CAD/CAM CRUISE SHIPS COMMUNICATIONS PROPULSION LNG BUNKERING

THE
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JAN 2022

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MSC AND THE CHALLENGE OF DECARBONISATION

By **Richard Halfhide**

MSC GÜLSÜN. SOURCE: MSC

In early January, it was announced that Swiss-Italian owner-operator Mediterranean Shipping Company (MSC) has usurped Maersk as the world's biggest shipping line by capacity, according to analytics firm Alphaliner. The advantage is only slight, a mere 1,888TEU out of a total 4,284,728TEU, and perhaps says more about MSC's bolstering of its 645-strong fleet with chartered vessels over the past few years, at a time when Maersk has sought to shift some of its investment towards the wider (land-based) logistics chain.

Time will tell which proves the savvier policy, and Maersk CEO Soren Skou was somewhat dismissive when the subject was broached during a Bloomberg interview in December, but for MSC it completes a remarkable rise for the company founded by Gianluigi Aponte little more than half a century ago. With that has come a number of eye-catching newbuildings, such as the six-strong 23,756TEU MSC Gülsün class (the lead vessel, delivered in 2019, was briefly the world's largest container ship) which are said to deliver an efficiency of 7.49g of CO_2 per ton-mile. MSC's commitment to improving the environmental performance of its fleet was further underlined in September last year when it was announced that Silverstream Technologies has secured a contract to supply more than 30 air lubrication systems for large container ships MSC currently has on order.

Appropriately then, the speaker at RINA's President's Invitation Lecture held at the start of December (sadly again an online-only affair due to Covid) was Bud Darr, MSC Group's EVP for maritime policy and government affairs, who used the platform to explain something about how a large diversified shipowner goes about managing the challenges of decarbonisation.

As a privately owned company, still very much under the auspices of the Aponte family, Darr noted that MSC is better situated than many operators, not to mention the industry's administrators, to take a long-term approach to meeting shipping's climate goals. In addition to the aforementioned Silverstream contract, the company is using fuel blends of up to 47% biofuels (in 2020 it blended 850,000tonnes of used cooking oil) and also prides itself on being an active member of the Hydrogen Council, Methanol Institute and Getting to Zero Coalition.

"A good environmental decision is a good commercial decision," declared Darr, noting the correlation between efficiency and operational savings. But he cautioned that while technology is winning the race in developing solutions, the sticking point in attaining decarbonisation is likely to be the availability and scalability of the fuels themselves.

Darr says that he's an advocate of synthetic methane as a possible pathway, something that – while potentially the most convenient (clean) option for shipping – doesn't take into account the significantly greater power required for this form of energy conversion.

This seemed a little incongruous with his later suggestion that shipping might need to "hitch a ride" from bigger energy consumers. The biggest problem facing energy provision across all sectors, notably the seemingly preferred option of hydrogen, is a shortage of infrastructure. Personally, I struggle to reconcile how long-term use of gas, whether fossil based or synthetic, is consistent with minimising environmental impact (although I welcome the thoughts of any readers who wish to counter this).

But Darr, like many, leans towards the likelihood of multiple different fuel pathways, possibly even within the same company depending on the vessels' operational profiles. Interestingly though, having previously been a nuclear engineer for the US Navy who felt that the commercial application of pressurised water reactor technology "never made sense", he believes molten salt reactors are very much among the viable options (on pages 22-27 we take a further in-depth look at this fascinating subject and the opportunities it could present).

There's a certain irony that, having overtaken Maersk, MSC perhaps now finds itself in a rather similar position; that of wanting to lead while being hindered by the recalcitrance of competitors that aren't flush or brave enough to match that commitment. Darr also noted that while consumers generally express their willingness to accept additional costs, the same can't always be said for the freight forwarding middlemen who are MSC's main customers.

The need for the speedy implementation of a market-based measure such as the International Chamber of Shipping's (ICS) proposed carbon levy to generate a US$5 billion R&D fund is growing sorely apparent, with the ICS lamenting the "missed opportunity" to sanction the initiative at MEPC 77 in November (see also News Analysis p.10). One can only hope that 2022 is the year that the maritime sector stops prevaricating and starts coming good on its climate obligations, but past experience has surely taught us all to take nothing for granted. ■

NEWS

ALTERNATIVE FUELS

NET ZERO NOT A ONE FUEL SOLUTION

The maritime industry will have to embrace a variety of different fuel transition pathways in its efforts to steer a course towards decarbonisation, according to a new report from researchers at the Technical University of Denmark (DTU).

The report, which presents analysis of the MarE-Fuel project, estimates the total owner cost for a maritime company from the use of several different green fuels. The analysis assesses the current situation (2020) as well as the situation in 2030 and 2050 on parameters such as prices, taxes, emissions and availability.

It also outlines a roadmap illustrating possible transitions from the current situation to zero emissions by 2050. The roadmap considers emissions connected with the use of different fuels, various biomass availability scenarios, and global emission ceilings for the sector. It also identifies the cheapest long-term solutions.

"Our analysis shows that there isn't one single kind of green fuel that can solve the challenges of the maritime sector, but that a combination of several technologies is required," says Marie Münster, Professor of Energy System Analysis at DTU Management.

Münster adds that although the analysis pinpoints which fuels and technologies will be beneficial for the maritime sector, there are several challenges that the sector cannot solve by itself due to the need for heavy investments in technology and the establishment of smart energy solutions.

According to the analysis, the cheapest solution for the industry to achieve a reduction of emissions is to initially use green fuels produced by means of sustainable biomass, first in the form of pyrolysis oil and then in the form of bio-e-methanol. However, the researchers say that in the long term there may be a shortage of sustainable biomass as other sectors will also look to exploit it.

SOURCE: DFDS

"How big a role sustainable biomass can play in green shipping depends entirely on how much of it we have access to in the future," says Münster. "If there is plenty available, it will certainly be one of the cheapest ways to go. However, everything indicates that low-cost sustainable biomass will be in great demand, and we must consequently also focus on optimising Power-to-X technologies, because we will need them."

She says that all the calculated scenarios indicate that, in the long term, ammonia will be essential in making the shipping industry climate neutral, providing the power used to produce it is green. "This is because ammonia is not dependent on carbon, and the price and climate gas emissions are comparable to the other green fuels," she explains.

"We can see that ammonia will be one of the important green fuels for the shipping industry the closer we get to 2050," says Professor Peter Vang Hendriksen, an expert in electrolysis and energy conversion at DTU Energy.

He warns, however, that if the need for green fuel for international shipping is to be met, it will require a significant increase in the construction of plants capable of producing electrolysis. "With the current expansion rate (2019), it will, in fact, take up to 3,000 years before we have enough plants," he says.

Significant improvements in green energy infrastructure and technology will also be required, according to Vang Hendriksen.

"Electrolysis requires power," he says. "If, for example, we're only going to sail on green ammonia by 2050, and we continue at the same wind power expansion rate as today for the next 29 years, we would have to use all the new capacity to produce green ammonia for shipping.

"However, having cheap green power isn't enough, it must also be available most of the time to avoid having to over-dimension our production plants. Therefore, we must ensure flexible plants and preferably efficient storage of our wind and solar energy."

The analysis also shows that the price of producing green fuels is about four times higher than the price of the corresponding substances produced today from fossil sources. However, scaling up production capacity, gains from mass production, and improvements in technology are expected to halve the price of green fuels by 2050.

The MarE-Fuel project was financed by the Danish Maritime Fund and Lauritzen Fonden and undertaken by DTU, Anker Invest, Maersk Line, Copenhagen Economics, OMT and DFDS.

RENEWABLE ENERGY

LR WORLD'S FIRST IECRE RENEWABLE ENERGY CERTIFICATION BODY FOR MARINE ENERGY

Lloyd's Register (LR) has been accepted as the world's first renewable energy certification body (RECB) for marine energy by the IECRE, the International Electrotechnical Commission's (IEC) system for certification to standards relating to equipment for use in renewable energy applications.

The recognition allows LR to certify complex hybrid renewable energy projects on behalf of the IECRE that involve multiple technologies, such as wind, wave and tidal.

Through its RECB status, LR can conduct end-to-end certification activities for marine energy converters that seek compliance with the IEC 62600 technical specification and operational documents published by the IECRE.

MARK DARLEY, LR MARINE & OFFSHORE DIRECTOR

LR can also support marine energy technology developers by providing independent assessment and certification, which uses IEC standards as its basis.

Mark Darley, LR Marine & Offshore director, says: "Lloyd's Register's new status as the world's first IECRE renewable energy certification body for marine energy is a testament to our strong capabilities across a range of technical disciplines and our commitment to safety in the renewable energy market. We look forward to working with new clients in the future, certifying marine energy or complex hybrid renewable energy projects in line with the IECRE scheme."

Darley adds: "Given the expected rapid growth of the marine energy industry, we anticipate the IECRE system will be widely adopted by the industry and become increasingly important in providing the assurance required by project stakeholders, which LR can provide, while ensuring this process adds value to projects."

RO-ROS

UECC TAKES DELIVERY OF FIRST DUAL-FUEL LNG BATTERY HYBRID CAR CARRIER

Norwegian ro-ro carrier United European Car Carriers (UECC) has taken delivery of the world's first LNG battery hybrid pure car and truck carrier (PCTC), which the company says will provide significant gains in energy efficiency and emissions reduction.

The vessel, named *Auto Advance*, is the first in a series of three newbuild 169m by 28m PCTCs – each with capacity for 3,600 vehicles on 10 cargo decks – that are being delivered from China's Jiangnan Shipyard. The remaining two sister vessels are scheduled for delivery later this year.

UECC'S FIRST NEWBUILD DUAL-FUEL LNG BATTERY HYBRID PCTC IS SET TO START COMMERCIAL OPERATION AFTER DELIVERY FROM JIANGNAN SHIPYARD. SOURCE: UECC

"Having brought into operation the first-ever dual-fuel LNG PCTCs five years ago, UECC is now taking delivery of the first of three of the world's first dual-fuel LNG battery hybrid PCTCs to be built. This is another big step forward in eco-friendly ship operations that shows we walk the talk," says UECC chief executive Glenn Edvardsen.

UECC developed the design with DNV and Jiangnan's in-house ship designer, Shanghai Merchant Ship Design & Research Institute, to incorporate technology in a new configuration geared to enhancing operational and environmental performance.

LNG battery hybrid technology, together with an optimised hull design for better fuel efficiency, will enable the newbuilds to exceed the IMO requirement to cut carbon intensity by 40% from 2008 levels by 2030.

Emissions of CO_2 will be reduced by around 25%, SOx and particulate matter by 90% and NOx by 85% from the use of LNG, while the newbuilds will also meet the IMO's Tier 3 NOx emissions limitations for the North Sea and Baltic Sea.

IN BRIEF

DECOMMISSIONING

RECYCLING REBIRTH FOR INCHGREEN

Scotland's historic Inchgreen Dry Dock is to become a centre for recycling global shipping fleets in a major long-term deal expected to create 100 new, skilled jobs. ATLAS Decommissioning has leased the dry dock and says it has contracts in place with "blue chip" container lines for multiple vessels being removed from their fleet.

LNG

LNG FIRST FOR BRITTANY FERRIES

Brittany Ferries has taken delivery of *Salamanca*, the next ship in its fleet renewal programme and the first to be powered by LNG, from construction partner Stena RoRo at a hand-over ceremony in Sweden. Work has also recently started on LNG bunkering terminals in the ports of Bilbao and Santander.

ALTERNATIVE FUELS

X-PRESS BOOKS METHANOL FEEDERS

X-Press Feeders has ordered 16 dual-fuel containerships capable of running on regular or green methanol fuel. To be built in China, the first of the 1,170TEU vessels will come into operation on the Europe and Americas trade routes by Q4 2023.

LAUNCH SHIPS

CHINA BUILDS FIRST 'ROCKET' SHIP

Construction has started on China's first offshore satellite launch ship. The 162.5m long by 40m wide "new-type rocket launching vessel" will be delivered by the end of the year and is being built for use with the new China Oriental Spaceport at Haiyang, Shandon province. It will be capable of facilitating seaborne launches of medium- to large-sized solid-propellant rockets and small- to medium-sized liquid-propellant rockets.

HYDROGEN

WÄRTSILÄ AND RINA PARTNER TO DELIVER HYDROGEN FUEL SOLUTION

Wärtsilä and Italian classification society RINa, together with other stakeholders, have joined forces to deliver a viable hydrogen fuel solution.

The partners aim to have a scalable and sustainable solution that exceeds the IMO 2050 target for a 70% reduction in carbon intensity without the need for an extensive infrastructure investment, offering the shipping industry a pathway to low-carbon operations within a reasonable time frame.

Current difficulties and cost considerations regarding the production, distribution and onboard storage of hydrogen have so far limited the sector's interest in its direct use as a marine fuel. However, by producing hydrogen onboard, and using readily available LNG, the solution becomes far more viable and in a much faster time than would otherwise be possible.

Lars Anderson, director of product management & sales support at Wärtsilä Marine Power, says: "Our gas engines are already able to use mixtures of hydrogen and LNG, and our future efforts will be to reach 100% hydrogen fuel. We are totally committed to supporting in every way possible the decarbonisation of shipping operations.

"This project is one more example of this commitment, and we are very pleased to be partnering with other stakeholders to make the IMO 2050 target achievable."

The concept is based on combining LNG with steam to produce hydrogen and CO_2. The hydrogen produced will be used directly in a mix with natural gas in internal combustion engines or in fuel cells, thus eliminating the need for hydrogen to be stored onboard.

The CO_2 will be liquefied using the cryogenic stream of LNG that would be used as fuel anyway, and later disposed ashore for carbon storage. Tankers can use the stored CO_2 as inert gas during discharge.

The necessary equipment can easily be fitted on the deck of a commercial vessel. The concept will support the marine sector's gradual transition from LNG to hydrogen, without any major adjustments to a vessel's onboard technologies.

Only LNG bunkering will be required and, by progressively increasing the production of hydrogen, the consumption of fossil methane and associated methane slip will be reduced at the same rate.

GREEN SHIPS

GREEN AWARD FIRST

Singapore-headquartered ship manager Synergy Group has secured a Green Award for the 2014-built, 131,095dwt *Cap San Maleas*, the first-ever for a container vessel.

The certification follows a Green Award quality, safety and environmental performance audit.

"The Green Award is designed to independently recognise ship managers that see it as their duty to owners and the environment to reach the pinnacle of excellence on environmental performance, so we are delighted to be the first manager to achieve such a standard for container ship management," says Captain Rajesh Unni, Synergy Group founder and CEO.

The Green Award audit process includes a full office audit to observe the company's management system and its operational policies and procedures. This is followed by a two-stage ship survey which incorporates a documentation review and a survey onboard the ship.

THE *CAP SAN MALEAS*

NEWS ANALYSIS

HAS SHIPPING'S MARCH TO DECARBONISATION BEEN KNOCKED OF COURSE?

By: **Malcolm Latarche**, Correspondent

ICS SECRETARY-GENERAL GUY PLATTEN. SOURCE: LISW

Shipping managed to shake off some of its laggardly image over the course of COP26 and MEPC 77, at least to those who understand the separation of the industry itself from the IMO in its role as international regulator.

Right through to and including COP21 in Paris in 2015, shipping was always the whipping boy for environmental activists, with the industry having to defend its environmental performance and reliance on fossil fuels. Perhaps that was because the 'solutions' proposed for reducing emissions seemed entirely dependent upon being forced into adopting slow steaming.

Since then, there has been a lot of focus on alternative fuels that will allow shipping to reduce emissions while carrying out business as normal. More importantly, the shipping industry itself has become a driving force in advocating change. For more than two years it has been attempting to get the IMO to agree to establishing a research fund based on a US$2 per tonne bunker levy.

At every COP since Paris, the shipping industry has taken on a larger and more environmentally proactive role. At COP26 it excelled itself, being perhaps the only bright point in an otherwise negative outcome for the event.

At the ZESTAs (Zero Emission Ship Technology Association) 'SHIP ZERO: Charging to True Zero' event, a delegate poll suggested that the regulators were not moving fast enough. Elsewhere, a new initiative in the shape of the Clydebank Declaration was born when more than 20 nations signed up to a concept whereby national governments, ports and ship operators would attempt to develop zero emission green corridors between fixed points. Six such corridors are targeted for the middle of this decade and more for the future. The corridors – between two or more ports – will be used by ships producing no carbon emissions, though other vessels will be permitted to use them.

Recognising the role seafarers have played through the pandemic and looking forward towards the transition to different fuels, another initiative was a rare piece of cooperation between two sides that are so often in conflict. The Just Transition Maritime Task Force established by the ITF and the ICS aims to drive decarbonisation of the industry and support millions of seafarers through shipping's green transition. Other partners include the United Nations Global Compact, the world's largest corporate sustainability initiative, the ILO and the IMO.

Just weeks later, at MEPC 77, where many expected the IMO to push forward with the impetus from its recent fourth GHG study, the mood of COP26 seemed to have evaporated. In summing up MEPC 77, ICS secretary-general Guy Platten said: "We are disappointed that the words and commitments made by governments at COP26 have not yet been translated into action. This week's meetings have missed the opportunity to take forward a range of GHG reduction measures which would accelerate the development of zero emissions ships that are urgently needed at scale to decarbonise our sector. It's almost as if COP26 never happened."

Of course, the problem is that at COP26 the number of governments supporting the shipping industry was way below the number of states represented at the IMO. Just as several states were seen to be rowing back on commitments at COP26, so it would appear that an equal number are not particularly behind the IMO's commitment. And since it is member states at the IMO that determine the direction of travel, the shipping industry will also need to decide if it wants to move as a whole or whether individual companies or regional groupings will make the journey independently.

At least there are signs that LNG is gaining favour as a means of reducing carbon emissions. The EU seems to have accepted its role as a fuel and DNV reported that up to the end of November no less than 238 LNG-fuelled ships had been ordered since the beginning of 2021. In December, Gibson said in its market report that 23% of the orderbook for tankers of all types was for LNG-fuelled vessels. ■

NAVALIA

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NEWS EQUIPMENT

WASTE HEAT RECOVERY

ALFA LAVAL AND ORCAN ENERGY PARTNER UP ON ORC TECHNOLOGY

LARS SKYTTE JØRGENSEN, LEFT, AND DR ANDREAS SICHERT, RIGHT

Sweden's Alfa Laval and German cleantech company Orcan Energy have signed a sales cooperation agreement covering marine energy efficiency solutions based on Orcan's Organic Rankine Cycle (ORC) technology.

The agreement is part of Alfa Laval's strategy of establishing commercial partnerships to help drive the industry towards its decarbonisation and energy efficiency goals.

"As the marine industry pursues decarbonisation and transitions to new fuels, a wide range of technologies will be needed to boost energy efficiency and maintain the energy balance onboard," explains Lars Skytte Jørgensen, vice president at Alfa Laval's Marine Division.

"The solutions must become available rapidly, which demands that we work together across the industry. Orcan Energy shares our determination to provide complete, reliable energy solutions to marine customers."

Orcan Energy develops and manufactures ORC solutions for the direct conversion of waste heat energy into electricity. Under the new agreement, the company's technology will be marketed and sold by Alfa Laval to the marine market.

Alfa Laval, whose plate heat exchangers are an integral component of Orcan Energy's products, will further develop and market the renamed ORC solutions.

Dr Andreas Sichert, CEO of Orcan Energy, says: "Alfa Laval, as a trusted global supplier with more than 100 years of marine experience, is a strong partner and the right choice for implementing ORC technology in the marine sector. The partnership is having a major impact, supporting ship operators' growing need for solutions to decarbonise their vessels."

ENGINES

ME-GI ENGINES BOUND FOR 'THRIVING' CHINESE MARKET

Yangzijiang Shipbuilding Group has ordered 10 MAN B&W 7G80ME-C10.5-GI engines in connection with the construction of 10 7,000TEU container ships for Seaspan Corporation.

The contract includes an option for five further vessels and engine delivery is scheduled from October 2023 to 2024.

Upon completion, the newbuildings will become the largest ME-GI-powered container vessels built by a Chinese shipyard. Seaspan has already chartered the ships on long-term contracts.

MAN ENERGY SOLUTIONS HAS RECEIVED MULITPLE ORDERS FROM CHINESE SHIPYARDS FOR ME-GI ENGINES

Thomas S. Hansen, head of promotion and customer support at Denmark-based MAN Energy Solutions, says: "Our ME-GI engine continues to enjoy success within new vessel segments – including non-LNG-bearing carrier applications – primarily due to the ever-increasing focus on methane-slip reduction and fuel efficiency."

This latest mark of the engine comes with a gas-optimised tuning that significantly improves fuel efficiency when operating on gas, while simultaneously maintaining an industry-leading, low methane-slip of just 0.20-0.28g/kWh over its entire load range, Hansen adds.

Over the course of the past year, MAN Energy Solutions has received multiple orders from Chinese shipyards for ME-GI engines for a variety of projects, including pure car-truck carriers, bulk carriers and oil tankers. "The Chinese market has great potential for us and we plan to increase the more than 1.8 million running-hours that the ME-GI has accrued to date running on LNG alone," Hansen says.

LUBRICANTS

SHELL MARINE UPGRADES LUBEMONITOR FOR THE DIGITAL ERA

Shell Marine has introduced a suite of digital enhancements to its LubeMonitor service, opening up a wider range of technical and operational insights.

While its features have become more sophisticated, Shell Marine says the system's user interface and reports are now easier to use.

Upgraded fleet and vessel insights allow users to compare vessels from fleet level all the way down to its cylinders, and a step-by-step guide for onboard engineers can help standardise the inspection process.

A comprehensive engine inspection feature has also been added which allows inclusion of recorded measurements of piston ring clearance, piston ring coating and liner wear. All data can be stored and organised with the photos captured, so that users can come back to them at any point in time.

LubeMonitor is available via the internet, iOS and Android operating systems and as an offline logbook, depending on connectivity at sea.

"Our goal goes beyond just making the programme an easy-to-use central data repository," says Gareth Lowe, Shell Marine's technical product manager for LubeMonitor. "By surfacing relevant information from onboard data, running parameters, lab data and inspection photos all from within LubeMonitor, we can start to deliver vital insights.

UPGRADES INCLUDE NEW FLEET AND VESSEL INSIGHTS

"This provides customers with a comprehensive picture of their engine's health, and they can then use this information to make informed decisions on feed rates and maintenance schedules, which can help maintain optimal engine performance and lower operating costs."

ENGINES

WÄRTSILÄ LAUNCHES POWER LIMITATION SOLUTIONS FOR EEXI COMPLIANCE

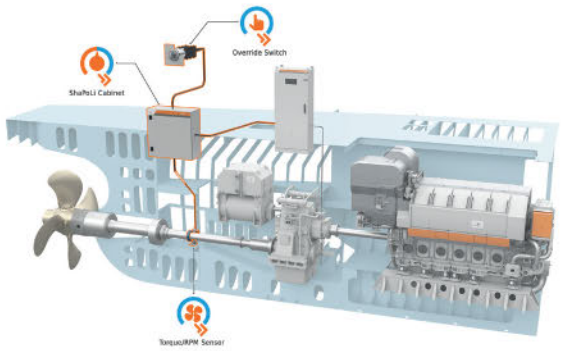
Technology group Wärtsilä has launched a series of power limitation solutions that enable compliance with the IMO's Energy Efficiency Existing Ship Index (EEXI) regulation, which comes into effect in 2023.

According to Wärtsilä, the new systems will allow owners to meet this requirement, despite the tight implementation schedule.

"With this latest launch, Wärtsilä once again emphasises its commitment to supporting customers in their decarbonisation efforts in line with the global targets set by the IMO. We can offer a complete set of opportunities for complying with the existing and upcoming regulations," says Giulio Tirelli, director of business development at Wärtsilä.

The power limitation upgrades are verified and approved systems. They comprise Engine Power Limitation for four-stroke engines, Engine Power Limitation for two-stroke engines, Shaft Power Limitation for vessels with a controllable pitch propeller (CPP) and a Wärtsilä Propulsion Control System, and Power Limitation specifically dedicated to diesel-electric installations.

The upgrades effectively limit the engine or shaft power during normal operation, regardless of the power train combination and control system arrangements. The set limits of the solutions can all be overridden from the bridge. This is a mandatory feature stipulated by the IMO/MEPC guidelines, as are the monitoring and recording functions. The system data is stored in accordance with the regulations for inspection purposes.

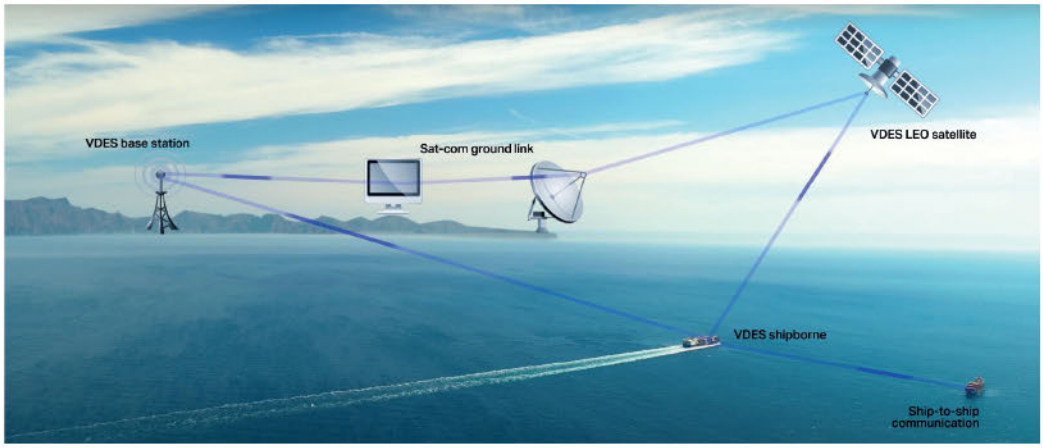


WÄRTSILÄ SHAFT POWER LIMITATION FOR VESSELS WITH CONTROLLABLE PITCH PROPELLERS AND A WÄRTSILÄ PROPULSION CONTROL SYSTEM

COMMUNICATIONS

VDES PROMISES A NEW ERA FOR MARITIME COMMUNICATIONS

By **Daniel Johnson**



WITH ADDITIONAL BANDWIDTH AND EXPANSION OF AIS COMMUNICATION TO THE OPEN OCEAN, VDES WILL OPEN UP NEW POSSIBILITIES FOR TWO-WAY HIGH-SPEED DATA EXCHANGE. SOURCE: SAAB

The design and implementation of VHF Data Exchange System (VDES) services has the potential to revolutionise ship tracking communication in the decade ahead, providing major improvements in terms of cost-effectiveness, sustainability and safety over the current Automatic Identification System (AIS). However, the transition to VDES will not only provide the opportunity for positioning and communication – as the AIS system does – but will also open the door to new uses, such as e-Navigation and autonomous shipping.

First identified almost a decade ago as a long-term solution to overloading issues on the AIS VHF Data Link (VDL), and a facilitator of the International Maritime Organization's (IMO) 'e-Navigation strategy', VDES is well on its way to becoming an International Telecommunication Union (ITU) standard supported by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and it is anticipated that both shore and ship side AIS infrastructure will be upgraded with VDES capabilities in the years ahead.

The system includes the two existing AIS channels and the messaging system Application Specific Messages (AMS), with the addition of a new highly flexible third component (VDE) for digital maritime communications of any kind. Importantly, VDES significantly expands the available bandwidth and allows for true two-way high-speed data exchange between ships, satellites and shore.

The satellite component of VDES (VDE-SAT) reached an important milestone at the ITU World Radiocommunication Conference (WRC) in 2019, when it was allocated a new radio frequency spectrum in the VHF band. By adding space-based capability to VDES, the communication system's range increases from the shoreline to anywhere in the ocean, converting what is currently a predominantly coastal system into a global maritime system. VDE-SAT will be an important option for e-Navigation services as many will require close-to-real-time or, at the very least, periodic connectivity globally.

As well as the new radio frequency spectrum, another major driver helping to accelerate VDES closer to reality are the major advances in terms of access to space offered by small satellite constellations. These smallsats enable high-performance technology to be deployed faster and more economically than ever before and can be used in lower earth orbit (LEO) for higher data exchange speeds due to its lower latency.

Swedish/US partnership

This development was highlighted towards the end of last year with the formalisation of a collaborative partnership between Swedish aerospace contractor Saab, US satellite operator ORBCOMM and Swedish smallsat builder AAC Clyde Space to create a dedicated global maritime communication system based on VDES that will enable "ship-to-ship and ship-to-shore communication everywhere on the globe".

"Our work with Saab and ORBCOMM to establish the next generation of maritime communications has been underway since August 2020, but the formalisation of this cooperation, now branded AOS, creates an important platform on which to fine-tune our efforts and develop value-driven commercial and government applications for VDES," states AAC Clyde Space CEO Luis Gomes.

He adds: "This will not only improve the safety of seafarers but will also contribute to a greener shipping industry – a critical part of the climate change mission. For example, with up to 32 times more bandwidth than the current, widely used Automatic Identification System, VDES can be

integrated with e-Navigation systems to enable savings in fuel and emissions of up to 25%."

Gomes says the ability to send information, instructions and commands to ships opens up an all-new set of applications, not only on existing vessels but also on future autonomous shipping.

The project is co-funded by the Swedish Transport Administration and will occur in phases, including both terrestrial and space-based demonstrations of selected applications. A demonstrator satellite, Njord-1, is slated for launch in mid-2022, with in-orbit VDES capability assessment expected to be completed in the first quarter of 2023. If successful, Njord-1 could be followed by a constellation of up to 100 satellites that will form a new part of the maritime communication infrastructure.

Njord-1 will be constructed at AAC Clyde Space's integration facility in Uppsala, and will carry a VDES payload from Saab. ORBCOMM will integrate the data in its distribution centre for maritime communications.

A leader in AIS technology, Saab is currently undergoing core product development of a complete VDES portfolio that will succeed its RS AIS portfolio.

"Saab were pioneers in AIS and had the first type-approved product in the world in May 2002, so we have a strong heritage to maintain," says Peter Bergljung, technical director at Saab TransponderTech and co-chairman of the recently formed VDES Alliance.

"VDES is backward compatible with AIS," Bergljung says. He explains that antennas and interfaces can be reused from existing AIS installations, meaning that to upgrade from AIS to VDES onboard a ship only requires the exchanging of the transceiver box. Bergljung believes that the solution will sit on most ships within four to six years.

As a long-term provider of AIS and spaced-based maritime data solutions, ORBCOMM says that it is relishing the opportunity to demonstrate the benefits that the significantly increased bandwidth of VDES will offer.

"ORBCOMM has had a long history in the space-based maritime data business dating back to the early 2000s," says Greg Flessate, senior vice president and general manager of the company's government, AIS and business operations. "We're very pleased with this ground-breaking project that we're undertaking with Saab and AAC Clyde Space. We think it will help revolutionise maritime communications, providing additional coverage and increased bandwidth and enhance versatility for some of the data sets that are available for the maritime market."

With the launch of Njord-1 imminent, the maritime communications revolution may be getting a little closer. ■

NICHE NETWORKS ARE THE NEW NORMAL

By **Tore Morten Olsen**, president, Maritime, Marlink

CRUISESHIP OPERATOR PONANT CAN PROVIDE A RECORD AMOUNT OF DATA TO ITS GUESTS THROUGH A SMART HYBRID NETWORK

Satellite connectivity used to be all about 'the pipe'. While a big pipe is desirable, it's an experience most end users rarely enjoy. Connectivity remains a scarce resource in remote locations, but even so, users still expect the highest possible performance. The challenge this creates is that a single pipe sourced from a single operator cannot meet the needs of diversified, digitalised and remote operations.

Digitalisation starts with connectivity; it remains the foundational principle and achieving the required throughput will always be a central issue for customers. But these days a network must be able to do more than simply work, it has to work smarter.

In the maritime industry, user demand is becoming increasingly specialised and stretching the capability of traditional networks to the limits.

Hastened by the pandemic, customers are increasingly looking to new techniques for their operations. These include remote access to the IT network itself and for intervention and maintenance on connected systems. Vessel crews want to use MS Teams, Zoom and the rest; these collaborative workflow tools have come into their own in the last two years.

In industries such as shipping, there is an increasing need to monitor machinery performance for operational and environmental reasons. High efficiency is critical in global transport supply chains while regulation increasingly requires collection and reporting of emissions data for compliance.

All remote operations are safety focused and an enterprise network may be required to support CCTV for video monitoring, capture equipment status and provide secure personal communications for crew.

In any scenario, customer demand for data and digital services is increasing very quickly.

For the network operator, the issues centre around providing a solution that can achieve far more than was envisaged even a few years ago and also reflects the fact that no network is ever designed to serve a single market.

This has created the need for a hybrid 'network of networks' that combines any combination of connectivity services into one seamless offering.

Delivering the network of networks means creating a bespoke service which is flexible, future-proof and always available when needed. This is possible by combining any number of services into one network for a customer, including new constellations as they become available.

However, this concept also goes beyond the network. We are used to ideas such as cloud computing and smart routeing of data but the ability to deliver these and other services via satellite requires a highly specialised approach.

On-demand data transfer is relatively easy to accomplish but the ability to store access and process data in the cloud requires a higher degree of specialisation, employing applications and enabling multiple users to access the data.

It also depends on software tools deployed to manage and optimise the traffic for transport in a smarter way. Tools such as software-defined routeing can calculate the optimum available channel for connectivity.

The need to deliver services with ever lower latency naturally leads to a discussion about the future of satellite connectivity. Next-generation constellations will play a role in this conversation once commercial services become available.

Much will depend on whether the provider has a direct-to-market model or chooses to work with partners to provide an integrated approach to operations, safety and security. But there's no need for users to wait for an experience that delivers very high bandwidth and lower latency by blending the best available network with advanced managed services.

In real life Marlink helped expedition cruiseship operator Ponant to provide connectivity to its guests with a smart hybrid network comprising dual C- and Ku-band VSAT connectivity, GEO and LEO L-band connectivity and a high-data volume LEO store and forward capability.

An LTE/GSM service completed the hybrid network solution enabling Ponant to provide aggregated delivery of hundreds of gigabytes per month, offering a record amount of data to connectivity-hungry customers.

For an energy major operating offshore West Africa, the requirement was to combine existing terrestrial links with satellite signals to provide a fully redundant service. The operator wanted to maintain connectivity using 4G and different 'flavours' of satellite service over multiple frequencies at very high bandwidth, including a 250mbps MEO-based link.

Fixed installations represent different challenges to mobile ones, but the network of networks concept proved itself applicable to meeting diverse requirements, regardless of location.

A definite trend we observe is the increasing demand for networks designed around applications for specific services not the size or shape of the pipe. Just because VSAT has been the primary signal for a decade, it doesn't mean that in future it could be the back-up if terrestrial or non-GEO services are more suitable and this makes sense for customer demands.

Client demand is for applications delivered as a service to any location. They don't want to hear about the hurdles; they want MS Teams to work. In future we will hear much less about the pipe and more about how the service can enable the various channels to operate in harmony.

Meeting this kind of demanding scenario requires a deep integration with the customer so that the solution provided has the functionality and scalability it needs, with an eye on future-proof operations too.

It is in part for this reason that Marlink created a new Digital division to meet the need for closer customer support for digitalisation and provide even more closely designed network of networks to meet the demands of these high-demand markets.

It may not be possible to predict the future, but a network of networks approach makes it easier to plan for it because the integration of satellite constellations, beams and frequencies with managed services provides a highly adaptable model.

Networks are becoming ever more niche in order to meet ever more sophisticated requirements. Achieving the required quality of service means having clearly-defined KPIs on network quality and availability that can be demonstrated and judged. By combining all available services into a hybrid network, it is possible to provide the uptime guarantee that customers need to run their operations.

The need for more complex, real-time data will continue to grow and maritime markets will need a different blend of GEO, LEO, NGSO or 4/5G services. The important element is to combine the right technology package with the right service. Each customer is different; now the way their network is constructed can be too. ■

CAD/CAM

SSI'S SHIPCONSTRUCTOR 2022 R2: TAKE BACK CONTROL

By **Daniel Johnson**

Subcontractor workflows are often at risk of being impeded with the introduction of variables added at late stages of production that were outside the scope of the original approved assembly level drawings. Welding schedules, painting programmes, project expenses and even assembly alignment can all be negatively impacted by unexpected modifications. The rework and time involved in tracking down uncontrolled changes can prove to be costly, especially on projects with narrow margins of error.

With a focus on providing more effective change management processes for shipyards, the latest SSI release for ShipConstructor, 2022 R2, has introduced assembly level locking features that provide project management with high-level change controls throughout the design approval workflow.

"Assembly locking dramatically improves permission controls by restricting end users from adding, deleting or moving parts within the finalised and approved assemblies," says SSI. "Such controls can reduce or even remove potential rework from unapproved changes and help avoid knock-on effects that may cause project delays and cost overruns during later production and assembly phases."

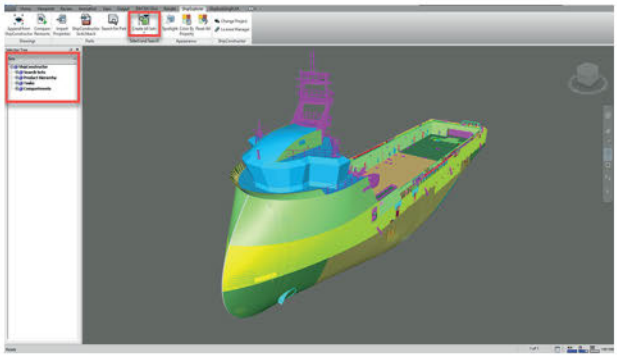
The US-based company adds that assembly locking provides robust yet easy to implement controls that protect source of truth project data from inadvertent modifications once the final approval of production sequencing has been passed. "With assembly locking enabled, end users are now provided clear, concise notifications that their changes need to be approved by project supervisors, effectively preventing uncontrolled changes from taking place," the firm says.

ShipExplorer

The assembly locking upgrade in this new release is one of several enhancements that have been introduced to provide improved solutions for project management and analysis, including feature updates with ShipExplorer, a Navisworks Manage plugin launched in 2020 that allows existing ShipConstructor files to be managed within Navisworks, and updates for the Project Item List (PIL).

"ShipExplorer has proved to be a powerful and important tool, not only for team collaboration, but for data analysis as well. Working within ShipExplorer provides the ability to quickly import product data sets with a click of a button," says SSI.

SSI 2022 R2 introduces the 'Create All Sets' function in ShipExplorer which allows end users to quickly generate all available set lists for the project, including search sets, hierarchy sets, task sets and compartment sets. In addition, when importing SSI extended properties, the major part type property has now been included as well as the assembly property for all associated product hierarchies for any given part within the product model.



THE CREATE ALL SETS FUNCTION ALLOWS END USERS TO QUICKLY GENERATE ALL AVAILABLE SET LISTS FOR THE PROJECT

Project Item List

Feature enhancements to the PIL include updates that make importing and exporting data much more direct.

"The ability to export, import and update equipment and pipe parts, including both modelled and non-modelled stocks is a key component in the transition from functional to detailed design," explains SSI.

There are now options in PIL to define unique identifiers from source data sets as well as the ability to define UDA (User-Defined Attributes) comparator values for easier part associations. The ability to easily import and export these data sets, combined with the sorting functionality now specified from within the project, mean that the time-consuming process of comparing part information between source and project data is now virtually instantaneous, according to SSI.

The company adds: "With enhancements to the PIL import and exporting functionality, data formatting is now optimised to allow that information to be exported, reviewed, updated, modified and then re-imported into the project, removing the need to perform this formatting manually." ■

A webinar detailing the enhancements introduced by the SSI 2022 R2 release is available on the SSI Nexus learning portal.

HYDROSTATICS AND STABILITY INNOVATIONS

Vancouver-based Autoship Systems Corporation's (ASC) hydrostatics and stability program Auto*hydro* has marked its 30th year of development with the addition of some innovative new features and tools.

A true 'floating simulator', the software reports the reaction of the model to various conditions such as a loading configuration, a damage situation, conditions involving outside forces, wind or high-speed turning momentum or combinations of these. It can also be used to obtain hull form characteristics and capacities and evaluate stability criteria.

"Auto*hydro*'s current operating version has now evolved to 6.10," ASC tells *The Naval Architect*, "representing continual software improvement with features such as accidental oil flow performance, oil fuel tank protection, second method for intermediate steps during flooding calculations and dynamic limit detection."

A recent beneficiary of the upgrades in the latest iteration of Auto*hydro* is Floridian naval architecture and marine engineering firm Boksa Marine Design (BMD). ASC says it has enjoyed a long and successful relationship with BMD, with the two companies working closely together to deliver engineering packages for vessels ranging from workboats to commercial ships.

BMD has been designing and engineering projects for leading shipyards since 2003. President Nick Boksa says: "We use Auto*hydro* to submit stability books to classification societies for a wide range of vessels engineered by BMD. Complicated stability issues require the Auto*hydro* Hydrostatics and Strength software to analyse and solve."

"To date, all of BMD's stability books have been approved by the designated class society, including ABS1," he adds.

Boksa says that it is easy to import a hull derived from different 3D model files directly into Auto*hydro* through its Modelmaker module with the full Windows interface and pull-down menus. "We can get right to work defining tanks and selecting hydrostatic values critical for safe vessel operation," he says, adding: "Additionally, Auto*hydro*'s tech support is excellent, providing solutions for our questions." ■

UNLOCKING A NEW ERA OF SHIP DESIGN WITH 3D MBA

By **Mikko Forss**, executive vice president, NAPA

One of the most glaring contradictions of the vessel design, check and approval process is that while ships have been designed in three dimensions for many years, the process of rule checks still requires designers to export 2D information from 3D models. Class societies must also then reconstruct 3D models themselves to analyse. Of course, in a safety-critical industry, there are solid reasons for this. It's important that rules can be applied consistently and that class societies can handle data from a range of different software applications. Given the amount of data to process, technical limitations have also restricted how yards and class societies can share and revise 3D models.

However, this process is not only time-consuming but also risks changes becoming lost and errors being easily misconstrued as revisions that are then passed back and forth. It also means that structural designers don't have an overview of the whole process, which means that it is difficult to optimise the overall design.

Ultimately, this division between 3D design and 2D rule checks restricts the design possibilities that naval architects can work with. It introduces unnecessary friction to the design process and it encourages siloed work, with separate teams working on different models, with different software applications. Ships are three dimensional objects, and we need to be able to design and assess them in every plane.

3D MBA feasibility study

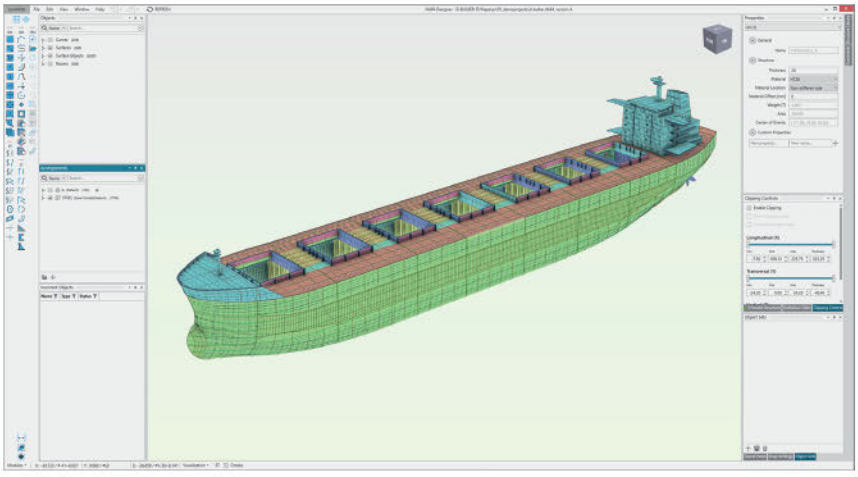
NAPA has been working with various partner organisations to develop 3D model-based approval (3D MBA) processes, including several class societies around the world, for many years. In 2019, NAPA, classification society ClassNK and shipbuilding company Japan Marine United (JMU) completed a joint feasibility study on 3D MBA using 3D CAD models. In the feasibility study, ClassNK conducted a trial evaluation of hull structural design on a 3D CAD model of a large ore carrier. The model was designed and created by JMU, using NAPA Designer – a 3D CAD software application for ship design developed by NAPA – as a 3D model viewer.

One clear finding from our research is the need for a sophisticated data linkage system. A system that was highly accurate and guaranteed consistency between the 3D model and calculation model, without the need for external confirmation work.

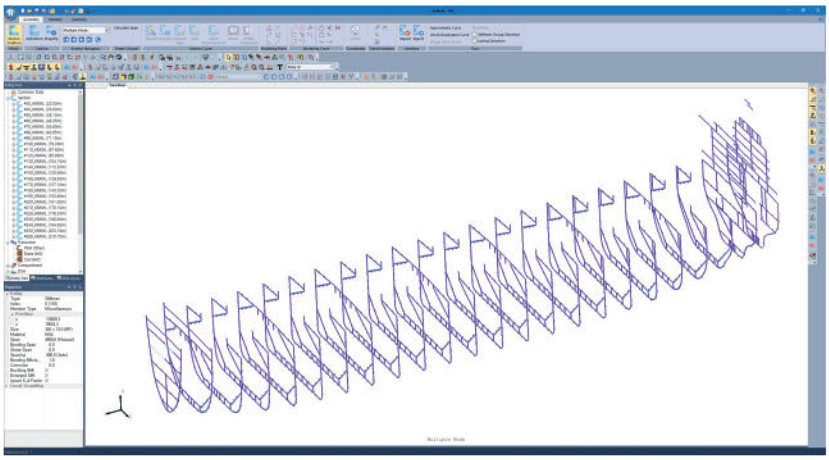
Recognising the need for this interface between the 3D model and the calculation model, we recently teamed up with Korean Register (KR) to further develop an interface linking structural design software NAPA Steel to KR's SeaTrust-HullScan rule-checking software. SeaTrust-HullScan performs structural analysis for vessels, to which common structural rules are applied, and is widely supported by shipbuilding companies around the world.

NAPA Steel is used for designing, viewing and evaluating 3D designs, enabling designers, engineers and class societies to rely on a single source of truth. Many Korean shipyards use SeaTrust-HullScan for class approval after designing with NAPA Steel. Because each software used its own file format, users previously had to enter data into SeaTrust-HullScan based on 2D drawings, even though it existed in NAPA Steel.

The live interface we created allows SeaTrust-HullScan users to access critical information such as Section, Compartment and Principle Particulars for Rule Scantling in real time from NAPA Steel's 3D model at the click of a button. We expect that this will lead to a significant increase in design productivity and quality, as users can now access accurate information within seconds, as opposed to inputting information over several hours. KR and NAPA plan to provide the live interface functions soon and further expand the interface area through additional joint development.



3D MODEL IN NAPA DESIGNER



2D SECTIONS FROM NAPA 3D MODEL IN SEATRUST-HULLSCAN

This switch to 3D assessment and approval means more than just saving time. It provides the means for class societies and designers to communicate efficiently and effectively and collaborate more closely on vessel designs. It means that designers can test and check ideas earlier in the process and explore a greater number of concepts.

Digital twin systems

Looking to the future, including all data in a single, accurate model of a vessel is the first step on the way to developing true digital twin systems. Considering the digital twin as a complete digital representation of a vessel is not reflective of the current reality in which only some sub-assets are represented. As modern ships contain hundreds of thousands of sub-assets, representing their inherent properties and how they interact with the rest of the vessel, within a single digital twin, is a huge undertaking.

However, the more that we can develop and use consistent, complete 3D models throughout the design process, the easier it will be to use this data in digital twins.

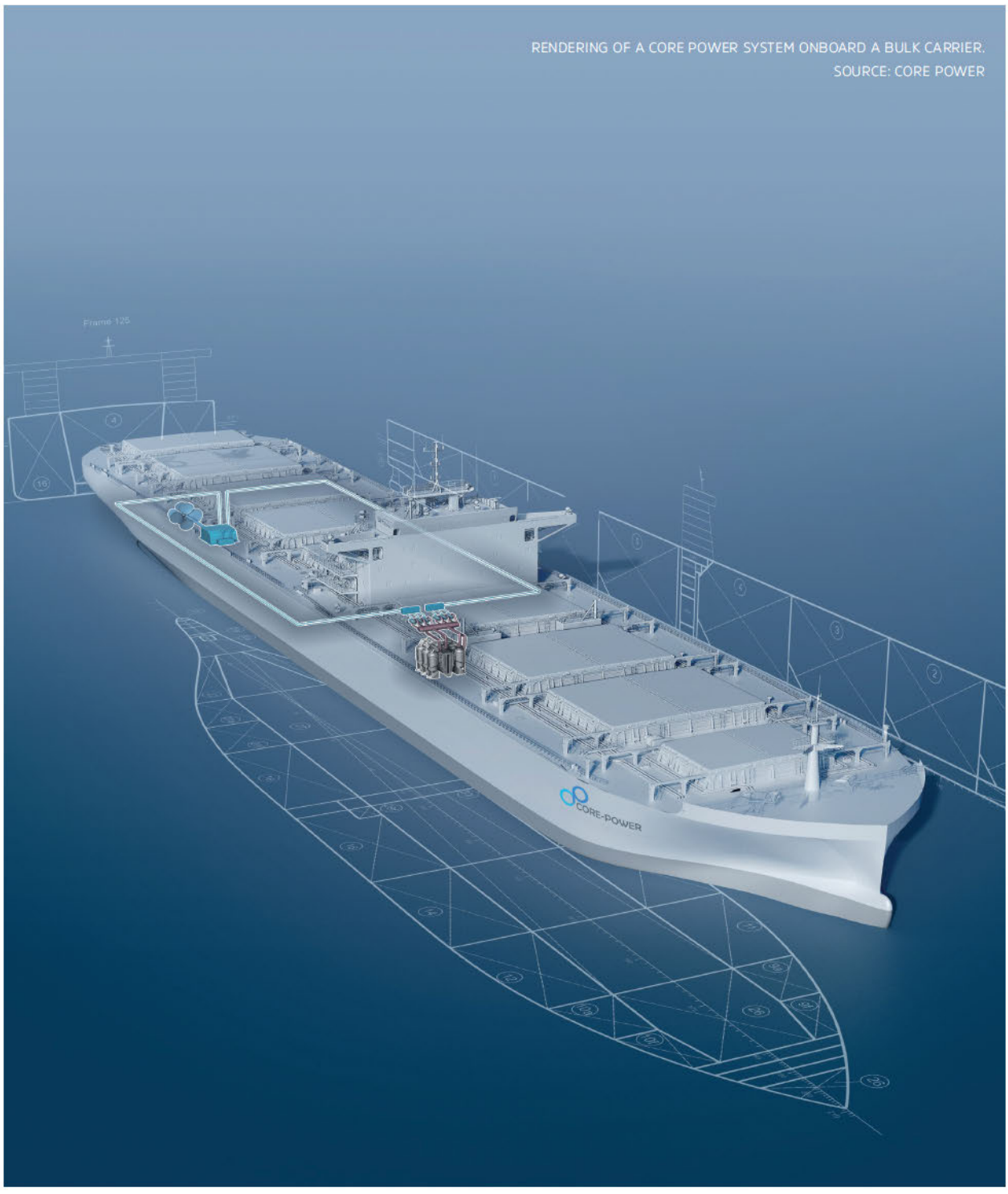
Just as 3D design has enabled breakthroughs in vessel design, 3D model-based approval will unlock further innovation. And industry collaborations are bringing this new era of naval architecture one step at a time. ■

NUCLEAR POWER

PUTTING NUCLEAR AT THE CORE OF A BRITISH MARITIME RENAISSANCE

By **Richard Halfhide**

Proponents of molten salt reactors argue the technology is clean, efficient and, given the opportunity, could reinvigorate the Red Ensign



RENDERING OF A CORE POWER SYSTEM ONBOARD A BULK CARRIER.
SOURCE: CORE POWER

Despite being a nuclear nation for nearly 70 years, no civilian nuclear-powered vessel has ever operated under the United Kingdom's Red Ensign. What's perhaps surprising is that there's never even been any provision for it under UK maritime law despite IMO's provisions for nuclear ships, SOLAS Chapter VIII (Nuclear Code), being in place since 1981. But in August 2021, the UK Maritime & Coastguard Agency (MCA) published a consultation document seeking views on the proposed Merchant Shipping (Nuclear Ships) Regulations 2021, legislation designed to open the door to both UK-flagged nuclear-powered ships and foreign-flagged nuclear vessels to call at UK ports, including a pre-commissioning test programme and surveys dedicated to nuclear ships.

Theoretically, the new regulation is intended to fill the regulatory gap and enshrine the Nuclear Code into British maritime law, a process known as ambulatory referencing that will keep the UK nuclear rules in line with those of IMO. But the consultation is also seen as an opportunity to evaluate the role such vessels might potentially have in the pursuit of decarbonised solutions and allow the MCA leverage in pushing for updates to the Nuclear Code with IMO's Maritime Safety Committee in the coming years.

Responding to a question by *TNA* during a webinar at last September's London International Shipping Week, Katy Ware, the MCA's director of UK Maritime Services and permanent UK representative at IMO, described the subject of nuclear-powered vessels as "hugely political" but that she personally believed there was a future for them.

"The concept is a very difficult one for the public. At this particular moment in time, we are not backing any one specific fuel but our teams have been working on a hypothesis moving forward longer term. LNG and biofuels we believe are transitional fuels and the direction of travel is pointing towards ammonia, hydrogen and nuclear," said Ware.

In parallel, Lloyd's Register's (LR) class rules for nuclear shipping are shortly expected to receive an overhaul, in addition to the development of new insurance policies for nuclear vessels. The classification society was somewhat coy when asked for comment although speaking about the MCA consultation Matthew Palmer, LR's senior specialist for submarine rules, told *TNA*: "The update will set the scene for the consideration of the use of different nuclear technologies and not constrain the industry to pressurised water reactors. The new Nuclear Ships (2022) regulation will set the regulatory framework for the adoption of different nuclear technologies to be used under the UK flag, as well as allowing nuclear-powered ships to trade in UK waters."

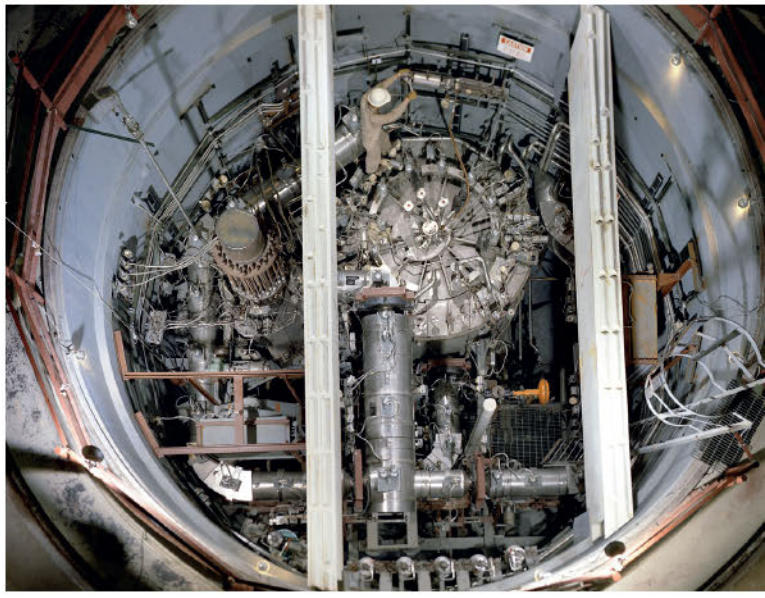
It's perhaps worth remembering that icebreakers notwithstanding, only four nuclear-powered civilian vessels have ever been built, of which only the Russian-flagged *Sevmorput* (built 1988) remains in service. Earlier this year the US Department of Transportation awarded the decommissioning contract for the non-operational reactor onboard the only American nuclear cargo vessel, MS *Savannah* (built 1959), which has spent the last 50 years as a museum ship, a relic of the Atomic Age.

Molten salt reactors

So what's changed now with nuclear and why might it be the key to a renaissance in the UK flag? Ironically, the answer lies in a form of nuclear fission that was first developed during the 1950s but was effectively discarded.

Research into molten salt reactor (MSR) technology, where a molten salt mixture is both the fuel and primary reactor coolant, was originally driven by the US military in the 1950s as it explored the feasibility of using a compact nuclear reactor to power supersonic bombers that could stay in the air for very long periods of time. Although a working reactor was successfully operated under experimental conditions, the invention of the Inter Continental Ballistic Missile (ICBM), meant the 'Aircraft Reactor Experiment' was canned early.

A second experiment in the 1960s, the Molten Salt Reactor Experiment, was conducted by the Atomic Energy Commission, now the US Department of Energy, and led by the nuclear physicists Alvin Weinberg and Eugene Vigner (who had worked with Oppenheimer on the Manhattan Project), this time using a larger thermal spectrum liquid cooled reactor, which was operational between 1964 and 1969. But despite successfully demonstrating the viability of the technology the experiment was terminated, even after having achieved its objectives. The UK and Soviet Union also considered the potential of MSR during the 1970s but decided not to pursue it. The main reasons cited for the MSR not being developed further was a lack of demand for small-scale nuclear reactors both from the military and electric power utilities just as the more conventional



THE MOLTEN-SALT REACTOR EXPERIMENT WAS SUCCESSFULLY OPERATED AT THE OAK RIDGE NATIONAL LABORATORY, TENNESSEE, BETWEEN 1964 AND 1969 BUT THE TECHNOLOGY WASN'T PURSUED FURTHER AT THE TIME. SOURCE: CREATIVE COMMONS

MIKAL BØE, CORE POWER'S CEO

Pressurised Water Reactor was becoming popular as a means to produce base-load electricity in large-scale power stations.

However, as the pursuit of low-carbon energy has gathered momentum, MSR technology has emerged as one of the front runners of the so-called Generation IV reactors; inherently safer, cheaper from mass-assembly, and far more fuel efficient than conventional nuclear technology. In December 2020, an international partnership involving the US-based Southern Company, the Bill Gates-founded TerraPower and UK firm Core Power secured 80% funding from the Department of Energy to take part in cost-share risk reduction awards under the Advanced Reactor Demonstration Programme to build a 'proof of concept' medium scale commercial MSR, which is now under construction at Idaho National Laboratory, the world's largest nuclear research facility.

MSRs for maritime

Core Power, which was founded in 2018, plans to put MSR technology at the heart of ocean transportation, collaborating in the development of land-based modular MSRs for the mass production of green synthetic fuels, with the ultimate aim of installing MSRs onboard larger vessels and floating production platforms. Unsurprisingly, it has taken a strong interest in the MCA consultation and solicited support from a large number of industry players, many of whom believe that IMO's target of a 50% reduction in overall greenhouse gas (GHG) emissions will simply not be possible without nuclear-powered oceangoing ships.

It's commonly understood now that shipping represents one of the hard-to-abate sectors of global industry when it comes to GHG reduction, but perhaps less appreciated that while there is ongoing heavy investment in the potential of hydrogen, ammonia and methanol, the viability of their lower energy density compared to conventional fossil fuels represent an enormous challenge in scaling the technology up for the largest vessels. The Fourth IMO GHG Study, published last year, found that of the 919 million tonnes of CO_2 emitted by international shipping during 2018, only 30% was caused by domestic shipping.

Moreover, Core Power's own analysis, based on shipbroker's fleet data, indicates that of the roughly 100,000 vessels operating globally that are over 100 gross registered tonnes, the largest 17,000 vessels are accountable for 80% of global emissions, and of these the largest 7,300 ships make up close to 50% of all emissions. It's these 7,300 vessels which the company is targeting as the prime candidates for nuclear propulsion.

A vessel equipped with a small MSR would feasibly never need to bunker for its entire operational life, nor would there be any need for speed reduction as a means of lowering its emissions, as these would be eliminated. Core Power calculates that an MSR-powered Capesize bulker operating continually on a Brazil-Asia route for 25 years with 18MW on the shaft line, only stopping every five years for statutory drydocking, would use just under 200kg of fissile fuel. Operating as fully electric ships, with no need for fuel tanks, would also offer enhanced cargo capacity and make it possible to sail at higher speeds. For large containerships, that could mean up to 30knots for 30 years on a single MSR fuel load. Further benefits might be realised when the ship is berthed, with the possibility of ship-to-shore power that could improve port air quality.

Changing perceptions

"Many people still confuse nuclear weapons and nuclear reactors as being the same thing. The difference between a nuclear weapon and a reactor is like the difference between a gun and a teaspoon," says Core Power CEO Mikal Bøe, an expat Norwegian and shipping executive, speaking to *TNA* at the company's offices in Chiswick, west London. "Shipping industry executives are waking up to this, and we expect perceptions to continue shifting over the next few years." Despite its negative perception, particularly among the older generation, Bøe notes that the evidence for long-term harm caused by well-publicised nuclear incidents such as Chernobyl, Three Mile Island or Fukushima is at best contentious, certainly by comparison with the damage caused by air pollution from fossil fuels and resulting climate change.

The ships Core Power is proposing are, Bøe says, almost completely the opposite from the nuclear ships of the past, or even today's icebreakers. "Between the 60s and 90s, people talked about putting conventional naval reactors onboard ships and there's a fundamental reason why that doesn't work. Nuclear as we know it today is basically one technology, the pressurised water reactor (PWR), which is solid fuelled uranium cooled with water under very high pressure to generate steam."

Conventional naval reactors, such as those found on nuclear submarines, use highly enriched uranium that allows them to run for as much as 40 years without refuelling. Although it's feasible to use lower grade uranium for ships this would require refuelling as frequently as every 18 months, not to mention disposing of the spent fuel. It would also need ports capable of handling the material, restricting the options down to the handful of nuclear nations. In short, it's a major deterrent to any upscaling of the world's nuclear fleet.

From the outset, Core Power decided to look at the challenge afresh and reconsider some of the previously discarded nuclear technologies. Bøe explains: "If you take the various core components of what makes a reactor – the actual vessel, fuel, moderator and systems around it – you get almost 1,000 different reactor designs. Then we started looking at these and the criteria we need in order to make this function in shipping.

"The first one is safety and security; we avoid a pressurised system, so that no matter what happens it's not going to expel toxins into the environment. A Fukushima Daiichi event would simply not be possible with an MSR. The other is to avoid solid fuel reactors with a moderator (coolant), so instead of having a separate moderator we combine the fuel and coolant together as a design requirement. Then, we simply can't lose the coolant. If it overheats, the MSR shuts itself down automatically. No operator assistance required. At the same time, since the reactor has a liquid fuel instead of solid then no matter what happens it's not going to meltdown. These things wrap into a holistic passive safety design. Imagine a machine where if you don't press the on-button it will switch off.

"If you have a disaster at sea, whether it's an explosion, a collision or a terrorist attack, the system would stop itself. You have this coke can in a cathedral concept of the reactor, which shuts itself down and as the liquid fuel cools it becomes a solid, like a rock. After thousands of years the MSR itself might eventually disintegrate but by that point the

UK-BASED CORE POWER'S MSR REACTORS ARE SAID TO AVOID MANY OF THE PROBLEMS ASSOCIATED WITH HPW TECHNOLOGY CURRENTLY USED FOR NUCLEAR-POWERED MARINE PROPULSION

fuel is harmless. We found MSR technology to be an ideal solution for shipping."

Another essential criteria was the ability to run on the same fuel for the lifetime of a ship, up to 30-40 years, just like nuclear submarines. By essentially idling the MSR it is possible to achieve this. Bøe says: "If you run a 180MW thermal reactor and convert that into electric power of 15-25MW at 70% MCR, with load following for 30-40 years, then at the end of that time you still have most of fuel left useable in the reactor. That means we don't have to refuel them in ports and therefore tackle the thorny issue of nuclear non-proliferation."

The last criteria, according to Bøe, is to achieve an economy of scale by developing a compact, modular design for the MSR that can be easily manufactured, exported and decommissioned. "We seek that single design and single licence so we can mass produce the MSR with a very fast innovation cycle," he says.

Case study

Compared with conventional propulsion, a nuclear-based solution is going to be more expensive, at least at the front end. During a recent study for a major dry cargo owner, Core Power concluded that for a 390,000dwt very large ore carrier (VLOC) the capex of the propulsion system could be around US$300 million for a vessel equipped with a modular MSR, compared to US$20 million for one capable of running on HFO.

The difference comes with the opex; although there would be higher costs for crewing and insurance, with bunkering costs completely removed from the picture and emissions (carbon taxation *et al*) not being a concern, the total lifetime costs could be as low as US$360 million, against US$575 million for the VLOC with a long-term HFO reference price at US$350 per tonne. Adding significant carbon pricing to bunker costs would make this difference far greater. Similarly, large vessels switching to zero-carbon synthetic fuels like ammonia would see significant increases in opex from much higher fuel costs, increased fuel tank space and less cargo carrying capacity as well as the safety systems required to contain fuel toxicity.

In addition to the built-in safety elements of the MSR itself, the vessel would be designed so that the MSR could be installed and retrieved with ease, yet also (in accordance with the Nuclear Code) embedded deep within the hull for added protection. It's anticipated, to ensure redundancy, that some vessels could be equipped with two MSRs with flow-battery back-up for take-me-home power, although alternatively diesel generators running on light fuel might also be installed as a back-up.

In the case of the VLOC study, Core Power proposed that rather than the conventional single fixed-pitch propeller and single rudder, the electric propulsion system powered by the MSR could allow it to be complemented by a contra rotating fixed-pitch podded CLT propeller for improved steering. Further design improvements included a bulbous bow (to take advantage of the faster design speeds), moving the superstructure to midship, removal of the funnels, boilers, and the inclusion of stern and bow thrusters. Although the reactors would increase the ship's lightweight, this is more than compensated for by the removal of the drastic reduction in tankage. The absence of an internal combustion engine would also allow for a greatly simplified oil lubricating system.

Overall, Core Power projected that deadweight cargo capacity would increase by as much as 3% compared to the HFO-fuelled reference VLOC, with additional gains when compared against equivalent designs for other alternative fuels or fuel cells. However, notwithstanding current market conditions, it's anticipated there is also great benefits for a nuclear-powered container sector, where fuel costs (and eventually carbon taxes) are driving inflation in the cost of consumer goods.

Reimagining ownership

There's also a significant difference with the ownership model that Core Power is proposing. Bøe explains: "We do not anticipate a shipowner to be a licensed nuclear operator. What we need to have is an organisation that has the ability to take back control of the ship in the event of a counterparty default. You don't want one of these ships sitting under the purview of a sheriff and auctioned off to an 'unfriendly' flag. What we're looking at is a sort of private finance organisation that owns the vessel and provides it on a long-term, if not lifetime, leasing basis to the operator, who could then paint their own liveries on it. Similar organisations exist and thrive today, so what we are looking at is a hybrid bare-boat model, with certain requirements, such as an embedded reactor crew. The operator wouldn't have to think about training his crew to work the reactor – they'll already need to be trained on turbo machinery and electrical systems – but the reactor compartment and management of that technology comes with the lease. Like the airlines where they lease their engines, even their planes."

Because such leasing organisations would require regulatory oversight to ensure the highest standards of build quality, safety, security and management, it is seen as further justification why the vessels should be registered to reputable flag states, such as the UK or the US and Japan, and benefit from the ultimate protection of their respective navies, rather than flags of convenience where the instinct to be cost competitive could undermine standards. Moreover, Bøe thinks focusing on such high-end vessels with specialised requirements has the potential to reinvigorate the British maritime economy.

"The UK registry is now down to 10 million tonnes, the lowest it's ever been and down 70% in 10 years and yet Maritime UK wants to rebuild Britain's status as a maritime centre," he says. "We should think about what's going to sit at the centre of that. If these largest 7,300 ships could be powered by MSRs, and are regulated here, you can rebuild the register and on the

back of that a resurgent maritime sector. We have to rebuild the officer class, create substantial engineering and maintenance facilities, as well as boosting the insurance, the brokerage and banking sectors with all the systems around it. Those 7,300 ships are over 700 million gross registered tonnes, which is 70 times what the UK has now. Spilt that with partner-nations, and you have the basis for a superior solution."

Even at the end of its working life a nuclear vessel's residual value is likely to be significantly greater. Notwithstanding its scrap value, around 97% of the fuel in the reactor can be recycled for re-use in a new reactor. The small quantity of remaining waste would be placed in a small concrete box either above or below ground. Radioactivity of the spent fuel will have dropped to low levels within two decades. Importantly, the nuclear industry is the only energy generating industry that has a full fuel-cycle management requirement, and all nuclear 'waste' is carefully managed and always accounted for. "We've been managing spent fuels for 80 years now, and we're very good at it, but with the MSR the waste footprint is miniscule. The entire waste footprint of the global capsize fleet operating for 25 years would fit in a 40ft shipping container. Compare that to the 2.5 billion tonnes of CO_2 emitted by the current fleet," says Bøe. With further re-processing of the spent fuel from an MSR, it could be used as a source for rare materials such as radioisotopes which in some cases could be worth millions of dollars per gram.

The future

The proof-of-concept MSR now under construction in Idaho is scheduled to be completed in 2025 and Bøe is confident that everything will proceed according to plan. "We've done the metallurgy, the salt chemistry and most of the thermal dynamics. Certain aspects of the practical neutronics still need to be shown but computer simulations show how this is going to work within an expected margin of error. Once the first proof-of-concept reactor is operating the licensing authorities can start their approval process. If all goes well, we expect there to be a demonstration vessel or floating production platform at sea sometime between 2028 and 2030."

He believes that within 20 years, less than a decade short of IMO's 2050 targets, it would be possible to have somewhere between 500 and 700 ships powered by MSRs, which would represent 10% of Core Power's target market. He admits though that forecasting too far into the future is risky. "It could be that by the 2040s people will have found a better way of using this technology to do something else, but for now the maritime sector represents the best combination of reliable true-zero emission energy technology, and what we need to move global trade into a sustainable future for generations to come." ■

CRUISE SHIPS

SPACE, WEIGHT AND ACCESS TO DRAWINGS IN FOCUS TO ALLOW SMOOTH CHANGE TO NEW FUEL

By **Kari Reinikainen**, Correspondent

Cruise ships that have entered service recently, or that are currently on the drawing board, will quite likely use a different fuel towards the end of their lifespan than in the beginning of it, which poses a number of challenges when it comes to future proofing them, according to senior naval architects.

"P2X [Power-to-X] or synthetic fuels will come in about 2040, which means that many the cruise ships now in service will be using them. A question is whether these are liquid, such as methanol, or gas. I would presume that as far as passenger ships are concerned, also biofuels, both as liquid and gas, will be in the spotlight in the next five to 10 years," says Vesa Marttinen, development executive at MarineCycles in Finland.

From the ship design point of view, space poses a challenge. While on bulk carriers and tankers outer deck areas aft of the accommodation block offer an obvious location for fuel tanks, outer decks are very much a premium location on cruise ships. They also differ from many cargo ships when it comes to height; there is plenty of height for technical equipment under the accommodation block on tankers, bulk carriers and container ships. However, on cruise ships lower decks above the water line are often taken up by crew quarters and, for example, galleys and store areas.

Space at premium on cruise ships

"We have a challenge when it comes to space and for that reason, the use of tanks in the hull should be favoured. Consequently, methanol produced from biological material will probably the next step forward," Marttinen says. Space constrains would probably make it impossible to store enough ammonia or hydrogen onboard to give the ship a range of 20 days, he adds.

Hans-Otto Kristensen, director at HOK Marineconsulting in Denmark, says that the cruise industry is likely to follow in the wake of Maersk Line and look for green methanol as the next step forward.

"[In] my opinion in the case of future cruise ships, which shall be climate neutral, the owners need to follow the same strategy as Maersk has now started. It will absolutely require a lot of planning, but also investments both with respect to knowledge and the technical installations. It will really be a great challenge for an industry where the future is very unknown, especially in relation to the outcome of the new Covid-19 situation worldwide," he tells *The Naval Architect*.

Methanol tanks will take up a lot of space onboard and fuel tanks need to be surrounded by cofferdams. The tanks should be cubic form to optimise the ratio of cofferdam to fuel tank space, and the tanks must be coated like those on chemical tankers to ensure that the surfaces are smooth.

"Smooth tank insides mean structural stiffening in the cofferdams leading to ventilation challenges in cofferdams as well as access challenges in both tanks and cofferdams. The need for structural stiffening of the shell makes it hard to arrange tanks adjacent to the shell," says Kristensen.

Given the uncertainty about the future supply of green methanol, the first movers will still require the flexibility of using oil as fuel in the future, Kristensen points out, adding that this means that the issue of space becomes even more important.

Switchboard must cope with new modules

Anders Orgaard, chief commercial officer at OSK ShipTech, also in Denmark, says that in addition to space, the weight of future installations also has to be considered. This is mainly because of battery packs that are already used on some cruise ships to provide emission-free power, for example, when leaving or entering port.

ANDERS ORGAARD, OSK SHIPTECH

VESA MARTTINEN, MARINECYCLES

Battery packs are heavy: a 6.1MWh installation on the recently completed 15,776gt *Havila Capella* weighs 86tonnes, according to the ship's Norwegian owner Havila Voyages.

"The challenge is predominantly to make sure that the electrical installation is ready to accept upgrades. This can mean shore power, fuel cells or battery packs," Orgaard says. Each new module must be connected to the switchboard and it should be able to receive these connections.

Many cruise ships in service today face a shortage of space that could be used for future fuel installations. A reason for this is that they are optimised for stability, in accordance with the latest SOLAS rules.

However, this means that many designs are sub-optimal when it comes to future fuels and the space and weight that they involve. Lengthening of these ships can also be difficult, given the stability focused foundation of their design, Orgaard explains. The technical challenges that many cruise ships may face in the future when it comes to the adaptation for a new fuel has an economic consequence as well; such vessels may not be very profitable over their entire lifespan.

Marjo Keiramo, head of R&D programmes at the cruise ship builder Meyer Turku in Finland, thinks that there is no clear answer at the moment as to what fuel or fuels cruise ships of the future will use.

Include fuel change from design change

"This means that the new aspects and changes regarding energy solutions and the technology, equipment and systems linked to them will have to be taken into account already at the design stage – whatever the solutions that are chosen for new concept may be," she says.

While flexibilities in the design are essential in terms of future proofing a ship, matters are sometimes complicated as owners who have bought a cruise ship design from a shipyard may not have access to the original drawings, says Orgaard, adding that shipyards often only give the owner a pdf of them. This can pose a problem later as a pdf cannot be edited to update the drawings to include changes to the ship.

As a result, some owners have started to develop designs of their own and then approach shipyards to launch a tender process, which was the case some seven to 10 years ago. Tight availability of building slots at leading cruise ship builders encouraged owners to accept designs that yards offered to them, making it easier to secure a slot, but now the trend appears to be turning, Orgaard points out. ■

ACCOMMODATION & INTERIORS

HIGH-QUALITY INTERIORS HAVE A RICH HISTORY OF INTERNATIONAL COOPERATION

By **Bruce Peter,** Professor of Design History, Glasgow School of Art

The design and making of interiors for passenger ships is a subject that has long fascinated me, involving as it does the application of many of the conventions of architectural design ashore within otherwise entirely engineered structures, built to withstand movement in harsh and unforgiving environments while complying with highly complex regulatory frameworks.

Nowadays, many passenger ships, most notably large ro-pax ferries, are being built in shipyards in Southeast Asia for operation by shipowners in Europe. But as the majority of know-how with regard to outfitting remains with European designers and suppliers, ship interior design and outfitting are globalised businesses, involving so-called 'turnkey' outfitting companies whose specialities are the procurement and installation of all the comfort-giving services, finishes and furnishings to create complete interiors of high quality and precision.

Grand vistas

One might think that this internationalisation is a relatively recent phenomenon, but a quick glance through century-old copies of journals such as *The Shipping World* and *Shipbuilding and Shipping Record* reveals that the interior design and outfitting of ships involving international cooperation between designers, makers, shipbuilders and owners actually began in the latter 19th century. At that time, the larger European liner shipping companies first sought to compete in attracting wealthy first-class passengers by providing accommodation comparable with that of the era's best city hotels. The employment of the architectural firm Mèwes and Davis (famous for having designed the fabulous Ritz Hotel at Place de l'Opéra in Paris), initially by the Hamburg-Amerika Linie and later by Cunard, was one manifestation of this. Mèwes and Davis had offices in Paris and London, the former headed by the French architect Charles Mèwes, who in the early-1900s had the idea of dividing ships' boiler flues to open up grand vistas along their centerlines, thereby enabling more spectacular spatial effects to be achieved, unencumbered by the presence of casings at regular intervals to block the view.

Thus, architects whose training was in designing buildings ashore first entered a dialogue with naval architects and shipyards with regard to how vessels' technical arrangements should be achieved. Each contributor to the discussions had their own point of view: architects desired spatial drama, whereas naval architects insisted upon constructional strength, systems that would function well and the compliance with regulations. Shipyards, on the other hand, had a preference for what was known to work and was fastest and least expensive to achieve to avoid construction delays and additional costs. The negotiations required between the various professionals involved in building large passenger ships remain familiar today. (Open-planning had considerable safety implications and, sadly, the largest liners to incorporate central 'grand vistas', the French *L'Atlantique* of 1931 and *Normandie* of 1935, were both entirely destroyed by fire after careers lasting less than a decade).

Turnkey pioneers

A bigger surprise is that even in the 1900s, ship interior paneling, fixtures and fittings were not infrequently commissioned from manufacturers in different countries from the ones where the ships themselves were built. An advertisement in *The Shipping World* for the London-based interiors specialist Waring & Gillow, which was Britain's leading maker of complete ship interiors in the first half of the 20th century, illustrates the Austro-Hungarian liner *Kaiser Franz Joseph I*, built at Monfalcone, near Trieste, and is captioned 'Decorated by Waring's'. Also listed are the *Principessa Jolanda* and *Principessa Malfada*, built at Riva Trigoso in Italy. A little later on, in the 1920s, the Italian decorators Casa Artistica di Mariano Coppedè & Figli of Florence supplied complete interiors for the Clyde-built Italian liners *Conte Rosso*, *Conte Verde* and *Conte Biancamano*. Such Italian baroque designs were spectacular, and one can only imagine the complexities of ensuring their safe delivery to Scotland and subsequent installation at a time when European trade was much less open than today and conventional freight shipping was far less secure than current containerised methods. Coppedè & Figli's craftsmen stayed in Glasgow – where there was already a large Italian community – for the duration of the outfitting process to advise the shipyard's own staff on the installation. So, what today is referred to as 'turnkey outfitting' actually has a history dating back more than a century.

When the use of sprinkler systems for firefighting became commonplace in the 1930s, it was usual for shipyards and their subcontractors to commission these systems before the outfitting commenced and also to immediately lock newly completed sections of the accommodation to prevent pilferage – indeed, such measures were insurance requirements. In Britain, there were consequently very few serious fires on vessels under construction, and one may add that the construction industry ashore would have benefitted from emulating the same approach.

The outsourcing of the construction of passenger ships to countries where labour is cheaper first began on a significant scale in the latter 1960s and early examples with complex interiors were two rather sophisticatedly appointed cruise ferries for the Swedish shipowner Rederi AB Gotland that were built at Trogir in Yugoslavia and

THE GRAND SALON OF *NORMANDIE*, CIRCA 1935. *NORMANDIE* WAS ONE OF THE LARGEST LINERS TO INCORPORATE CENTRAL 'GRAND VISTAS'

delivered in 1972-73. *Visby* and *Gotland* were designed for summer service in the Baltic Sea, carrying holidaymakers to the island of Gotland, but the intention was that during the winter they would be chartered out for use as Caribbean cruise ships (though due to the oil crisis, this never happened). Thus, their passenger facilities were far in excess of what would have been expected of short-haul ferries at that time. As the Yugoslav shipyard lacked the ability to produce interiors to the required standard, the Danish naval architect responsible for the design of the ships, Tage Wandborg of Knud E. Hansen A/S, contacted a West German specialist metal fabricator, Horst Warneke, whose company, HW Metallbau, prefabricated the entire interiors, including modular en-suite cabins. Being entirely of metal with various decorative surface finishes, these interiors were also fire-proof and compliant with the forthcoming SOLAS 1974 regulations (and indeed most of the rules applied since). The components were packaged in containers and sent to Trogir for installation, the result being highly lucrative for Rederi AB Gotland which received two vessels of very high quality for the same price one vessel constructed in Sweden would have cost. (Incidentally, nearly half-a-century later, both remain in service today with Mediterranean operators).

During the 1970s, the pre-fabrication of interiors using metal or composite extrusions became almost standard practice and, for example, the Finnish Wärtsilä shipyards built their own factory to mass-produce ferry and cruise ship cabins using modular systems. This was also a major change from craft-making to Fordist assembly-line production and from the specification by designers of mostly bespoke items to the specification of fixtures, fittings and furnishings from catalogues.

Aspirational and reassuring aesthetics

Aside from the ways in which ship interiors are made and procured today, what of their aesthetics?

From the outset, ship interiors, like those of hotels, were intended to appeal mostly to an aspirational taste that was quite conservative and so they have only very rarely incorporated avant-garde ideas – such stylistic modernity as they did possess being instead Janus-like (simultaneously backward- and forward-looking). Indeed, there is usually a lag of between 10 and 20 years from a new design style first emerging ashore and elements of it appearing in ship interiors. Moreover, taste is cyclical and so 'retro' styling is often employed as its themes are recognisable to shipowners and passengers alike. Just as in hotels, typical cruise or ferry passengers desire reassurance through the presence of familiar elements, tempered with a frisson of glamour. If this sounds depressingly formulaic, one should remember that making the travelling public feel happy and at ease is not an easy task and the successful ship interior design specialists must therefore be praised for finding middle-of-the-road approaches that achieve widespread popular appeal.

Junk space

As passenger ships go through their existences, they will occasionally be partially refitted and, sadly, it is typical that due to quick and short-term changes accumulating, vessels that initially were coherently elegant inboard end up becoming increasingly fragmented and banal. The Dutch architect Rem Koolhaas uses the term 'junk space' to describe commercial environments in which cheap and tacky alterations have accumulated to the extent that there is no longer anything of quality left to be observed. Indeed, many older ferries and more than a few cruise ships contain large amounts of junk space.

At present, one of the most pressing concerns for all involved in the creation and maintenance of ship interiors is their environmental impact and end-of-life recyclability. In the past, interior outfitting has involved the use of several nasty materials, ranging from asbestos to formaldehyde, and the composite materials often used for walls and other fixtures do not easily lend themselves to recycling. Nowadays, some designers and many suppliers are considering the impacts of the materials they specify over vessels' lifetimes. Another separate environmental concern is the maintenance of safety during the Covid pandemic, enabling passengers and crew to be sufficiently distanced and having finishes that can be easily sanitised. Environmentally sound ship interiors, just like 'green' propulsion systems, are an emergent phenomenon and there remains much developmental work still to be done. ■

PROPULSION

HOW HYBRID SYSTEMS WILL TRANSFORM PROPULSION

By **Børge Nogva**, CEO, Høglund, and **Bengt-Olav Berntsen**, CEO of Haf Power Solutions AS (a Høglund company)

As we look back on the industry's environmental milestones in 2021 – namely the CO_2 emission targets set by the IMO, and the CII and EEXI decisions – it is clear that the pressure to decarbonise the global fleet will only increase. With 2030 climate targets on the horizon, the next decade will be decisive in radically reshaping the way in which shipping operates. Crucially, shipowners will have to transform the design and engineering of their vessels to reassess their energy needs, improve their sustainability credentials, and upgrade their assets to meet environmental regulations.

While the debate on how this can be achieved has mainly centered around future fuels and the ways next generation technology will support the optimisation of fuel use, the role of propulsion systems has – regrettably in our view – often been overlooked. However, hybrid propulsion systems (HPS) have the potential to be an instrumental ally for shipowners in their decarbonisation journey.

Hybrid power opens up a world of opportunities as it shifts away from traditional power systems and disrupts the classic, internal combustion engine (ICE) based technical paradigm for vessel power management by decoupling the electrical and power systems. Currently, fossil-fuels and oil are inextricably linked with the ICE, and this relationship has determined the evolution of shipping technology for over a hundred years. The adoption of HPS is one of the most significant changes that decarbonisation will have on ship technology.

Variable speed shaft generators

By decoupling propulsion from electrical systems, hybrid solutions can, for example, allow propellers and cargo discharge pumps to work at different speeds, while at the same time providing valuable back-up emergency power using variable speed shaft generators (VSSG). VSSGs give crew more control over the power supplied to the propeller, with additional generators supplying power to the propeller at different speeds when necessary. The hybrid drive allows excess energy from the propeller shaft to be recovered and reused for additional power when needed, reducing overall power consumption.

VSSG systems enable smaller main engines to be installed and are boosted by running the main engine and the shaft generator to power the propeller, ultimately increasing the power supplied in demanding operations like towing or icebreaking. VSSG also allow cargo discharge pumps to operate at different speeds, increasing the range of terminals they can discharge at and provide additional flexibility in loading and unloading locations. The overall effect of these innovations is that the vessel will be able to operate at greater efficiencies over a wider range of speeds and propeller pitches.

BØRGE NOGVA

BENGT-OLAV BERNTSEN

By connecting Energy Storage Systems (ESS) to the embedded DC-link of the VSSG, peak load or transient load conditions can be smoothed out, making operations more efficient and increasing safety due to optimised generator capacity onboard. The spinning reserve mode of ESS, safely and seemlessly provides power, removing redundant running of backup generators in crucial manoeuvring conditions, reducing the amount of emissions emitted from vessels due to low loaded ICE. Additional battery capacity could allow for vessels to enter and leave ports with zero NOx or CO_2 emissions emitted.

Pushing the battery boundaries

While considerable developments are required to make fossil fuels redundant, we are pushing the boundaries for what we can do with ESS based on battery technology combined with cold ironing. For example, HAF Power Solutions recently signed a contract with Norwegian Shipyard Brødrene AA to commission a fully electric passenger catamaran that is able to obtain a speed of 20knots, carrying 150 passengers, while operating 100% from batteries.

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With this, hybrid systems unlock a range of new operational possibilities and efficiencies, which in turn increase the importance of automation. Automation is what gives crew control over these systems, another aspect that has historically been overlooked by the industry. As a consequence, many vessels' integrated automation systems are a mix of software and hardware from different suppliers and eras, preventing crew from solving issues, having optimised systems, or in some cases, using certain systems at all.

The range of future projects that will require hybrid system expertise is increasing, and we predict most vessels in the future will have some degree of hybrid or peak shaving capability. While these types of solutions will play a bigger role for short-sea vessels, bulk and container vessels will likely use ESS for manoeuvring or other operations where additional power is required. ■

HYDROCOMP ANNOUNCES NEW FEATURES FOR PROPELEMENTS

US-based propulsion solution specialists HydroComp says that user testing is now underway for the new coupling of its successful PropElements propeller design optimisation tool with NUMECA's FINE/Marine CFD software.

The computational load required for 3D modelling is a perennial problem of CFD propulsion analysis, but HydroComp believes it has found a solution to this problem by using FINE/Marine as a higher-order actuator disk replacement. This allows PropElements to calculate velocity fields and propeller body forces for the wake field with a significantly improved model of propeller performance, thereby offering self-propulsion simulation at a fraction of the computational cost of a full 'sliding grid' 3D analysis.

In addition, the latest iteration of PropElements incorporates a number of updates for modelling and analysing the nozzle's contribution to propulsion performance with ducted propeller designs. These include an updated model for 19A and High Efficiency nozzles; scale correction for nozzles to better predict large nozzle; the addition of nozzle style 30 for minimum drag non-contributing nozzles, and style 38 for symmetric fore-aft performance; and an indicator for the potential inception of critical nozzle cavitation.

Prediction of streamline parameters

Further enhancements include the development of a new script-based module for the prediction of streamline axial and tangential velocities at positions some axial distance from the propeller's design reference origin (both upstream and downstream), as well as corresponding jet compression (contraction) and twist angle.

Figure 1 shows the results of axial tangential velocities for the Potsdam Propeller Test Case (PPTC) benchmark established at the 2011 Symposium on Marine Propulsors (SMP'11), for a reference plane 20% diameter aft of the propeller plane. In the diagram the markers show the test data while dashed lines record the PropElements prediction. These were compared against the CFD predictions of multiple participants, with PropElements matching these figures very closely. HydroComp says the work constitutes a foundational piece of the upcoming contra-rotating propeller analysis module that is being developed for this year.

Bring the noise

Follow-on noise and vibration analysis are a crucial component in modern propulsion analysis and PropElements has built the prediction of various such properties into its Performance and Strength calculations, and they can be generated for output using simple scripts.

Parameters that are calculated include: key frequencies, including shaft and blade pass; entrained water properties, including wetted added mass and moment of inertia; tip vortex parameters, including inception cavitation number, resonance frequency, and core diameter; and singing parameters, including estimation of the blade natural frequency and the radial exciting 'vortex street' frequencies.

Yet more miscellaneous enhancements to the software include automatic estimation of ideal angle for imported geometric data and improved influence of the hub's effect on induced velocities. ■

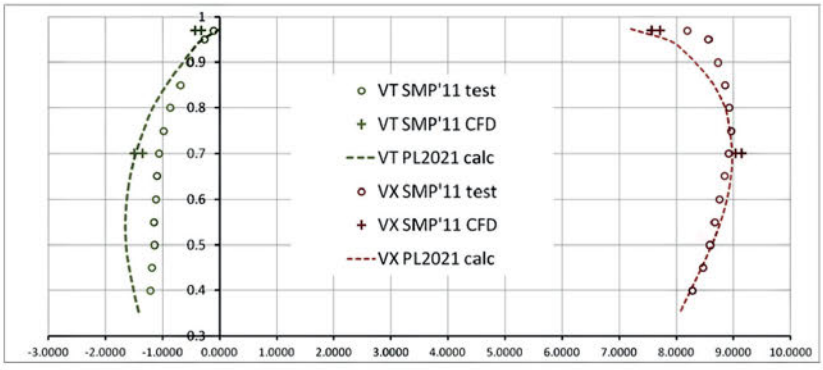

FIGURE 1: PREDICTING STREAMLINE AXIAL AND TANGENTIAL VELOCITIES

LNG BUNKERING

TITAN LNG'S NEW TANK DESIGN BOOSTS BUNKERING CAPACITY

By **Douwe de Jong**, marine asset development manager, Titan LNG

CONCEPT ILLUSTRATION FOR TITAN'S 8,000M³ HYPERION SERIES BARGES

Titan LNG has developed an innovative concept for the fuel storage tanks used in its liquid gas bunker barge design series 'Hyperion'. The 8,000m³ inland waterway version will specifically target the market for LNG and bio-LNG for larger ocean-going vessels in the Amsterdam-Rotterdam-Antwerp region and will boost supply and bunkering in the region.

The rationale for the new tank design comes from Titan LNG's experience with the two LNG bunker barges it currently operates, the *FlexFueler 001* and *002*. The FlexFueler concept was developed in-house by Titan LNG, and this helped the company gain extensive experience with the European Inland Waterway (IWW) regulations, specifically its impact on LNG storage and handling systems.

Since the *FlexFueler 001* entered service in 2019, continued market growth and the higher tank capacity of the global fleet of LNG-fuelled vessels has led to demand for more and larger IWW dedicated bunker barges.

The ability to scale bunkering capacity up efficiently to meet this type of growing capacity is made difficult by a particular rule in the European code for carriage of dangerous goods. Namely, a tank capacity limit of 1,000m³ per tank onboard gas carriers. Which – when conventionally interpreted – leads to a multiple of 1,000m³ cylindrical tanks. Though certainly valid from a safety perspective, the rule is a challenge when scaling up liquefied gas carriers as it tends to lead to designs with many small – and relatively expensive – tanks.

The solution: tank partitions

Titan LNG has devised a way to meet this safety criterion by introducing the principle of multiple 1,000m³ internal tank partitions into a single tank structure. The main benefit is that more fuel can be put into a single tank structure. As a result, the tanks take up less space, thus reducing the total footprint of the vessel while maintaining the cargo capacity. The internal partitions maintain their individual structural integrity in case of damage to a single partition, which can cause challenging combinations of vapour and hydrostatic pressure differences. This solution has been patented as well as technically validated by Titan LNG for one of the more challenging types of pressure vessel; a bilobe tank.

In relation to boil-off gas, sloshing and slamming resulting from ocean voyages, the tank performs in the same way as a typical Type C tank. As Type C is designed for high vapour pressures, sloshing and slamming rarely govern structural load cases and each partition may be seen as a structurally individual tank. The considerations for tank support, inerting the space around the tank, and material fatigue are also no different to other Type C tanks. The only difference is that tank domes should be grouped together around the fixed support (allowing

FLEXFUELER 001 AND *002* ENTERED SERVICE IN 2019 AND 2020 RESPECTIVELY

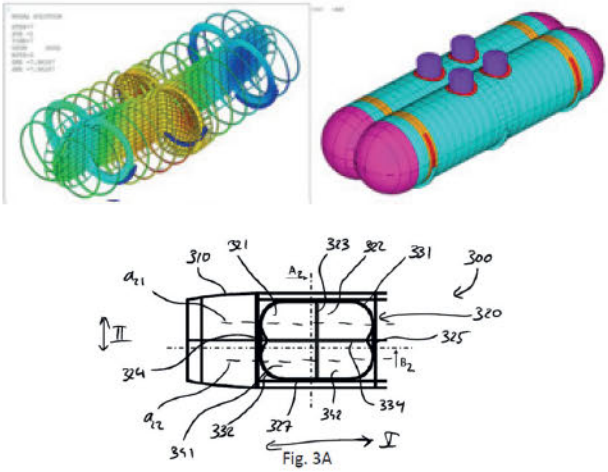

Fig. 3A

PARTITIONED TANKS: A SPACE-SAVING SOLUTION TO THE 1,000M³ VOLUME LIMIT. IMAGE COURTESY OF HB HUNTE

for no lateral movement due to temperature variations). This results in a central fixed support and two outer sliding supports. The new design does not affect bunkering procedures, equipment, or safety either. It uses the same number of pumps and the same transfer equipment as conventional IWW-compliant designs.

The larger tank size also creates the possibility of using lighter and cheaper foam insulation instead of the vacuum-insulated pressure tanks that are more common in tanks that are over 1,000m³ in capacity. This insulation concept has already been technically validated.

More efficient use of space offered by the new tank design meant that the vessel's length and breadth could be reduced by 10-20%, compared to a design with multiple individual cylindrical tanks. Fuel consumption, steel weight, outfitting costs and overall environmental impact of constructing and operating the vessel were reduced by similar percentages.

Growing potential

When combined with Titan LNG's broader design requirements for LNG bunker vessels it was found that the vessel lay-out of Hyperion could work as both an inland and seagoing vessel. As a result, the Hyperion design series currently features both seagoing and inland versions, making it ready for the market developments next decade and beyond.

Titan LNG cooperated with HB Hunte Engineering, who proved the structural feasibility of the tank concept. HB Hunte Engineering is also working with Titan LNG on the bunker vessel design 'Krios'.

Next to join the two FlexFuelers and the Hyperion, the Titan Krios bunker barge(s) will increase the accessibility of LNG as a marine fuel in the Port of Zeebrugge and in the English Channel ports from 2024. In line with Titan LNG's design philosophy, Krios is a compact seagoing LNG bunker vessel having 4,500m³ in capacity, thereby offering effortless client compatibility by virtue of its low air draught, high manoeuvrability, and small footprint.

Krios, which will fulfil part of the base demand in Zeebrugge that Titan LNG is already supplying, will operate with multiple tanks to segregate streams of LNG and bio-LNG – the sustainable carbon neutral fuel produced from biological waste streams. As it can be stored and supplied using existing infrastructure, blended with LNG, and dropped into existing engine technology, bio-LNG presents a financially sound long-term investment for many operators and owners looking to decarbonise operations, and comply with emission reductions regulations.

LNG and bio-LNG create a pathway to decarbonisation that leads to the introduction of hydrogen-based LNG which can use the same storage and handling infrastructure and engine technology. Liquid biogas – from organic waste – and liquid synthetic methane – from green hydrogen and captured CO_2 – are scalable solutions for the maritime sector, and the expanding LNG infrastructure in EU ports such as the Port of Antwerp is fully future-proofed and able to supply carbon-neutral LNG.

Mature technology

It took around a decade for LNG as a marine fuel to mature, and it is now at the point where it is fully established, proven to be safe, accessible around the world through an expanding infrastructure, with processes and protocols to support its use. More terminals are comfortable with LNG bunkering vessels lying alongside while working cargo (SIMOPS operations) rather than requiring a vessel taking on LNG had to switch to a layby instead.

Looking at the bigger picture of technology development, innovations in storage systems have primarily been developed for more mature (marine) fuels and cargoes, an important consideration when shipowners and operators are determining whether to opt for LNG fuelled vessels. As more LNG fuelled vessels are built, these existing innovations will become increasingly important to efficiently meet demand and effectively scale up supply infrastructure. ■

THE 4,500M³ KRIOS BUNKER BARGE CONCEPT WAS ANNOUNCED LAST YEAR

CALENDAR

What's happening next?

MARCH 31-APRIL 1, 2022
AUTONOMOUS SHIPS 2022
RINA conference
London

APRIL 26-29, 2022
CONTRACT MANAGEMENT
Training course
Europe/UK
Online

MAY 2-5, 2022
DRY DOCK TRAINING
Training course
Online

MAY 9-10, 2022
WEGEMT 2022 - GREEN SHIPPING
Training course
Online

MAY 17-20, 2022
CONTRACT MANAGEMENT
Training course
Australia/Pacific/Asia
Online

JUNE 8-9, 2022
WARSHIP 2022
RINA conference
Bristol, UK

SEPTEMBER 13-15, 2022
ICCAS 2022
RINA conference
Yokohama, Japan

For more information please visit:
www.rina.org.uk/RINA_Events

MARCH 28 - APRIL 4, 2022
SUB-COMMITTEE ON SHIP SYSTEMS AND EQUIPMENT (SSE)
IMO meeting
London/Online
www.imo.org

APRIL 4-7, 2022
NOR-SHIPPING
International conference
Oslo, Norway
www.nor-shipping.com

APRIL 4-8, 2022
SUB-COMMITTEE ON POLLUTION PREVENTION AND RESPONSE (PPR)
IMO meeting
London/Online
www.imo.org

APRIL 20-29, 2022
MARITIME SAFETY COMMITTEE (MSC)
IMO meeting
London/Online
www.imo.org

APRIL 28, 2022
CONFERENCE ON A-NAVIGATION
International conference
Moscow, Russia (online)
www.marinet.org

JUNE 6-10, 2022
MARINE ENVIRONMENT PROTECTION COMMITTEE (MEPC)
IMO meeting
London/Online
www.imo.org

JUNE 6-10, 2022
POSIDONIA
International exhibition
Athens, Greece
www.posidonia-events.com

JUNE 15-17, 2022
INTERNATIONAL CONFERENCE ON SHIPS AND MARINE RESEARCH (NAR)
International conference
Genova, Italy
www.atenanazionale.org/nav/nav2022

JUNE 26-30, 2022
INTERNATIONAL MARINE DESIGN CONFERENCE (IMDC)
International conference
Vancouver, Canada
imdc2022.org

SEPTEMBER 6-9, 2022
SMM
International exhibition
Hamburg, Germany
www.smm-hamburg.com

OCTOBER 17-21, 2022
7TH SYMPOSIUM ON MARINE PROPULSORS (SMP)
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Wuxi, China
www.smp2021.com

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