to integrate them with the onboard systems, and to consider each specific vessel and specific route.

"Like with a sailboat, you wouldn't use the same sail all the time; you'd have a main sail for certain legs, but also a jib for upwind sailing and a spinnaker for downwind sailing – so why not take the same approach for wind-assisted vessels?"

AI-optimised

K-Sail can be broken down into five key areas, including: initial analysis, as in "understanding the vessel's operational parameters and selecting the appropriate sail technology", the company says; ensuring the steering system can accommodate the additional thrust generated by the sails; ensuring the propeller operates efficiently with the additional wind propulsion; and balancing the power generated by the sails with the ship's energy requirements.

The fifth element concerns the use of AI and real-time data to optimise the ship's route and speed, for maximum operational efficiency. The K-Sail system continuously collects and analyses data from multiple sources (including wind conditions, vessel

speed, heading, sea state and onboard propulsion, steering and power management systems), using sensors, to monitor sail-generated thrust and engine power output in real-time. This then enables dynamic adjustments to maintain optimal performance.

So, for example, the system could reduce engine load (and thus fuel consumption) when winds are favourable. Alternatively, when wind strength drops, or there is a heightened requirement for speed, K-Sail can shift more power to the engines, automatically adjusting sail angles, engine RPM and propeller pitch to reach the most energy-efficient operational state. Based on the results of a pilot project aboard a tanker owned by Terntank, K-Sail could reduce engine power by up to 9-15% in strong winds, cutting fuel use and emissions.

"The real numbers"

Sjöblom says: "Putting a sail on a ship is of course not new. But the essence of using it successfully lies in the integration of these sails into the ship's systems. It's all about making the different components and technologies aboard the vessel play with each other better."

Expanding upon the importance of the pilot projects and forthcoming sea trials, Sjöblom adds: "The problem with WAP, as with any renewable energy, is that it's based on probabilities. Once you start operating, you get the real numbers regarding how this technology actually performs in winds." As befits a system designed to be compatible with various WAPS (including Flettner rotors, suction sails, soft sails and rigid sails) and vessels ranging from small fishing boats to bulkers, the K-Sail's use of AI will help the system to learn how each WAPS-equipped vessel performs in different wind directions, considering factors such as the aerodynamics around the vessel – "which can be more challenging for, let's say, a cargo vessel with block structures on its deck," Sjöblom says. ■



The K-Sail service is intended to integrate the WAPS technology with the other onboard systems, to optimise the ship's route and speed

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GREENER RUNS ON THE GREAT LAKES

The recently delivered M/V *Tamarack* has brought cement cargoes back to Canada's Great Lakes, albeit with enhanced manoeuvrability and reduced energy consumption, writes **Bruno Cianci**

On 22 August, the Canadian-flagged vessel M/V *Tamarack*, the first newly built cement carrier in two decades to enter service on the Great Lakes, called at the Port of Montreal, thus completing her maiden transatlantic voyage and proceeding to load her maiden cement cargo.

Owned by Eureka Shipping, this 12,500dwt vessel had been delivered in July by Holland Shipyard in Hardinxveld-Giessendam, the Netherlands, during a ceremony attended by over 150 invitees, including senior management and employees from Eureka Shipping, as well as shipyard directors, stakeholders and other guests. Eureka Shipping – a joint venture between Canadian Steamship Lines (CSL) Group, whose roots go back as far as 1845, and Cyprus-based SMT Shipping – was established in 2008, with CSL Group joining as a shareholder a decade later. Eureka, headquartered in Limassol, Cyprus and with a branch office in Bergen, Norway, owns and operates a fleet of cement carriers and barges ranging from 3,726dwt (M/V *Envik*) to 22,530dwt (M/V *Winterset*), with an average close to 7,000dwt per vessel.

“We are pleased to add M/V *Tamarack* to our fleet: bringing her to the Great Lakes has been a true team effort,” says Kai Grotterud, Eureka Shipping MD. “This highly efficient vessel is the result of a close collaboration with our customer, smart design and a shared vision of more responsible shipping.”



Tamarack | Ingridbot.nl-9



The diesel-electric-powered *Tamarack* was delivered to Eureka Shipping in August (image: Vincent Tremblay)

At the July launch event, Grotterud had previously highlighted Eureka Shipping's strategic commitment to Eureka's fleet rejuvenation, and underlined that *Tamarack* is the result of more than three years of dedicated development work, the outcome being “an exceptional vessel, completely tailored for its intended purpose, delivering highly efficient transportation with minimal environmental impact”. Although designed on a compact platform, this 123m vessel was commissioned to replace two older ships with a more streamlined, high-performance design that retains the same cargo capacity while significantly reducing the environmental footprint thanks to energy-saving handling systems.

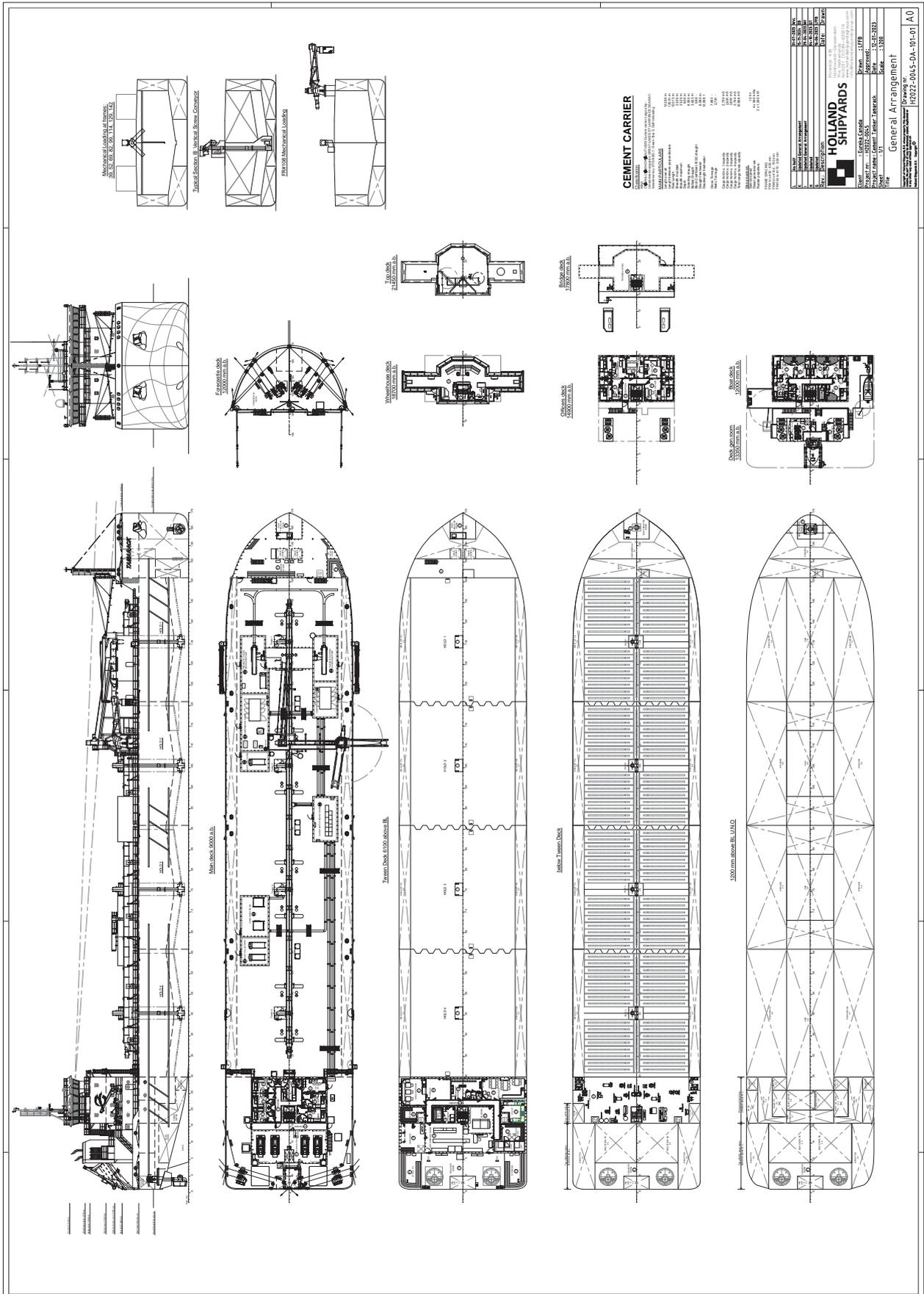
Alt-fuel option

The commissioning of *Tamarack* is likely to transform activities in the Great Lakes region. Named after a species of deciduous conifer tree native to Canada (*Larix laricina*), and specifically tailored for the North American Great Lakes and St Lawrence Seaway, M/V *Tamarack* features four dedicated cement cargo holds with a total capacity of 10,856m³, all supported by high-efficiency loading and discharging systems.

Tamarack is fitted with diesel-electric propulsion, featuring four generator sets, two 360° rudder propellers (which also perform as thrusters while docking) and a powerful bow thruster for optimal manoeuvrability. The vessel is also equipped to run on hydrogenated vegetable oil (HVO), thereby reducing greenhouse emissions.

The vessel was commissioned to replace two older ships with a more streamlined, high-performance design

The general arrangement of the cement carrier *Tamarack*





Features include a service speed of 10knots and 10,856m³ of cargo hold space

less electricity than traditional lighting systems, as well as heat recovery on the generator sets for the HVAC, plus other energy-saving technical measures.

When asked what *Tamarack* represents, Marco Hoogendoorn, director of all Holland Shipyards Group locations and product companies, replies: “This vessel demonstrates what collaboration can achieve. Together with Eureka and SMT, we’ve delivered a robust and efficient ship, tailored to her task. We’re proud to have contributed to this project that also confirms our

Furthermore, *Tamarack* is prepared for shore power connectivity, enabling zero-emission operations in ports, and the vessel features advanced insulation and silencing, which reduce the ship’s operational noise. The environmental goal is further enhanced by the wide use of LED lighting, which consumes

ability to handle complex cargo systems and very specific vessel designs.”

Precise manoeuvring

Regarding the vessel’s highlights, Hoogendoorn emphasises: “*Tamarack* is a sophisticated diesel-electric design with two L-drives: it has no main batteries and runs solely on generators. The diesel-electric propulsion system, powered by four Caterpillar generators [see Technical Particulars] always allows for the most optimal power setting, either in transit, when manoeuvring, berthed or during loading/unloading operations.

“The thrusters allow for precise manoeuvring in a confined space. There are quite a few stretches and terminals that require precise control. Some even invoke kilometres of sailing backwards: an operation that, with a shaft line, would be way more difficult.”

Another highlight rests on the abovementioned discharging system, which, Hoogendoorn underlines, “can operate both by air and mechanically, and has been selected by the owner to also serve remote places lacking their own cement-handling systems”. Indeed, the design utilises advanced cargo-handling systems that minimise overall energy consumption. The apparatus in question is a Lars Lovik AB cargo system with a 1,000-tonne loading capacity, with mechanical discharge amounting to 1,000tonnes per hour and pneumatical discharge of up to 480tonnes per hour.

Tamarack, which is handled by a crew of 15, has a range of 3,600nm and can spend up to 15 days at sea, and has a service speed of 10knots. Even though, Hoogendoorn says, “there can be a significant demand for this type of vessel”, there isn’t currently a sister ship on the drawing board. ■

TECHNICAL PARTICULARS
M/V TAMARACK

Length	122.9m (oa) 120.5m (bp)
Breadth	23.2m (max) 23m (moulded)
Summer draught	6.43m
Ballast draught	3.92m
Deadweight	12,500tonnes
Gross tonnage	7,683gt
Net tonnage	2,755
Cargo hold capacity	10,856m ³
Service speed	10knots
Main diesels	4 x Caterpillar C32 / 1 x Caterpillar C7.1
Output of each	994kWe / 106kWe @60Hz
Rudder propellers	2 x 1,250kW
Flag	Canada
Classification society	RINA

DECARBONISING DRY BULK OPERATIONS

A new partnership seeks to accelerate the adoption of energy-efficiency technologies within the global dry bulk carrier sector

Singapore-based non-profit the Global Centre for Maritime Decarbonisation (GCMD) and the International Association of Dry Cargo Shipowners (Intercargo) have signed a two-year decarbonisation agreement, focusing on the dry bulk carrier sector.

The partners aim to promote wider adoption of energy-efficiency technologies among dry bulk owners, and to facilitate the exchange of info and data on advancements in low-/zero-carbon-fuelled dry bulk vessels. GCMD states: “Dry bulk is the world’s largest shipping segment by tonnage and presents unique decarbonisation challenges, particularly for small- and medium-sized owners operating unpredictable tramp trades. Bulk carriers are critical to global seaborne trade, accounting for 42.7% of the world’s oceangoing fleet by deadweight tonnage [dwt].”

In turn, Intercargo’s members comprise more than one-third of global dry bulk tonnage. Professor Lynn Loo, CEO of GCMD, elaborates: “This partnership offers a valuable opportunity to deepen our understanding of the dry bulk segment’s operational realities and work collaboratively to address gaps in meeting the industry’s decarbonisation targets. Through Intercargo’s consultative status at IMO, we hope to contribute to the development of global regulatory frameworks for maritime decarbonisation.”

Challenges ahead

Accelerating decarbonisation across the dry bulk segment won’t be the most straightforward of tasks, GCMD concedes. For a start, there’s the fact that these vessels tend to operate on a ‘tramp’ trade basis, meaning they do not follow fixed schedules or routes; instead, they are usually chartered for specific voyages or periods. So, while planning alt-fuel bunkering for ferries and coastal vessels is simpler due to their fixed, predictable routes, ensuring access to zero- or near-zero (ZNZ)

GCMD and Intercargo aim to promote wider adoption of energy-efficiency technologies among dry bulk owners



emissions fuels for dry bulkers is much more difficult, as their routes are irregular.

Additionally, alternative fuel accessibility is a concern in its own right. “The global bunkering infrastructure remains in development, with ZNZ fuels unlikely to be available at all ports in the foreseeable future,” GCMD points out. To counter this, the partners want to foster “pragmatic, near-term solutions” to meet IMO’s decarbonisation targets.

One possible, pragmatic option is to use ‘drop-in’ biofuels derived from vegetable oils, animal fats or waste materials, which, being chemically similar to fossil fuels such as diesel, can be added directly to existing engines without the need for modifications. Onboard carbon capture systems present another option, enabling the capture and storage of CO₂ produced during the vessel’s operations.

PAYS approach

GCMD is now planning and conducting pilots and trials, intended to “lower barriers for the broad market adoption of these solutions” across the dry bulk segment. However, GCMD acknowledges: “Shipowners often face challenges in deploying energy-efficiency technologies due to fuel savings uncertainty, and some face limited access to financing.”

In turn, GCMD has adopted a financing model called ‘Pay As You Save’ (PAYS), for shipowners who may be discouraged by the upfront cost of new green tech installations. A third party (like a financier or technology provider – GCMD signed a partnership with the Asian Development Bank to this end in Q2 2025) covers the initial cost of installing energy-efficient upgrades on a ship. The shipowner repays this investment over time, but the repayments are tied directly to the fuel savings achieved by the energy-efficient technology.

So, for example, if the technology results in a US\$100,000 reduction in annual fuel costs, a portion of those savings is used to pay back the financier. The PAYS model reduces financial risk for shipowners because they only pay based on verified savings, and it encourages adoption of green technologies by removing the barrier of large initial investments. To verify these fuel savings, GCMD would install sensors aboard all participating vessels, to collect fuel consumption data and measure how much fuel the ship uses before and after implementing these energy-efficiency technologies. The goal is to validate fuel savings by collecting accurate, real-world data to confirm that these technologies actually reduce fuel use as claimed. ■

SGS divers recently removed a cruise ship tunnel thruster unit, allowing it to be rebuilt off-site before reinstallation

SWIFTER REPAIRS OUTSIDE OF DOCK

Repair projects in this sector have seen underwater diver technician teams help to ensure vessels avoid expensive downtime in dock. **Clive Woodbridge** reports

Miami-headquartered Subsea Global Solutions (SGS), which this year celebrates its 80th anniversary in the underwater shiprepair and maintenance business, has recently delivered a number of notable projects in US waters. A recent example involved its East Coast team, which completed the underwater removal of a Kongsberg TT3000 tunnel thruster from a cruise ship in Port Everglades, Florida.

A custom-built thruster removal sled and tunnel blank flange were designed and manufactured to ensure the safe extraction and sealing of the tunnel. After initially attending to remove gratings and prepare the necessary rigging, SGS divers removed the support strut, installed the sled system and worked in coordination with the cruise company's internal teams to prepare the top hat assembly. The thruster was then unbolted, lowered using the sled system, lifted ashore by crane and sealed with a leak-tested blank flange. The unit was subsequently rebuilt off-site for re-installation by SGS divers.

In another notable US project, SGS handled a significant repair job when a fully laden container vessel lost rudder control near Los Angeles. The SGS West Coast team removed the 110tonne rudder afloat, coordinated repairs ashore and reinstalled it.

San Diego job

SGS was also recently engaged to perform an urgent azimuth thruster repair for a subsea cable vessel in San Diego. The vessel was fully loaded with cable and preparing to depart for a seabed installation

project in Fiji when a slow leak was detected at the port azimuth thruster's steering seal. The scope of work undertaken by SGS included: conducting an inspection to locate the precise source of the leak; designing a customised packing gland housing as an alternative to a full seal replacement; fabricating the housing; and installing the solution underwater with its own dive team.

Upon initial inspection, it was determined that the steering seal, rather than the shaft seal, was the source of the leak. Given the vessel's pressing schedule, a traditional seal replacement was not feasible. Instead, SGS' technical services team engineered a customised packing gland housing that could be bolted onto the existing steering seal housing, effectively sealing the leak without requiring extensive disassembly. The vessel was cleared for departure on time, ensuring it could proceed with its seabed installation project as scheduled.

Earlier this year, SGS responded when a 120m ro-ro vessel required an immediate thruster installation and rudder bushing repairs, delivering an in-water solution at the Port of Portland, Oregon. Originally scheduled for drydock, the repair was re-planned to accommodate the vessel's tight operational schedule.

To facilitate dry repairs for the rudder bushing, SGS' technical services team designed and fabricated a customised reusable cofferdam, one of the largest of its kind ever built, directly at the repair location. The cofferdam fully encapsulated the 45tonne

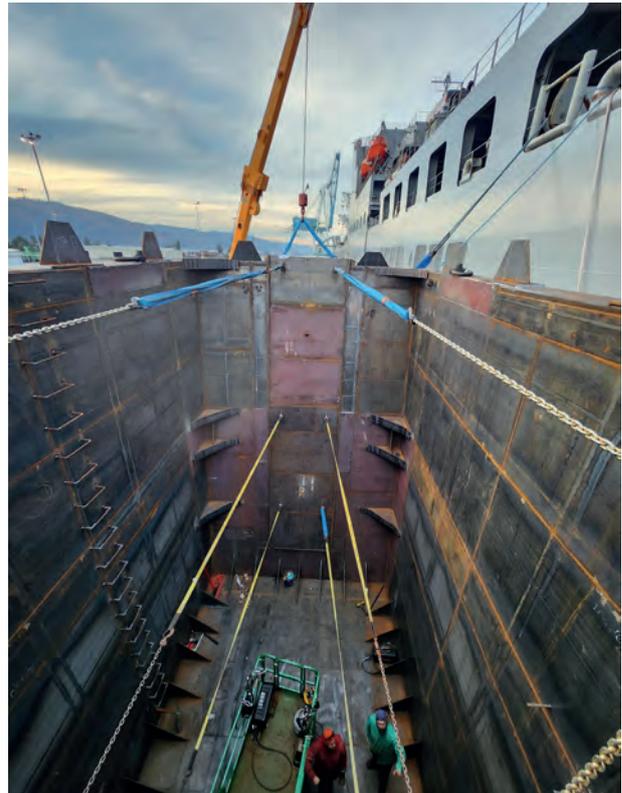
rudder, featuring a unique door configuration, and was constructed to handle the specific environmental conditions of the Willamette River. SGS installed two thrusters entirely underwater, while also replacing the rudder bushing without removing the rudder blade.

Custom-built cofferdam

Another major global underwater repair services provider, Wärtsilä Underwater Services, has similarly been kept busy this year with a wide range of projects. In April, the company was called out to support a vessel at Laem Chabang Port, Thailand, after it suffered significant propeller damage.

Due to a completely failed forward bearing, the shaft could not be rotated, and the vessel was unable to safely operate. While awaiting the arrival of a new bearing, the Wärtsilä Underwater Services dive team stepped in and repaired the damaged propeller blades. Once the bearing was renewed by the crew, the vessel was able to resume operations under its own power, without any vibrations.

More recently Wärtsilä Underwater Services has been supporting a major underwater repair in the Mediterranean, involving a 50m crack and extensive hull damage, which all needed to be fixed afloat



Earlier this year, SGS constructed one of the largest cofferdams ever built, for a ro-ro thruster repair project



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A T-foil being lifted prior to underwater installation by Hydrex

without drydocking. The company engineered and installed a custom-built 51m cofferdam, covering an area of 175m², which was entirely designed in-house.

With the water pumped out, the company's dive team entered the cofferdam, gaining access to the damaged hull while the vessel remained afloat. Over 140m² of steel had to be renewed, which was made possible by the precise fit and structural integrity of the in-house engineered cofferdam.

In an important strategic development for the company, Wärtsilä Underwater Services has in recent months entered into a partnership with Megatugs of Greece. The new venture aims to combine Wärtsilä's knowledge of shaft line and propulsion systems with Megatugs' expertise in underwater services and salvage operations, to offer a more comprehensive and proactive approach to vessel maintenance. The benefits of the alliance, Wärtsilä says, will be to reduce vessel downtime; implement greener, regulation-compliant solutions; and offer more advanced underwater diagnostics and repair services on a global basis.

T-foils and cracks

Meanwhile, Belgian underwater repair specialist Hydrex recently carried out the installation of a T-foil on a high-speed craft ferry during the vessel's stay in Fort Lauderdale, Florida. The project was performed underwater, allowing the vessel to continue its operations without the need for drydocking.

Before the installation could start, the external protection plugs on the hull were carefully removed to provide a clear surface for the new equipment. Hydrex divers/technicians then installed the threaded bars required to fasten the T-foil. This phase involved precise underwater work, as the correct alignment of the threaded bars was essential for maintaining the stability of the installed unit.

Once the preparatory tasks were completed, the T-foil was lifted into place and secured using tack welding. Following the installation, the Hydrex team conducted a thorough inspection to confirm that the T-foil was properly secured and aligned.

Hydrex has also recently undertaken a major crack repair to a car carrier during the vessel's stay in Durban, South Africa. The crack was found to be 650mm in length, covering the weld seam of the starboard side rudder cover plate. To prevent the crack from spreading, crack arrests were drilled at its extremities. Next, the divers/technicians ground out the crack in a v-shape over its entire length as well as the surrounding area. Subsequently, a root pass was made in the crack, which was then filled with full penetration welding.

As a result of this repair, the vessel did not have to make an emergency visit to drydock, but could instead make arrangements for a follow-up repair at a more convenient time and location. ■

THE EVOLUTION OF PORTSMOUTH DOCKYARD

Mark Barton provides the second of his two-part overview of how Portsmouth Dockyard, and other UK yards, developed over the centuries

The first half of this article (see *The Naval Architect* August 2025) looked at how the docks in the naval base at Portsmouth were established. This second part will look at the significant changes that occurred in the Restoration and Napoleonic eras; the changes brought about by the introduction of steam; and those needed to enable the introduction of the Dreadnoughts at the end of the nineteenth century. While focused on Portsmouth, it helps explain many of the features seen in dockyards to this day.

In 1690, the Royal Navy (RN) started a joint shipbuilding and dockyard improvement programme, which was completed by 1698. Ten acres were reclaimed from the sea and two non-tidal basins established. The first, the Great Ship Basin (later known as No. 1 Basin), had double lock gates. This was not just larger than the Tudor docks but incorporated a major technical improvement. Up to then, graving docks were wooden-sided, but Edmund Dummer designed stone docks for Portsmouth. The first one, the Great Stone Dock, is still there (and now called No. 5 Dock). This change enabled the introduction of stone slides to deliver materials to the dock bottom easily [1], speeding up refits [2]. The next decade saw a new dockyard wall and, in 1708, the building of the Porters Lodge, now the oldest surviving building in the dockyard, and then in 1715, Long Row, which were senior officer's residences, later known as The Parade.

Because of the strategic need to counter France and improve access to the Atlantic at that time, a Royal Dockyard, initially called Plymouth Dock and later Devonport, was created in the southwest. During wartime, Royal Dockyards focused on ship repairs due to their limited capacity, while commercial shipyards handled new ship construction, typically following Admiralty designs.

The Seven Years' War (1756–1763) highlighted Devonport's importance. Both dockyards underwent 'the Great Rebuilding', which introduced a structured layout plan for each yard, moving away from the earlier practice of adding buildings independently.

In Portsmouth, work started on the Great Rebuilding in 1761. That decade, the Lower Wet Dock (by then known as the Great Basin) was deepened and the Great Stone Dock was rebuilt, and a new dry dock (now No. 4) was added. The 1770s saw the Upper Wet Dock reconfigured to serve as a reservoir into which water from the dry docks could be drained by way of culverts to enable ships to be drydocked quicker. North of the reservoir, a new boat basin was

constructed, and beyond that there was reclamation of mudflats to create North Corner area, which initially had several shipbuilding slips on it.

The camber between the great storehouses and Semaphore Tower was started in 1764 and then rebuilt in stone in 1773, a camber being a quay built for the convenience of loading and discharging timber (it comes from the term for bending a beam upwards in the middle to arch slightly). This enabled ships to get closer to the storehouses, as well as supporting the manufacture of masts and spars. The area the other side of this was reclaimed at this time, with two warehouses built to be a sail loft and rigging store. This reclaimed land was later named Watering Island after a fresh water supply was fitted and ships went to it for that purpose. Most of the main buildings in the historic dockyard area come from this rebuild.

The arrival of steam

As war resumed, commercial shipyards primarily handled shipbuilding, while Royal Dockyards focused on repairs. Increased capacity was needed to address both battle-damaged vessels and those worn out by the operational strategy of maintaining fleets at sea, especially during blockades.

At Portsmouth in 1799, the first steam engine was installed to pump out the reservoir; stream dredging was introduced; and the first floating caisson was installed in 1801, as part of the entrance to the Great Basin. Steam engines were first used to power machinery in the block mills in 1803, and were so new and innovative that Nelson asked to see them on his visit to Portsmouth the day before embarking on *Victory* for Trafalgar. These changes increased



Dreadnought, launched in 1906, was fitted out at Portsmouth's No. 15 dock

HISTORY & HERITAGE

the capacity of the yard, particularly improving how quickly ships could move into the basins for repair.

While steam propulsion was initially used only on auxiliary vessels or as auxiliary propulsion, it still impacted on the yards and led to the creation of a steam yard at Woolwich in the 1830s. [3]

For the docks rather than the dockyards, the move to larger hulls that came with the change to iron from wood created the bigger effect, and meant the RN's London dockyards started to close, despite two of the three main marine steam engineering innovators being there: Maudsley's at Lambeth and Penn at Deptford [4]. Maudsley mounted a beam at the side rather than above the engine, which enabled them to fit into cramped engine rooms. His first commercial marine engine was built in 1815 and fitted to a Thames steamer. In 1823, it was a Maudsley engine that powered *Lightning*, the second steam-powered vessel commissioned by the RN. The commercial facilities at Millwall were using steam and this gave Woolwich a new lease of life as new buildings were constructed for steam manufacturing and maintenance, including a boiler shop, foundries for brass, copper and iron work, and an erecting shop for assembling the engines; by 1843 all were integrated into a single complex known as the steam factory. The factory was part of the dockyard but had a high degree of independence and was accessed by its own gate and overseen by its own official, the Chief Engineer.

While Woolwich retained its primacy as the Navy's steam engineering yard through the 1840s, both Portsmouth and Devonport had to adapt, with both seeing the creation of steam basins, where ships could moor alongside the factory while their

engines and boilers were fitted. The seven-acre great steam basin at Portsmouth was started in May 1843, now No. 3 Basin, and split into three separate basins originally. The entrance to the Camber was widened to allow paddle steamers to enter and No. 7 Dock was built end-to-end with No. 10 dock, so ironclads could be docked.

Ironclads meant dockings needed to be more frequent, because of the machinery and because iron hulls acquired growth quicker than copper-covered wooden hulls [5]. The docks also had to be longer to cope with the increased length of these new ships. It was recognised that the high cost of hulls meant the navy that could repair its ships quickest had a strategic advantage [6]. Conducting much of the work in an open river or under tidal influence was dangerous and slowed it down; therefore, large basins were needed to enable the vessels to be in still water without the risk of grounding which would damage the iron hulls.

At Portsmouth, this meant a tidal basin, which led into a repair basin and that into a rigging and a fitting out basin. There were two dry docks, No. 12 and No. 13, off the repair basin and provision for two more was made (14 and 15). Another dry dock was created off the tidal basin and two locks (A and B) were created to give access to the repair basin to speed up repairs. This work, known as 'the Great Extension', was completed in 1876.

Preparation for WWI

The 1890s saw three significant changes impact on the design and layout of all RN dockyards. The first was the move ashore. All the naval base barracks and training schools were developed in this era, enabling the hulks to be removed from the harbours, freeing

A sketch of Portsmouth Dock, looking east (image: Mark Barton's collection)



Year of first of class	Class	Length	Beam
1903	Pre-Dreadnought Edward VII class	139m	23.7m
1906	Dreadnought	160m	25m
1914	Queen Elizabeth	195m	27.4m
1916	Renown	242m	27.4m

Table 1: the Dreadnoughts compared in size to their predecessors and successors

up considerable space on wharves. This meant naval bases became more capital-intensive to construct and move and embedded naval personnel much more deeply into the local community.

The other two were related. There was a change in the composition of the fleet epitomised by the introduction of the Dreadnought battleships, and the recognition that a European War was coming. Therefore, there was an imperative to build bases in Scotland to enable vessels to be maintained at readiness. Thus, this era saw Rosyth and Invergordon developed as naval bases.

At the same time, the size of vessels acquired by the RN grew such that if they were launched at Chiswick, parts of the superstructure had to be removed to enable them to pass under the bridges on the Thames to sail on trials. For Thornycroft, then based in London, the solution was to move the bulk of its operations to Woolston, Southampton, in 1904.

The new classes of vessels, particularly the Dreadnoughts, were significantly larger than their predecessors (see Table 1).

Although the Victorian dockyard expansion was still finishing as the Dreadnoughts emerged, further expansion was needed. By March 1905, the design of the Dreadnoughts was complete and the keel of the first was laid down on Portsmouth's No. 5 slipway on 2 October that year. The dockyard worked a 69-hour week and six days per week, including Christmas and New Year, using searchlights to enable them to continue overnight. *Dreadnought* was launched on 10 February 1906 and was ready for sea trials that October. On acceptance, she made all other battleships obsolete.

The only dock that could accommodate *Dreadnought* as she was fitted out was No. 15 Dock. She also had access through either A or B lock into the rigging basin, but this was limited by tides, such that she could only get in or out on 14 occasions per year and on the daytime high tide only [7]. The Director of Naval Construction commented: "Had wider docks been available, it would have been possible to build

ships with a greater beam, and the designs on the same length and draught could have embodied more fighting qualities, such as armour, armament, greater stability in case of damage and improved underwater protection" [8].

In Portsmouth, the repairing, rigging and fitting out of basins, parade ground and coaling point were restructured to create one large basin (now No. 3 basin) with a new large lock, C lock, to get *Dreadnought* through. The initial plan left space for a second lock, and thus D lock was added. However, this increase was not enough to cope with the number of Dreadnoughts needing to be maintained, with Portsmouth being expected to deliver five lines of work, and so No. 15 and No. 14 docks were lengthened and an Admiralty Floating Dock commissioned, at the time the largest ever built, which was placed at the eastern end of Fountain Lake Jetty to provide the fifth location [9].

While there have been significant changes since – in particular, the covering of the slips in the North Corner area and the construction hall built over two docks – these developments still dominate the layout of Portsmouth dockyard. ■

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