

BULK CARRIER UPDATE

2018



New bulker designs

Alternative fuels

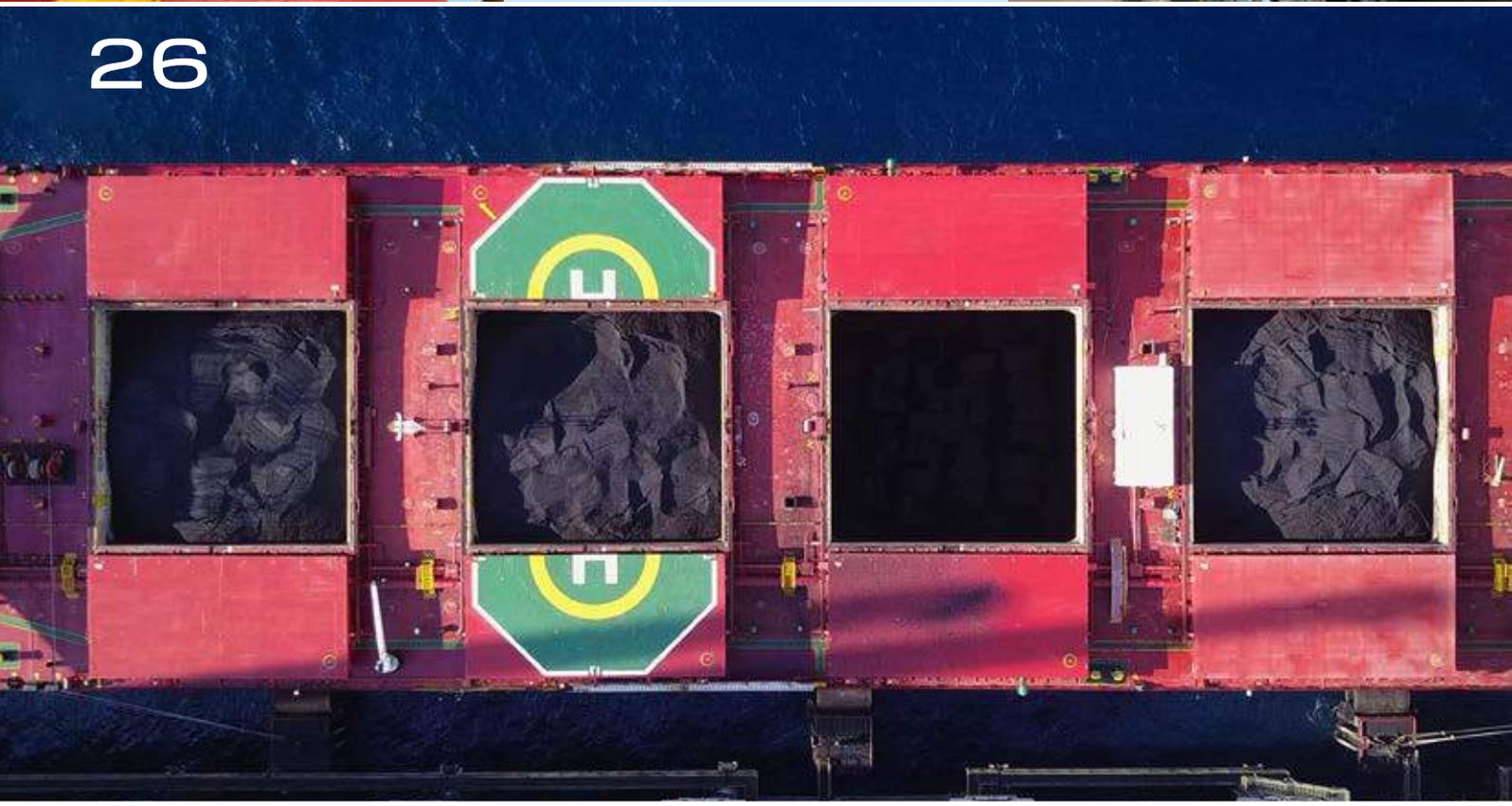
Cargo liquefaction

Composite tween decks

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Morten Løvstad
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DEAR READER,

It is a pleasure to introduce you to the latest BULK CARRIER UPDATE, which is released at the same time as the Posidonia 2018 exhibition is taking place in Athens, Greece! 2018 started with average bulk earnings 24 per cent higher than this time last year and with asset prices also going up. Earnings are expected to continue to rise this year as fleet growth is set to be the lowest in a decade. This is good news for everybody involved in the dry bulk sector. For DNV GL, our special focus on Greece as a home market is also showing encouraging results, with several large-scale entries of bulkers to DNV GL class over the last two years, combined with a leading position in newbuilding orders to our class.

To support the industry in complying with the new environmental regulations, especially those focusing on air emissions, DNV GL participates in several joint industry projects (JIP) to help develop new, compliant designs that will give shipping a “greener footprint”. In this issue of BULK CARRIER UPDATE, I would like to direct your particular attention to:

- the recent delivery of the world’s largest dry cargo vessel - *Yuan He Hai*, a 400,000 dwt ore carrier with innovative design features such as gas-ready. Also, as a specially constructed or fitted cargo ship she will be able to safely carry ore with a high moisture content
- the current status of the Green Corridor JIP currently developing an LNG-fuelled VLOC for the Australia-China trade
- the next-generation Ultramax bulk carrier with ultra-low fuel consumption at eco-speed - the 63,200 dwt “Diamond 2” Ultramax.

I hope you will also appreciate the articles about mitigations DNV GL has implemented to tackle major design and operational challenges in the dry bulk sector: For example, our new Shaft Align class notations address shaft bearing problems that have become an increasing problem in the industry; and the new class notation BCLIQ deals with the safety threats of cargo liquefaction on board bulk and ore carriers.

For those of you joining the Posidonia 2018 in Athens or SMM 2018 in Hamburg, I hope to see you and have some good conversations with you during these events. To all of you, I hope you will enjoy reading this magazine, and I look forward to seeing you at one of our many DNV GL bulk carrier seminars around the world during 2018.

Enjoy reading!

BULK CARRIER UPDATE

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GREEN CORRIDOR JIP TAKES LNG PROPULSION TO THE NEXT LEVEL

Now heading into Phase 2, the Green Corridor joint industry project (JIP) is looking to build on the success of their Newcastlemax design and bump it up to the VLOC level.

In search of the most cost-efficient and environmentally friendly solution for transporting iron ore and coal on the “Green Corridor” between Australia and China, the JIP that was established to develop an LNG-fuelled Newcastlemax design for the route is now at work on a 260,000 dwt dedicated ore carrier based on the same design principles.

In 2016, when the IMO confirmed the 2020 deadline for the 0.5% sulphur cap, major stakeholders serving the Australia-China iron ore and coal trade route, together with LNG supplier Woodside, ship designer SDARI, and class society DNV GL, decided to come together to develop a suitable LNG-fuelled bulk carrier solution for the route.

Paving the way for LNG fuel

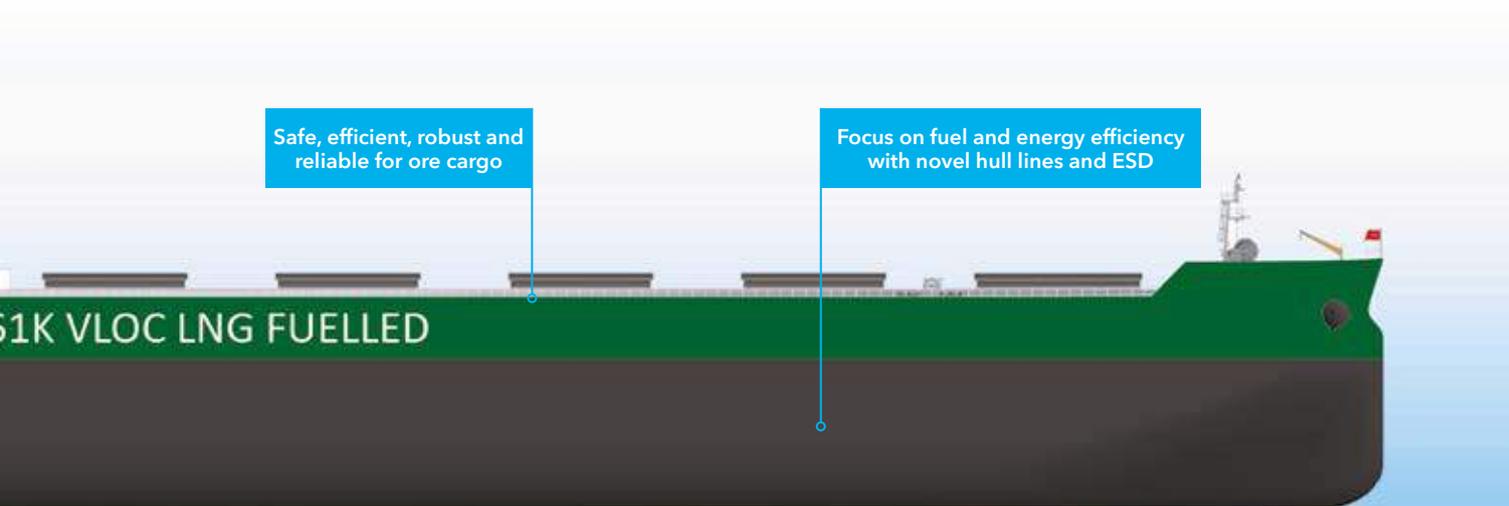
The result was a robust, commercially viable and safe LNG-fuelled bulk carrier design, developed using leading-edge but proven technology. The Newcastlemax design was well received, and orders for this vessel type are expected to be placed during 2018. After two more partners joined the project, shipowner China Merchants and LNG supplier Shell, the partners agreed to apply the same economical and technical

principles to a larger vessel dedicated to only iron ore and still running on dual fuels.

Now in Phase 1b, the Green Corridor JIP has performed a feasibility study on LNG as fuel for a VLOC (260,000 dwt) operating between Australia and China. The concept design is currently undergoing confirmation, awaiting approval in principle from DNV GL.

Phase 2 of the JIP is focused on implementation of the findings from Phases 1a (Newcastlemax) and 1b (VLOC). Bunkering issues are being addressed, such as compatibility and safety studies for ship-to-ship bunkering, shore-based bunkering vs ship-based bunkering, and the economics calculation is being updated accordingly to demonstrate the business case for LNG as fuel. The objective is to enable the development of optimized LNG bunkering supply chains to support efficient bunkering of bulkers trading from Western Australia, and give the industry the confidence to invest in LNG-fuelled bulk carriers.

The partners are also seeking to obtain more accurate market estimates of the cost of LNG-fuelled bulk carriers and the differential to conventionally fuelled bulk carriers in order to support the definition of realistic and economically viable rates for long-term charter parties.



260,000 DWT ORE CARRIER PARTICULARS (draft figures, may change in final design)

Principal particulars

- Length overall: ~327 m
- Length B.P.: 321.50 m
- Breadth moulded: 57.00 m
- Depth to main deck: 25.50 m
- Scantling draught (Ts): 18.8 m
- Deadweight at Ts: ~260,000
- Service speed: 14.3 kn (at scantling draught, CSR, 15% S.M., with ESD)
- Cruising range (oil mode): ~16,000 nm
- Cruising range (gas mode): ~18,000 nm
- Complement: 28

Main engines and propulsion

- Type MAN B&W 6G80ME-GI 9.5 or WINGD W6X82DF

Classification

- DNV GL ✱1A, Ore Carrier, ESP E0 IB(3) BIS TMON COAT-PSPC(B), BWM-T NAUTICUS(Newbuilding), GAS FUELLED or equivalent

Tank capacities

- Cargo holds: ~164,000 m³
- L.S. heavy fuel oil: ~3,400 m³
- Marine gas oil: ~800 m³

- Fresh water: ~600 m³
- Ballast water: ~200,000 m³
- LNG (Type C tank): ~8,000 m³

Power supply

- Main diesel generator (DF): 3 × 1,420 kW
- Emergency generator: 1 × 300 kW

Opening of cargo hatch

- No. 1 hatchway: 19.46 m × 16.50 m
- No. 2-9 hatchway: 16.68 m × 16.50 m

EEDI

- Attained (gas mode): 1.49
- Reduction on base line: 40%

For the new VLOC design, a fuel tank size analysis sought to strike the balance between minimizing LNG bunkering time per round trip and maximizing LNG fuel storage capacity in order to meet requirements for longer trade routes in the future. Tank size was ultimately set at 8,000 m³, based on two round trips from Western Australia to China using two LNG Type C tanks.

The tank layout is similar to that of the Newcastlemax, with two LNG tanks placed above the engine room but submerged from the main deck, giving the optimal balance between cost, operational flexibility, and safety. As with the Newcastlemax design,

Type C tanks have been chosen for maturity of technology, ease of installation and operation, general economic advantages, and minimal cargo capacity loss.

Building the business case

Economic feasibility studies were performed in Phases 1a and 1b to investigate dual-fuel CAPEX and OPEX, based on a wide range of possible capital cost, operational cost, and sensitivities to LNG and low-sulphur marine fuel oil prices.

Due to the rapid rise in crude oil prices over the past year, the price of low-sulphur marine fuel is now almost 50 per cent higher than when economics were analysed for Phase 1a in early 2017. With a slower growth in the price of Asian LNG, the gap between low-sulphur marine fuel and LNG is increasing, thus reinforcing the robustness of the business case from 2017. Hence, the latest study shows an even more encouraging payback time, less than eight years in the most realistic scenarios, compared to ten in the previous study conducted in 2017. ■ KG

GREEN CORRIDOR PROJECT PARTNERS

- BHP Billiton
- DNV GL
- Fortescue Metals Group
- Mitsui O.S.K. Lines
- Rio Tinto
- Shanghai Merchant Ship Design and Research Institute (SDARI)
- U-Ming Marine Transport Corp.
- Woodside Energy
- China Merchant Energy Shipping Co.*
- Shell Eastern Petroleum*

*Joined the project in Phase 1b



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ORE CARRIER CHAMPION

The world's largest dry cargo vessel to date was delivered in January 2018. Designated a specially constructed or fitted cargo ship, she will be able to carry ore with a high moisture content. DNV GL accompanied the complex project, helping incorporate several class notations into the design.

On a sunny morning in January 2018, *Yuan He Hai*, the first vessel of the second 400,000 dwt ore carrier series chartered by Vale, was delivered to China Ore Shipping, a subsidiary of China COSCO shipping, by Shanghai Waigaoqiao Shipyard (SWS). The festive naming ceremony was attended by the Vice President of COSCO Shipping, Huang Xiao Wen, the Vice President of CSSC, Nan Da Qing, the President of SWS, Sheng Ji Gang, and 80 other VIP guests, site project team members and DNV GL representatives.

During the naming ceremony, SWS President Sheng Ji Gang expressed his sincere appreciation to DNV GL: "Your professional work has made it possible for us to maintain a high quality level and deliver this complex vessel three months ahead of schedule. Without your strong support, we could not have achieved this great success!"

Class notations demonstrate future-readiness

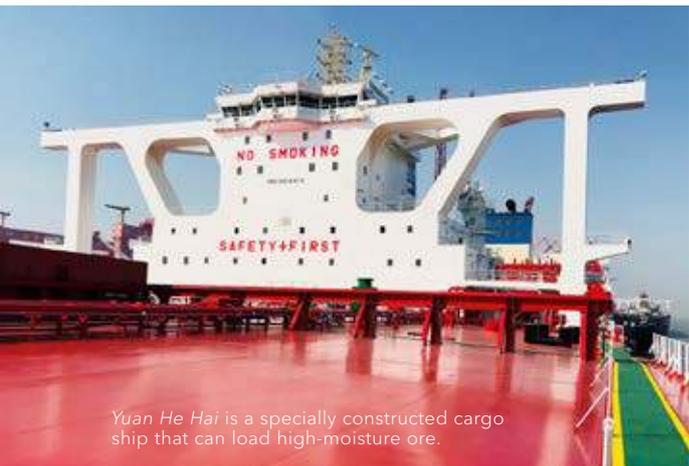
SWS is one of the most advanced and efficient shipyards in China, and *Yuan He Hai* is currently the world's largest dry cargo ship.

Based on the experience gained with the first generation of Vale's very large ore carriers (VLOCs), the hull structure was optimized and many new notations were added for the second generation of these ships, such as "Clean", "HMON", "Gas ready", "Shore power", in keeping with the motto "Safer, Smarter, Greener":

- Gas Ready:** The vessels are designed with the Gas Ready (D, MEc, S) notation, which indicates that they can be easily converted to operate on LNG fuel. The LNG-related design features comply with the requirements of the "Gas Fueled" notation, and the main engine can be converted to dual-fuel operation. A space located between the engine room and the aftmost cargo hold can accommodate an LNG tank. The relevant structural components are strengthened for future installation of a type B or membrane LNG tank.
- Liquefaction:** Iron ore fines with certain properties that are categorized as group A cargo may liquefy if the moisture content (MC) exceeds the transportable moisture limit (TML). By agreement between the charterer Vale and the owner, the design was developed as a specially constructed or fitted cargo ship pursuant to the IMO's IMSBC Code, featuring special arrangements that account for the particular stability requirements when carrying cargo with a moisture content above the TML.

The lettering on the bow shortly after being unveiled during the naming ceremony.





Yuan He Hai is a specially constructed cargo ship that can load high-moisture ore.



From left: Mao Zhen Yun, Project Manager; Chen Run Kun, Technical Director of China Ore Shipping; Boris Bondarenko, DNV GL Area Manager South China; Guo Xin, Senior Surveyor; Chen Keng, DNV GL Area Manager Singapore, Indonesia and Philippines; Kim Andersson, DNV GL Pudong NB & CMC Group Leader, accompanied by an actress from the yards performance group.

DNV GL acts on behalf of the shipyard in helping SWS fulfil its contractual obligations towards the owner and charterer. As this is the industry's first vessel designed with the stability features stipulated for the Liquefaction requirements, DNV GL approached the flag state to engage in a thorough discussion regarding the technical details and safety analysis. Both Singapore MPA and the Hong Kong Marine Department gave their approval.

- **Single pass loading:** The new VLOCs are designed for a higher loading rate (24,000 tonnes/h versus 16,000 tonnes/h for the previous VLOC generation) to make cargo loading more efficient and shorten loading times. Higher-capacity deballasting pumps make sure the deballasting rate matches the loading rate.
- **HMON:** *Yuan He Hai* and her sister vessel are equipped with a certified hull monitoring system, with sensors measuring hull girder loading and collecting data for decision support.

Implementing the requirements of these class notations was challenging for the designers and the yard since this was the first VLOC project of this size and complexity. "DNV GL places great emphasis on supporting customers extensively in projects involving highly sophisticated and unusual specifications", Boris Bondarenko, Area Manager South China points out. "In this project we took proactive measures from the beginning to facilitate the integration of all requirements into the design." Regular multi-party meetings were arranged to support the communication and collaboration of all involved partners. Workshops were led by experts from TCC to share relevant knowledge. A project steering

committee was set up to coordinate activities and allocate resources internally. Bondarenko further underlines: "With the joint efforts of all project members, we could overcome all challenges successfully."

Ready for the sister vessel

DNV GL's expert team in China not only helped maintain a very smooth and efficient communication channel with the flag state but also supported the shipowner's staff in familiarizing themselves with flag requirements prior to preparing registration and filling all documents. The outstanding cross-regional teamwork laid down a firm foundation for timely delivery and left a very positive impression with the customer. "Without the strong support from DNV GL we would not have been able to finish the registration in such a short time," says Zhang Fu Guang, President of China Ore Shipping.

Now that the first part of the project has been completed successfully, the project team is determined to deliver the second Vale VLOC to China Ore Shipping with the same high quality and in the same customer-centric manner so as to achieve unequivocal customer satisfaction. ■ KA



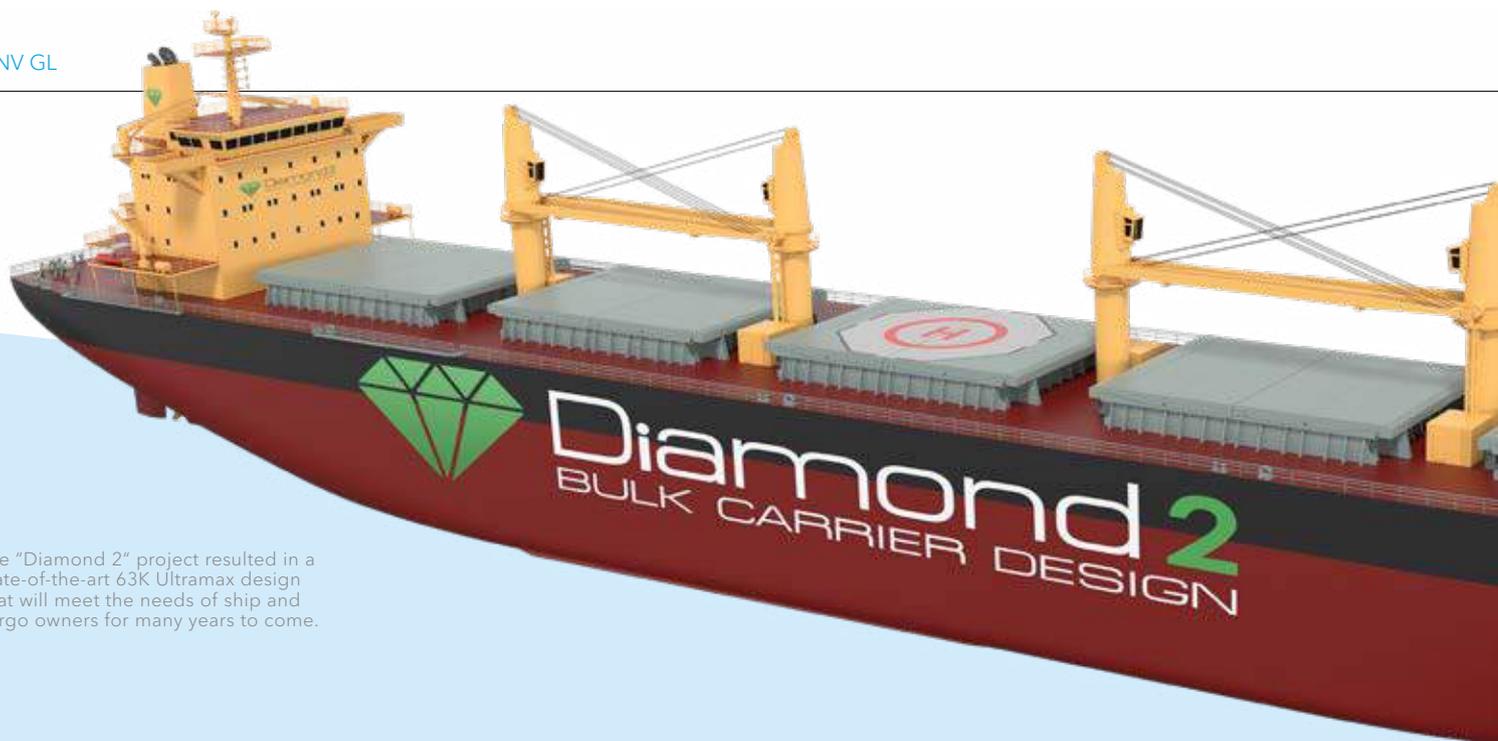
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MAIN PARTICULARS OF YUAN HE HAI

- | | | |
|---|----------------------------|--|
| ■ DNV GL ID number: 36239 | NAUTICUS (Newbuilding) | ■ Flag: Singapore |
| ■ Yard hull number: H1438 | OPP-F Shore power TMON | ■ Complement: 30 persons |
| ■ Class notation: *1A1 | ■ Length overall: ~362 m | ■ Main engine: MAN B&W 7G80ME-C9.5 TII |
| Ore carrier BIS BWM(T, E(s)) | ■ Breadth: 65 m | ■ SMCR: 24200 kW @ 58 RPM |
| Clean COAT-PSPC(B) | ■ Depth: 30.4 m | ■ Speed: 15 knots |
| CSA(2) E0 EL(2) ESP | ■ Summer draught: 23 m | ■ Delivery: 11/01/2018 |
| Gas ready(D, MEC, S) | ■ Gross tonnage: 203,403 t | |
| HMON(A1, C1, E1, G4, O1, S1, W1) IB-3 NAU(OC) | ■ Net tonnage: 66,606 t | |
| | ■ Deadweight: 398,595 t | |



Yuan He Hai is the world's largest dry cargo carrier.



The "Diamond 2" project resulted in a state-of-the-art 63K Ultramax design that will meet the needs of ship and cargo owners for many years to come.

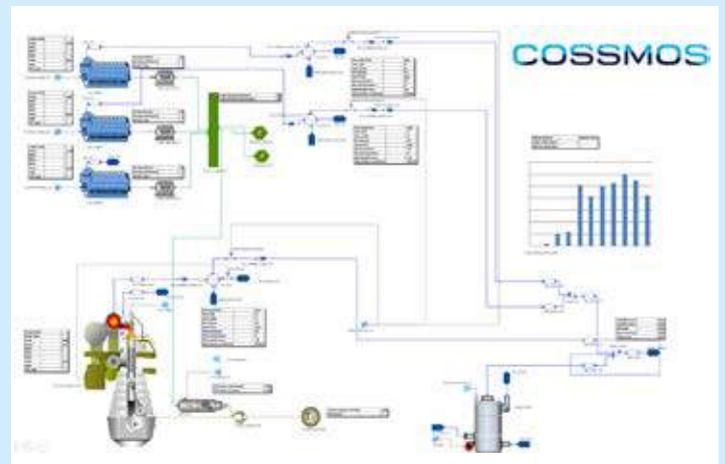
REINVENTING ULTRAMAX

As the dry bulk segment slowly emerges from its decade-long crisis, its fleet is in need of rejuvenation to meet new economic and ecological requirements. Continuing a long-standing partnership, the Graig Shipping Group and DNV GL have joined forces to develop the next generation of Ultramax bulk carriers.

In early 2017 Hugh Williams, Chairman and CEO of the Graig Shipping Group, and Andrew Westwood, Senior Vice President, Business Development Region South East Asia, Pacific & India at DNV GL - Maritime, met to brainstorm a new project. The two men were no strangers, having worked together on the development of the Diamond 53 bulk carrier design around the turn of the millennium, meeting the needs of the time for stronger, safer vessels. This had resulted in a highly successful project which shifted safety standards up and resulted in 110 Diamonds and Diamond derivative units being delivered from 2002 onwards. What followed was the financial crisis and a collapse in the bulk market, which brought newbuilding activities to a virtual halt and prompted the family-owned Welsh shipping company to focus on other initiatives.

Assessing market needs

Sensing the signs of recovery in early 2017 Hugh Williams and Chris Williams, Graig's Commercial Director, concluded that the time seemed appropriate to revisit what had been a highly successful Graig/DNV GL partnership. Graig thus approached DNV GL to discuss the prospects for a new generation of ships designed for today's market expectations, this time around with a main focus on fuel efficiency and utilizing cutting-edge technology. After all, most of the fleet currently in service was not designed to comply with the new and future environmental and efficiency standards, despite the dry bulk segment being under pressure from stakeholders to modernize ships and comply with



DNV GL's COSSMOS fine-tuned the machinery ecosystem to ensure excellent fuel efficiency.

a host of new regulations. "There is a gap in the dry bulk market for quality, fuel-efficient, competitively priced and environmentally friendly dry bulk ships to service the needs of end users," said Hugh Williams. So the Graig leadership team sat down with Andrew Westwood to assess what the industry really needed and how those needs could best be met.

They began by gathering all the requirements and standards that needed to be addressed, and spoke extensively with cargo owners and operators about their needs and how to future-



"There is a gap in the dry bulk market for quality, fuel-efficient, competitively priced and environmentally friendly dry bulk ships."

Hugh Williams, Chairman and CEO, Graig Shipping Group

proof the design they were envisioning. The proven Diamond 53 design served as a basis for the project they called "Diamond 2".

"One need not look further than the recent IMO meetings held in London to see that the rate of change is accelerating with respect to environmental requirements, in particular emissions. It is thus becoming essential that new designs are pitched at a high level if they are to retain value and be attractive in future markets. This can be viewed as both an opportunity and a threat. With the merger of DNV and GL we have been able to pool world-class maritime technology leaders and this project brings the focus on the real workhorses of the bulk industry. With more demanding cargo owners, who face pressure from shareholders, and the strong likelihood of increased and early scrapping, we see a strong market need for new cutting-edge technology to facilitate such a step forward. We are thus excited to once again be involved with Graig in this new 'Diamond 2' design," said Andrew Westwood.

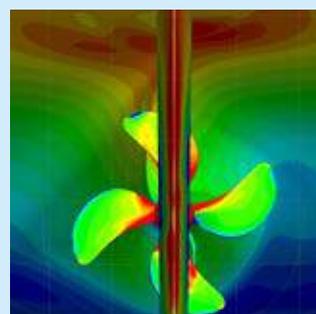
For this initiative to work, it was also essential to identify and work closely with designers with proven competence and experience in working with Chinese yards. In that regard Dr Zhao Ye and his team at Econovo Marine Engineering Co., one of the leading designers for bulk carriers, came with very strong credentials, including being responsible for the very successful Crown 63 Ultramax design (in excess of 80 vessels built), and as such a

wealth of experience in working with many well-known top-ranking yards in China. The result of this teamwork was the development of a sophisticated yet robust 63,200 dwt Ultramax dry bulk carrier, the "Diamond 2 63K".

Since the design was finalized, Graig has lead talks with all major dry cargo end users and the feedback has been very positive, with time charter offers for long-term periods.

The best of technologies

The "Diamond 2" Ultramax design aspires to become the class-leading ship of its type, focusing on operational efficiency and flexibility, low fuel consumption and compliance with all present and future environmental standards. It takes advantage of state-of-the-art hull optimization, ballast water management and easily installed exhaust gas cleaning technology. By DNV GL's formal hull optimization service ECO Lines the hull lines were extensively refined using leading-edge computational fluid dynamics (CFD) simulation technology, parametric modelling and systematic optimization for well-researched operating profiles. The design avoids using appendages, instead featuring an asymmetric stern, a high-efficiency propeller and a rudder with a vortex-reducing bulb. The vertical bow design improves performance across a wide range of weather conditions. Graig expects the efficiency enhancements to result in a fuel consumption of 14.6 tonnes >



CFD simulation was used to optimize the hull form, including the asymmetric aft section.



“With more demanding cargo owners, we see a strong market need to bring cutting-edge technology to facilitate such a step forward.”

Andrew Westwood, Senior Vice President, Business Development Region South East Asia, Pacific & India

> per day at an optimized speed of twelve knots. DNV GL’s Build2Design service will ensure close adherence to the design specifications in resistance-critical areas during hull construction.

The vessel will be equipped with a highly fuel-efficient, reliable MAN main engine. Sophisticated software was used to optimize the auxiliary machinery and all on-board power-dependent systems to provide maximum efficiency with minimum fuel consumption. To reduce the load on the generator sets, the designers opted for low-consumption, low-maintenance LED lighting as well as frequency-controlled seawater cooling pumps and engine room fans. Waste heat recovered from two auxiliary engines and an exhaust gas economizer are used to power a section of the boiler. DNV GL’s COSSMOS machinery modelling tool was used to assess and improve the integrated system of the vessel.

The vessel will be fully scrubber-ready so owners can choose between installing or retrofitting a scrubber system or operating on low-sulphur fuel to comply with SECA and in-port emission restrictions. The main and auxiliary engines are NO_x Tier III-compliant. The Energy Efficiency Design Index (EEDI) can meet Phase 3 requirements, which are 30 per cent below the IMO reference line for bulk carriers.

Ballast water management is handled using an IMO-approved treatment plant which conforms to the strict requirements of the United States Coast Guard. Advanced measuring and data capturing equipment will be installed on board to supply a constant

stream of data for comprehensive performance and efficiency monitoring and controlling, a key feature highlighted by cargo owners during the project development phase.

Tomorrow’s Ultramax

The ship’s five cargo holds provide plenty of loading flexibility and are designed to facilitate efficient cleaning. The tank tops are strong enough to carry heavy cargoes. The double-skin, hydraulic folding-type hatch covers are double-sealed to protect cargo such as grains from seawater ingress. Four on-board 35-tonne cargo cranes with efficient, pollution-free electric winches allow the vessel to perform loading and unloading operations without shore assistance. For crew security, the steering gear room doubles as a citadel in the event of a pirate attack. On-board noise and vibration emission levels are kept low to enhance crew comfort, and the accommodation is MLC2006-compliant.

Graig plans to expand the “Diamond 2” platform to include larger-sized vessels, including mini-Capesize ships. A number of delivery slots have been reserved with selected yards in China, and newbuilding deals with several owners and operators are currently being negotiated. Newbuilding supervision and post-delivery technical management will be provided by the Graig collaboration partner V.Group in Shanghai. “This advanced ‘Diamond 2’ family of designs responds to the industry’s needs,” emphasizes Hugh Williams. “We expect this design to be the first of several series of larger-capacity, future-proof vessels, backed by the strength of the ‘Diamond 2’ consortium. We have been able to draw on circa 25 years’ experience working in China and next year the group will celebrate 100 years since its founding.” The first “Diamond 2” vessels are expected to be delivered in 2019. ■ AK



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THE FUEL CHALLENGE IN SHIPPING

Choosing the most effective, sustainable and economically feasible strategy to comply with the new emission limits is not an easy task. The decision must be based in part on assumptions that may or may not prove to have merit. BULK CARRIER UPDATE summarizes the options and prospects.

Amid the international environmental and climate-protection efforts, an impressive number of emission restrictions for shipping have come into force recently or will do so within the next few years. They are driving the search for low-emission alternatives to oil-based fuels. In particular, the decision of the International Maritime Organization (IMO) to limit the sulphur content of ship fuel from 1 January 2020 to 0.5 per cent worldwide, and the recently adopted ambition to reduce GHG emissions by 50 per cent within 2050 have the potential to become game changers and have ship-owners, operators and shipbuilders wondering which way to go.

Currently up to 48 million tonnes of fuel with a sulphur content of 0.1 per cent or less will be then needed annually. Once the IMO sulphur cap is in force, most of the fuel consumed (70 to 88 per cent) will have a low sulphur content of 0.1 to 0.5 per cent and will take the role of the high-sulphur fuel used today. In 2016 an installed base of roughly 4,000 scrubber systems by 2020 was assumed, with no more than eleven per cent of the fuel consumed globally being high-sulphur fuel (HFO). Latest estimates assume only 1,000 to 2,000 scrubber installations, which leads to a high-sulphur fuel consumption well below 10 per cent in 2020. This raises the question whether HFO will be available in many ports due to low demand, and if so, at what price. To support the Port State Control and flag states with the enforcement the IMO at MEPC 72 agreed to establish

a ban on carriage of non-compliant fuels for all ships without scrubbers. This ban is likely to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Open-loop or closed-loop scrubbers?

Many owners decide for a hybrid option that provides the flexibility to operate in both open- and closed-loop mode. When at sea the switch can be made to open-loop using only seawater. The sulphur oxides in the exhaust react with the water to form sulphuric acid. Chemicals are not required since the natural alkalinity of seawater neutralizes the acid. When required to switch to closed-loop, for instance whilst entering a port in a low alkalinity area, the natural alkalinity of seawater is boosted by an alkali which uses caustic soda (NaOH) as a buffer.

Open-loop scrubbers are the second preferred option in the market as they comply with the IMO's 2020 regulations regarding SO_x emissions while being simpler, cheaper and quicker to install and as such requiring less time off-hire. >

Scrubbers are an option to meet the new emission limits.





ESL Shipping's new bulk carriers *Haaga* (left) and *Viikki* are the world's first LNG-powered Handysize bulk carriers.

The e4ships project focuses on fuel cell technology to improve the on-board energy infrastructure and the ecological footprint of shipping.

> An open-loop scrubber has less equipment for a crew to monitor and maintain. The shipowner also does not have to worry about the purchase of sodium hydroxide (caustic soda) or, more crucially, waste disposal in port.

New low-sulphur fuels

New, low-sulphur-compliant blended fuels (0.5% S) will be available in the market in 2020. It is expected that a varying range of products will be available in different parts of the world, depending on local refinery technology and crude oil quality. These fuels may prove to have different compositions than currently available HFO, hence predicting their compatibility with other fuel batches may be a challenge. It is expected that precautions with regards to fuel storage and mixing will be necessary. The ISO 8217 Fuel Standard working group is currently putting effort into selecting testing methods for fuel stability and compatibility. A draft standard should be available in autumn 2019, with the updated standard publication expected in 2022. First samples of blended fuels are expected to become available later this year, and this will allow all stakeholders to gain experience in using them.

These are some of the practical challenges resulting from sulphur reduction. At the same time the accelerating world-wide trend towards restricting NO_x, CO₂ and particle emissions is

reason enough to intensify the search for fuels and technologies that can help meet the challenges ahead.

Feasible alternative options

Among the alternative ship fuels being discussed to substitute conventional fuels, DNV GL has identified LNG, LPG, methanol, biofuels and hydrogen as the most promising options.

The world's first LNG-powered Handysize bulk carriers from ESL shipping will be delivered in spring 2018. They are built to comply with DNV GL Clean Design class notation. Contrary to many other LNG-powered vessels, its MAN B&W auxiliary engines and Alfa Laval Aalborg boiler will use LNG as well.

As DNV GL's PERFECT ship concept study has demonstrated, the well-known combined cycle gas and steam turbine technology might be a viable solution for ships in the power range above 30 megawatts once low-sulphur fuels are widely in use. Other new technologies with reasonable potential for application in certain ship types include battery systems, fuel cell systems and wind-assisted propulsion. The biggest hurdles for other alternative ship fuels and propulsion technologies are unrelated to whatever it takes to apply current engine and gas turbine technology. In conjunction with the low-emission fuels named above they are

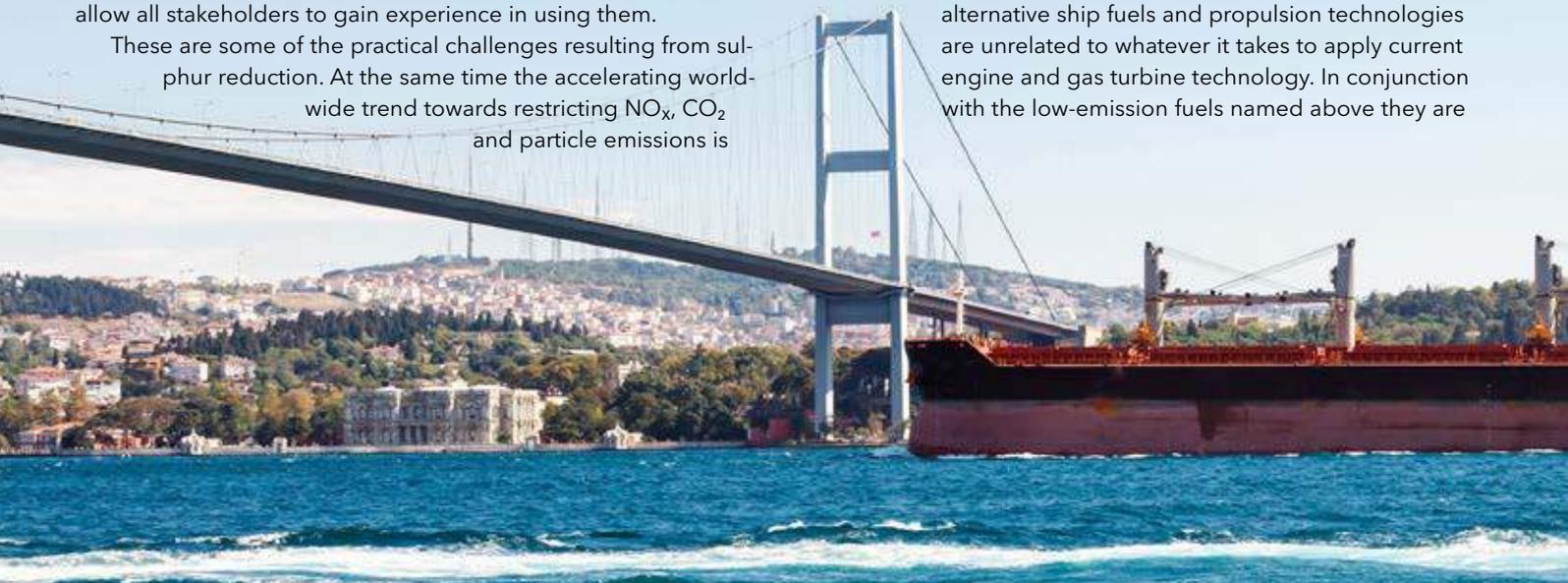
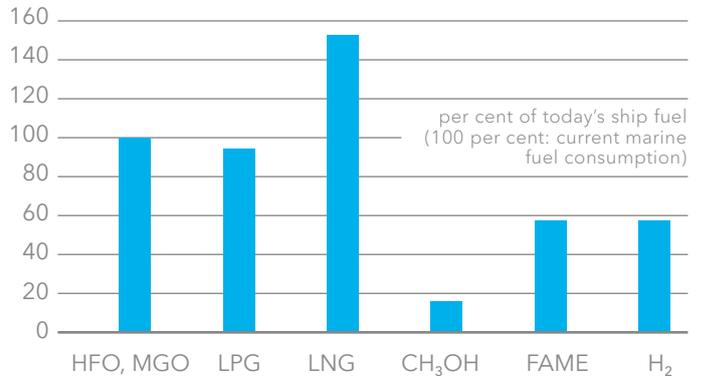




FIGURE 1: ANNUAL PRODUCTION OF ALTERNATIVE FUELS COMPARED TO CURRENT MARINE FUEL CONSUMPTION (2016)
relative energy content

All fuel alternatives can meet possible shipping requirements for the next ten years when a small growth in shipping applications is assumed. If the market share of any ship fuel except LNG increases rapidly, its production capacity will have to be increased accordingly.



readily available or can be developed without substantial effort. Fuel cell technology in combination with various fuels can achieve efficiencies equal to or better than those of current propulsion systems. However, fuel cell applications for ships are still in their infancy. The most advanced developments are those related to the DNV GL-supported e4ships lighthouse project in Germany, with Meyer Werft and Thyssen Krupp Marine Systems leading the initiatives for seagoing vessels. Wind-assisted propulsion likewise has a certain potential to reduce fuel consumption, especially on slow ships, but the business case remains challenging.

Batteries used for energy storage, while not a primary energy source, have major potential for ships running on short distances, or as supplementary energy sources on board any ship if used to increase the efficiency of the propulsion system. In deep-sea shipping, current battery technology cannot substitute liquid or gaseous fuels.

Where to go from here

The primary challenges associated with alternative fuels in shipping result from environmental considerations, availability of sufficient fuel quantities, fuel costs, and the rules of the IGF Code. Environmental and price challenges continue to drive the interest in alternative ship fuels, but the number of realistic candidates

remains small. After LNG has overcome the hurdles of international legislation, methanol and biofuels will follow suit very soon; the development of rules for LPG and hydrogen within the scope of the IMO IGF Code will take considerably longer. Yet, the foreseeable volume requirements for shipping could in principle be met by all fuel alternatives mentioned above over the coming years. But a major rise in demand would without doubt require massive investments in production capacity, except LNG, which can also be available in higher quantities than the currently forecasted demand (comp. Fig. 1 for production capacities. Note that LNG includes an increase in production until 2020).

Without government action in the form of tax breaks or subsidies, renewable fuels will find it difficult to compete with the prices of conventional fossil fuels. LNG and LPG are the only fossil fuels capable of achieving a reasonable CO₂ reduction in the next five to ten years. "CO₂-neutral" shipping seems possible only with fuels produced from renewable sources. If the shipping sector resorts to synthetic fuels produced from hydrogen and CO₂ using renewable energy, the available alternatives will be liquefied methane (which is very similar to LNG) and diesel-like fuels. ■ GW/CC

Download the complete guidance paper on alternative fuels at: dnvgl.com/alternative-fuel



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COMPOSITES SAVE WEIGHT AND ENERGY

In their open-hatch general cargo carrier JDP announced early last year, the Japanese shipbuilder Oshima and DNV GL are using strong, lightweight materials in innovative ways to increase energy-efficiency.

As the dry bulk sector recovers from its prolonged downturn, shipowners are seeking more economical, innovative and versatile solutions. A report in the 2017 issue of Bulk Carrier Update presented a joint development project (JDP) between Oshima Shipbuilding and DNV GL, a frequent partner, for a new, highly efficient 65,000 dwt open-hatch general cargo carrier concept. One of the key features of this concept is the use of lightweight composite materials for the tween decks.

Flexibility is a critical requirement of the open-hatch carrier segment and there is a growing tendency for vessels to carry various different cargoes during a single voyage. In the early stages of the JDP, Oshima had interviewed some of the leading players in this market to gain insight into the owners' particular demands for cargo carrying and loading capabilities, as well as their fleet profiles and typical trading patterns.

The 210-metre length design is characterized by a large cubic (77,000 m³) and deadweight capacity (65,000 tonnes) but with a comparatively shallow draught (13.1 metres) thanks to its wider breadth. It is equipped with eight box-shaped cargo holds with full-width hatch openings of both the "piggyback" (six holds) and folding types (two holds). The vessel has been further optimized for project cargoes with the inclusion of two longer cargo holds. Four of the holds can be fitted with tween decks to allow for segregating different cargoes. Because of the vessel's wide breadth and the hull's double sides and bottom it would not need to use the holds to carry water in heavy ballast conditions.

The new vessel concept draws heavily from the Oshima ECO-Ship 2020, a 2011 JDP between Oshima and DNV (prior to its merger with GL). The ready-to-order design gives shipowners the option of installing a number of innovations, such as battery-assisted hybridized cranes and an optimized main engine with a PTO/PTI (power take-out/power take-in) shaft generator.

Composite technology

Perhaps most notable though is the use of composite materials; whereas the ECO-Ship 2020 included composite hatch covers, the new design

extends their use to the tween decks. While the laminate lay-up composite uses similar raw materials to those found in the hatch covers of the ECO-Ship 2020, the solutions for some of the details are very different.

Made from glass-fibre-reinforced plastic (GFRP), prototypes of the tween decks solution were developed in partnership with Japan's I-Know Machinery and Norway-headquartered solutions provider Compocean, with manufacturing taking place at Compocean's Latvian plant. However, for production this task will need to be undertaken at a specialist workshop in Asia, within easy access of the shipyard or near a port where the ship can berth to pick up and install the tween decks.

From a shipbuilding perspective the use of composites is really no different from that of any other material used in ship construction: "Manufacturing outside the shipyard is not a particular challenge, given that most components in shipbuilding are manufactured outside the shipyard. There are also plenty of composites manufacturers in the world. The tween decks are designed to be installed (and moved/mobilized) by the ship's own cranes. When not in use the tween decks are stored on container sockets or on a dedicated support point. When mobilized for use, they are supported by dedicated support brackets in the cargo holds."

Aside from the material engineering there are essentially no additional considerations: "Composite material engineering allows for designing and optimizing the material easily, for instance a given structure in function of a load case. Raw materials (fibre, resin), laminate design, failure modes, composite material final properties as produced by manufacturer, quality assurance and quality control of the fabrication process are important features



Tween decks, two elongated cargo hatches, and various alternative options make this design highly flexible.

of composite material engineering, and hence also important aspects reviewed under an approval."

The tween-deck solution for one short cargo hold comprises two identical panels; each is constructed of a single skin composite, with the top plate connected to the corrugations, which are in turn fixated to end plates. Retractable brackets welded to the hold's transverse bulkheads support the panel ends.

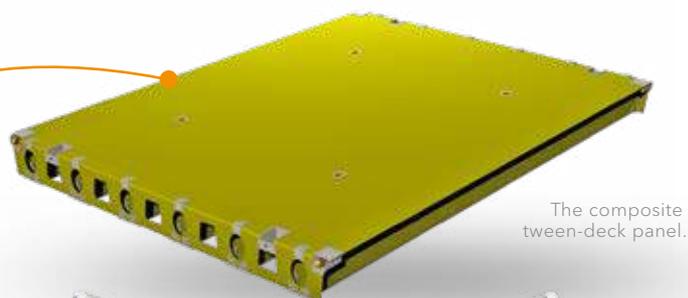
Raw materials for composites (glass fibre and resin) are typically more expensive per kilogram compared to steel. However, Oshima says that the production process (for its structural design) is also much more efficient compared to steel tween decks.

Oshima adds that the final tween deck is comparable in cost with its steel equivalent due to a significant weight reduction compared to its steel equivalent (around 40 to 50 per cent). Moreover, because conventional steel tween decks are smaller, more units are needed than in the composite solution, which also cuts down on installation time when in port.

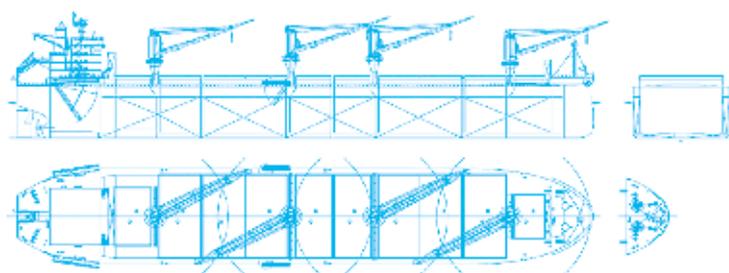
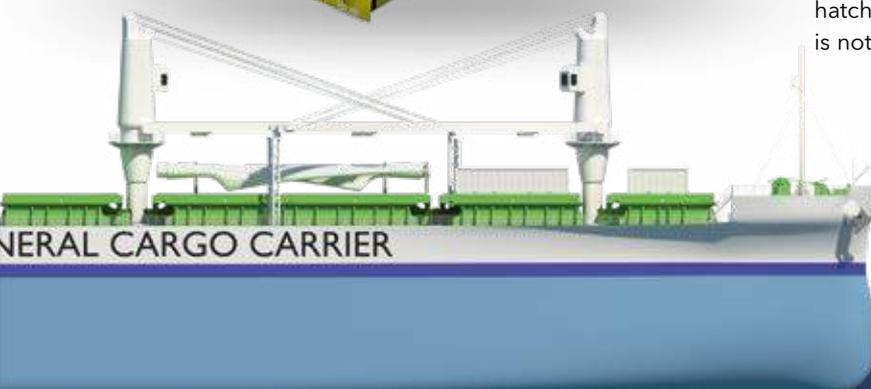
Oshima estimates that fuel savings of 0.25 per cent are achievable with four composite tween decks, but adds: "For the owner, the possibility to load more cargo is the largest contribution to the payback of the investment. There is also a saving in maintenance and reduced time in port due to shorter installation time, but the value of this has not yet been quantified."

DNV GL believes that recent progress at a regulatory level is helping to boost confidence among shipowners that composite materials can be a safe and economic solution. "The interest among shipowners but also well-known shipyards is increasing in our opinion. Recent advances at the IMO level on new guidelines for composite components (MSC.1/Circ.1574 on Interim guidelines for use of fibre reinforced plastic elements within ship structures: Fire safety issues) and the popularity of the ELASS network

Photos: DNV GL, Oshima Shipbuilding



The composite tween-deck panel.



The design features eight cargo holds and four deck cranes.

(the European network for lightweight applications at sea: e-lass.eu) are just two examples."

Batteries, engines and fuel

The overall efficiency savings must, of course, be viewed in the context of the vessel concept's other innovations. An optimal-size battery pack partially substitutes for the auxiliary engines and compensates for fluctuations in power demand. A DNV GL feasibility study concluded that the battery pack could allow a 20 per cent saving in crane operation fuel costs, with an estimated payback of six to nine years, while cutting engine running hours by 50 per cent. Overall, the vessel is 55 per cent below the EEDI reference line for cargo ships.

A study of comparable open-hatched cargo vessels with typical load profiles indicated fuel savings of up to 10 per cent in operating an optimized main engine with a PTO/PTI shaft generator, in addition to a significant drop in maintenance costs. The base design is equipped with a six-cylinder, two-stroke MAN Tier III engine configured to run on low-sulphur fuel oil (LSFO). There is also the low-sulphur super eco fuel, a mixture of light cycle oil (LCO), gas-to-liquid (GTL) and water which can be run without the use of EGR or SCR systems that Oshima has developed in partnership with the industry. Alternatively, owners will have the option of an engine operating on HFO and scrubbers.

Oshima Shipbuilding is confident that while the dry sector has experienced a lean few years, there remains a high level of interest and trading scope for mixed cargo carriers. "The demand predictions for newbuilds are readily available from companies specializing in market studies," says the shipbuilder. "However, composite tween decks are available for retrofit on existing open-hatch bulk carriers. Hence, the market for composite tween decks is not limited to the newbuilding market." ■



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TOWARDS ZERO EMISSIONS: ENVIRONMENTAL OUTLOOK

While the world is struggling to live up to its commitment to limit climate emissions, new data indicate that climate change may be more severe and occur more rapidly than anticipated earlier. The IMO is looking for ways to make shipping climate-neutral over the next decades. DNV GL gives an overview of the status of the discussion and potential future measures.

When the Paris Agreement was adopted in 2015 in response to the increasing signs of global climate change, shipping and aviation were not included. Instead, the IMO and ICAO were asked to come up with greenhouse gas (GHG) emission reduction schemes of their own. At MEPC 72 the IMO has now adopted a strategy to reduce emissions from shipping. This aims to reduce total emissions from shipping by at least 50 per cent by 2050, and to reduce the average carbon intensity by at least 40 per cent by 2030 while aiming for 70 per cent in 2050, all figures compared to 2008. The ultimate vision of the IMO is to phase out greenhouse gas emissions entirely at the earliest time possible within this century. This initial strategy will be reviewed in 2023 based on

information gathered from the IMO Data Collection System (DCS) as well as a fourth IMO GHG study to be undertaken in 2019.

As it must be assumed that the global shipping activity will continue to grow towards 2050, the 50 per cent emission reduction target is quite ambitious and will most likely require widespread uptake of zero-carbon fuels in addition to other energy efficiency measures. However, there are no zero-carbon fuels available today. A concerted research and development effort is needed not only to develop such fuels but also to make them available in the required volumes.

To implement its ambitious strategy the IMO must develop new policy measures and regulations. The strategy contains a long list of options, such as

The IMO is looking for strategies to eliminate greenhouse gas emissions from ships by 2100.

strengthening the EEDI, applying operational indicators, reducing speeds, rolling out market-based measures, or developing zero-carbon fuels. Work on an action plan to kick-start the development of appropriate measures will start this fall.

While limited immediate impact on ships is to be expected, the efforts required to reach the long-term goals will have to build over the coming years, with a real impact starting to materialize in the 2020s. In a long-term perspective, DNV GL expects this strategy to fundamentally change the way ships are designed and operated.

More information on low-carbon shipping and alternative fuels is available at www.dnvgl.com/low-carbon-shipping and www.dnvgl.com/alternative-fuel

CO₂ data collection in the EU and at the IMO

In the EU, regulations for monitoring, reporting and verification (MRV) of CO₂ emissions have entered into force, requiring all ships above 5,000 GT sailing to or from European ports to report CO₂ emissions, cargo data and average energy efficiency. 2018 is the first year of reporting, with data being published annually by the EU as of mid-2019.

One purpose behind the EU MRV regulations was to encourage the IMO to work on a similar mechanism with global coverage. The EU regulation itself contains a provision for a review aimed at alignment with a future international system, if in place. It is therefore significant that the IMO has adopted a global mechanism for mandatory monitoring, reporting and verification of fuel consumption data for all ships 5,000 GT and above. The scheme, known as the IMO Data Collection System (DCS) on fuel consumption, will have 2019 as its first year of operation.

The IMO DCS differs from the EU MRV in several important aspects, including the confidentiality of data, the calculation of efficiency metrics, and the requirements for data verification. While these are all issues where the EU has a strong preference for the requirements of its own system, the European Commission has nevertheless initiated a formal review process aimed at aligning the EU MRV with the IMO DCS. There are encouraging signs of a legislative proposal to be published in May 2018, though it is expected to be challenging and likely time-consuming for the commission, the parliament and the council to come to an agreement. DNV GL believes that full alignment is unlikely, and that the industry may have to cater to both reporting regimes for the foreseeable future (see article on page 22).

More information on EU MRV and IMO DCS is available at www.dnvgl.com/mrv and www.dnvgl.com/dcs

SO_x regulations

IMO has agreed that the 0.5% global sulphur cap will be implemented from 1 January 2020. The decision is final and will not be subject to renegotiation, which gives certainty to the maritime and bunker industries. There were intense discussions on both the practicalities of implementation and on how to ensure robust enforcement and a level playing field. IMO is continuing to discuss implementation and supporting measures on a priority basis and is holding an intersessional meeting dedicated to the topic

The EU's CO₂ monitoring, reporting and verification (MRV) scheme is in effect as of 2018.

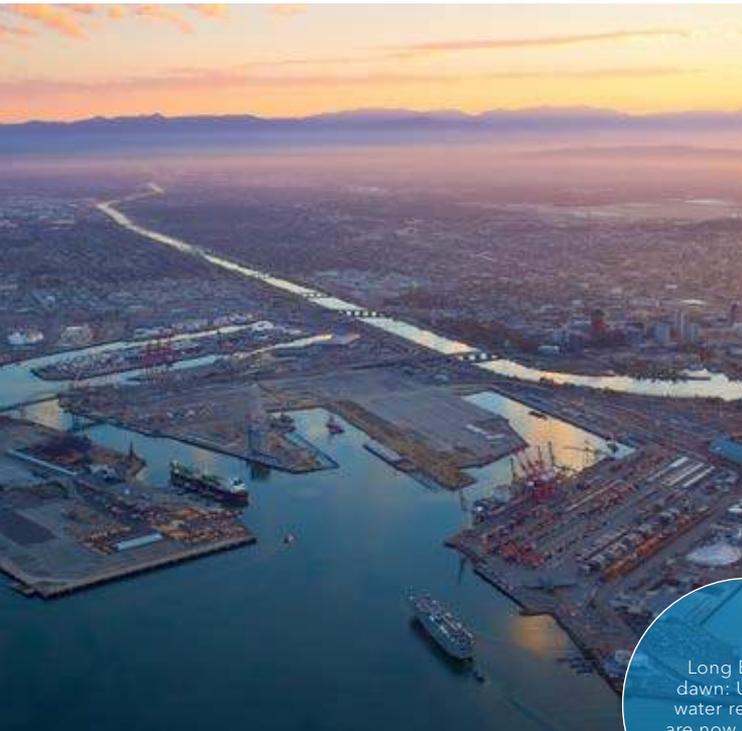


in July. The meeting is expected to provide robust guidelines for industry and authorities; these will be finalized at MEPC 73 in October and then circulated.

Ship operators will have to choose their preferred compliance strategy, a decision with far-reaching operational and financial implications. There is no one-size-fits-all solution on the table; scrubbers, LNG, and "hybrid" fuels are all realistic options, but most vessels are expected to default to using 0.5% marine gas oil (MGO) and blends, at least initially. Local availability issues and price volatility are expected to result from the dramatic change of the fuel demand situation as of 1 January 2020, and the number of non-compliance cases, especially because of insufficient tank cleaning at bunker facilities and on board ships, is likely to be rather high during a transitional period.

Enforcement remains a critical concern, especially on the high seas. Contrary to emission control areas (ECAs), where enforcement is up to the respective port state, monitoring of operations on the high seas is the responsibility of the flag state. Legitimate questions are being asked about the readiness of all flag states to provide uniform and robust enforcement to ensure a level playing field around the globe. To alleviate the enforcement issue to some extent, the IMO at MEPC 72 agreed to establish a ban on carriage of non-compliant fuels for all ships without scrubbers. This ban is likely to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Moving to regional and domestic matters, it should be noted that in the EU the Water Framework Directive is imposing restrictions on the discharge of scrubber water. Belgium and



Long Beach at dawn: US ballast water regulations are now being fully enforced.

> Germany have prohibited the discharge of scrubber water in most areas, thereby limiting the operability of open-loop scrubbers. Similar restrictions apply in some US coastal waters, e.g. off Connecticut.

In Asia China's regulations for domestic SECA-like requirements are being rolled out in the sea areas outside Hong Kong/ Guangzhou and Shanghai as well as in the Bohai Sea. China is taking a staged approach, initially requiring a 0.5% maximum sulphur content in fuel burned in key ports in these areas, gradually expanding the coverage to finally apply fully to all fuels used in these sea areas from 2019 onwards. Conceivably the allowable sulphur content will be tightened to 0.1% by 2020, and China may eventually submit a formal ECA application to the IMO. In our view there is a real possibility of these zones being extended to include further Chinese sea areas.

More information is available at dnvgl.com/maritime/publications/global-sulphur-cap-2020.html

NO_x regulations

The NO_x tier III requirements have entered into force in the North American ECAs for ships constructed on or after 1 January 2016. Anyone constructing a ship today needs to consider whether operation in the North American ECAs will be part of the operational pattern, whether upon delivery or at any time in the future. If so, NO_x control technology will be required on board. When choosing an NO_x control technology operators should consider how they intend to ensure compliance with the 2020 sulphur cap to avoid system integration issues.

With respect to upcoming regulations, IMO has agreed to apply NO_x Tier III requirements to ships constructed on or after 1 January 2021 when operating in the North Sea and Baltic Sea

ECAs. There are presently no indications of plans for additional NO_x Tier III areas.

Ballast water management

The Ballast Water Management (BWM) Convention entered into force on 8 September 2017, more than 27 years after the start of negotiations, and 13 years after its adoption in 2004. The implementation schedules was revised at MEPC 71 in July 2017. Briefly put, every ship in international trade will be obliged to comply at some point between 8 September 2017 and 8 September 2024. For ships from 400 GT upwards, the compliance date is linked to the renewal of the International Oil Pollution Prevention certificate, while ships below 400 GT must comply by 8 September 2024. By that date the entire world fleet must be in compliance.

In the US, the domestic ballast water management regulations entered into force in 2013. New ships must comply upon delivery, while existing ships must comply by the first scheduled dry-docking after 1 January 2014 or 2016, depending on ballast water capacity. USCG type approval is required for ballast water treatment systems; six such approvals have been granted so far, with eleven more in the approval pipeline. The USCG's previously liberal extension policy granting deferred installation dates to more than 12,500 ships due to the unavailability of approved systems has changed since the first type approvals were issued. Presently the USCG is very restrictive on granting extensions and this policy is likely to tighten further. In practical terms, operators should now plan their installation dates based on the compliance dates in the regulation and not gamble on receiving an extension.

For more information on ballast water-related topics please visit dnvgl.com/bwm

Emerging issues

There are a number of new environmental regulations under consideration at the IMO as well as in various countries. They cover a broad range of topics, such as plastic pollution from ships, the impact of noise on cetaceans, particle emissions, hull biofouling, and a ban on heavy fuel oil in the Arctic. The discussions are at various stages; New Zealand, for example, has introduced biofouling regulations in May this year. The noise issue is primarily a concern of a few isolated stakeholders, while plastics and an Arctic HFO ban are under consideration at the IMO. Nevertheless, most if not all of these topics are likely to be the subject of further domestic or international regulations sooner or later during the next decade. ■ EN



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WHEN BULK CARGO BECOMES LIQUID

The IMO's IMSBC Code addresses the safety threats resulting from cargo liquefaction on board bulk and ore carriers. A new DNV GL class notation defines appropriate stability and hull strength requirements for specialized ships.

Transporting large quantities of bulk cargo can be a tricky affair: depending on its physical properties, granularity and water content, the material may change its behaviour under the influence of ship movements and vibration and adopt the properties of a liquid. This means that it will develop the so-called free-surface effect and begins to move similar to a liquid in response to the vessel's attitude, which can cause the ship to lose stability and capsize. Between 2005 and 2015, cargo shifting and liquefaction caused eleven fatal ship accidents with 102 human lives lost at sea. Cargoes that are especially affected by this phenomenon include iron ore fines, nickel ore and bauxite, when the water content exceeds the transportable moisture limit (TML).

Another challenge associated with liquefied cargo is the hull strength. The weight of the compacted cargo can put extreme pressure loads on the sides of the cargo hold that can exceed the yield strength of the structure.

Containing the free-surface effect

The IMO addresses these issues in its International Maritime Solid Bulk Cargoes (IMSBC) Code which became mandatory in 2011. It requires cargoes with a moisture content above the TML to be carried on board specially constructed cargo ships (SCCS) that are to be approved by flag administrations. DNV GL's new class notation BCLIQ, published in January 2018 and due to enter into force on 1 July 2018, interprets the IMSBC Code and specifies stability and strength requirements for these ships. It is mandatory for SCCS Ships but may also be applied on a voluntary basis



Ship movements and vibration can cause ore (left) with a high moisture content to liquefy and slosh inside the hold, compromising the ship's stability.

to any other bulk or ore carrier. It has already been confirmed by major flag states that the set of requirements in the class notation complies with the IMSBC Code.

The BCLIQ notation confirms that the vessel is built to minimize the free-surface effect, for example by featuring wide wing tanks and reinforced structural focus areas on the cargo hold side walls, and is consequently able to carry cargoes with a moisture content exceeding the TML.

The notation confirms compliance with the SCCS requirements of the IMSBC Code and enhances the ship's loading flexibility, efficiency and safety. There are two versions of the class notation: BCLIQ(Cat1) and BCLIQ(Cat2), distinguishing between cargoes that resettle in a stable condition after becoming liquefied, such as iron ore fines, and those that stay liquefied, including nickel ore, bauxite fines and similar materials. The latter are subject to stricter requirements. ■ AK



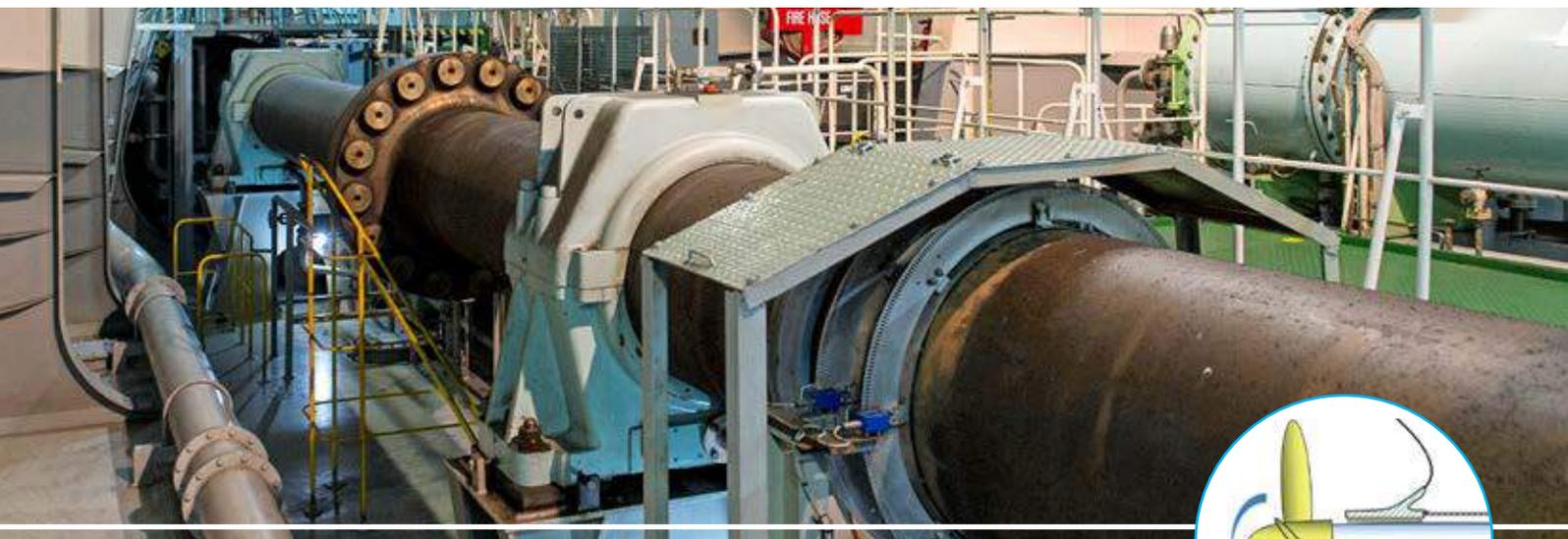
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Some bulk cargoes can absorb significant amounts of water, which changes their flow properties.

DNV GL TACKLES SHAFT BEARING CHALLENGES



DNV GL has revised the main class rules for single stern tube bearing installations and now offers new optional shaft alignment class notations.

In the wake of a reported upsurge in stern tube bearing failures, DNV GL has revised main class rules for single shaft bearing installations and introduced two optional shaft alignment class notations: Shaft align(1) and Shaft align(2). The revised rules for single-bearing installations, included in Part 4, Chapter 2, Section 4 of the DNV GL Rules, mitigate the impact of potential influencing factors behind the failures, while a recently announced joint research project into environmentally acceptable lubricants (EALs) will investigate the performance of biodegradable lubricants compared to traditionally used mineral oils.

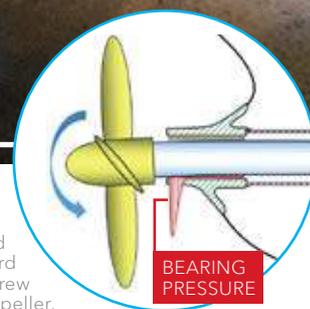
Both notations can be assigned to newbuilds as well as vessels in operation (in conjunction with a propeller shaft withdrawal). Design and in-service follow-up rules for the notations are included in DNV GL's January 2018 rules for ships, Part 6, Chapter 2, Section 10, and Part 7, Chapter 1, Section 6 (38) respectively.

DNV GL observes keen interest from the industry in the new class notations and is currently engaged in many live projects.

Reliability challenge

Oddvar Deinboll, head of the machinery approval section, DNV GL, explains: "The industry has faced challenges with some of the more recent single stern tube bearing installations with respect to the reliability of the propeller shaft bearings. Extreme turns in the upper speed range have been observed as one of the predominant scenarios in which many of the failures have been reported."

Downward bending moment induced during a starboard turn on a single-screw right-handed propeller.



Most of the reported damages have been observed on the aft-most part of the aft bearing and were accompanied by high bearing temperatures with an abrupt rate of rise. Expensive and time-consuming repairs were the consequences.

"We hope that ships complying with the revised main class rules for single bearing installations and Shaft Align(1) or (2) will have substantially reduced risk for stern tube bearing failure. Hence DNV GL will meet the industry needs for more reliable stern tube bearing installations," Deinboll adds.

Monaco-based Scorpio Shipping, a frontrunner with DNV GL in many evolving trends in classification, is the first operator to opt for the Shaft align(1) notation. Dean Mihalic, Technical Director at Scorpio, notes: "We are looking forward to deriving early benefits from this DNV GL class notation by being the first to bring it to the market. Our immediate plan is to use it on an 82,000 dwt bulk carrier being built under DNV GL class."

DNV GL is currently the only classification society requiring verification of the hydrodynamic lubrication of the aft bearing in continuous operation. Larger propellers with lower rpm in combination with hydrodynamic propeller loads make it challenging to maintain an effective shaft-to-bearing contact area and keep the aft bearing well lubricated, DNV GL's internal research has shown. This realization has benefitted many applications and helped resolve issues in ships both in and out of class.

Extra focus

The new rules put additional focus on the impact of transient hydrodynamic propeller forces and moments on the aft-most propeller shaft bearing during turns, specifically at hard-over steering angles at maximum continuous rated (MCR) speed.

The Shaft Align class notations and revised requirements for single stern tube bearing installations call for a multi-sloped aft bearing design. This is supplemented by an additional evaluation of the aft bearing lubrication under an increased propeller-induced hydrodynamic downward bending moment on the aft bearing (corresponding to 30 per cent of MCR torque).

The requirements are formulated to improve bearing performance during turning conditions. The additional design and installation criteria will also increase operating margins and enhance bearing performance and lifetime under normal continuous running conditions.

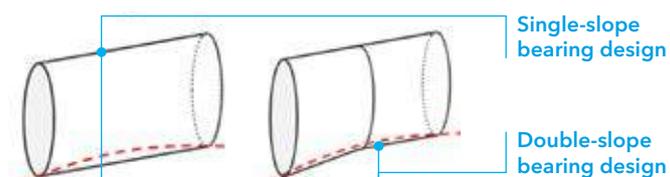
Shaft align(1) is a cost-effective option for vessels with conventional hull forms, improving aft bearing performance in normal operation and in turns. Shaft align(2) is intended for propulsion systems requiring additional calculations to predict hydrodynamic propeller loads during extreme turning conditions, typically on vessels with unconventional hull forms such as asymmetric sterns or twin-skeg configurations.

The main benefits of the notations include prescriptive design criteria beyond generic class requirements; increased operating margins for continuous and transient (turning) operation; potentially more accurate installation by enhanced sighting methods (laser-aided or equivalent); and the owner's benefit of having an additional notation in the vessel's certificate.

Bearing interaction

This shaft alignment philosophy aims to achieve an acceptable load distribution on shaft bearings while accounting for the hydrodynamic loads induced by the running propeller. The propeller weight as well as hydrodynamic forces and bending moments influence the angular misalignment of the shaft inside the aft bearing (relative slope) and, subsequently, the shaft-to-bearing contact area. The hydrodynamic lubrication - the formation of an adequate oil film - is mainly influenced by rpm, the shaft diameter, the oil viscosity, the net effective shaft-to-aft bearing contact area, and the bearing load and clearance.

The aft bearing design geometry must ensure a satisfactory shaft-to-bearing contact area in relevant operating conditions.



Multi-sloped bearing improves the contact area: the coloured plot reflects the extent of the gap between the shaft and the bearing.

This will also mitigate extreme localized loads (edge loading), the surface pressure on the aft bearing and associated thermal loads.

The most predominant hydrodynamic propeller loads are typically caused by continuous ahead operation under hydrodynamic lubrication conditions (typically a lifting bending moment induced by the propeller) or extreme transient manoeuvre (typically, hard over turning at MCR speeds with exaggerated hydrodynamic propeller loads acting downwards on a reduced area of the aft bearing).

Transient extreme turning conditions at the maximum speed can lead to mixed or boundary lubrication condition, which is not calculated under the main class criteria but is deemed satisfactory based on experience, provided that the installation complies with the applicable rule criteria for continuous running and incorporates the relevant range of bending moments.

A hot static starting condition, i.e. starting the prime mover to the minimum continuous propeller shaft speed, is also of interest with respect to hydrodynamic lubrication under the relevant rule criteria.

"A multi-sloped bearing design helps better optimize the shaft-to-bearing contact area in all operating conditions with regard to hydrodynamically induced propeller loads," observes Arun Sethumadhavan, Senior Principal Engineer, fleet in service for hull, materials and machinery, DNV GL. In the case of a single-sloped bearing, improving the contact area for one operating condition may reduce the contact area in another operating condition.

CFD calculations and finite element analysis - Shaft align(2)

On some installations, such as vessels with asymmetric sterns and twin skegs, propeller water inflow conditions during a turning manoeuvre may be altered beyond what is normally seen on more conventional designs. For such vessels there is a risk of excessive propeller loads and an empirical approach to stern tube bearing performance assessment may be insufficient. Rather, an additional evaluation of hydrodynamically induced bending moments and forces from the propeller on the aft stern tube bearing is mandatory for the Shaft align(2) class notation. Similar requirements may also apply upon evaluation under main class criteria.

Based on DNV GL's experience, this evaluation is essential to ensure satisfactory shaft-and-bearing interaction during extreme turning conditions at maximum speed. Computational fluid dynamic (CFD) propeller load calculations combined with finite element analysis (FEA) of aft bearing contact pressure/area are best suited to support aft bearing evaluation and design.

CFD predicts the bending moments and forces induced by the propeller during continuous straight-forward operation and under hard-over MCR turning conditions as input to the aft bearing contact area and contact pressure estimation. A class guideline, CG-0283, will be published in 2018 to provide easy reference on the expected process and results in this regard. ■

Edited version of an article originally published in The Motorship.



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MRV AND DCS: ON TRACK FOR GREENER SHIPPING

Monitoring fuel consumption and CO₂ emissions is the first step towards significantly reducing greenhouse gas emissions from ships. DNV GL helps shipowners and operators comply with new EU and IMO requirements for energy efficiency management.

Just a few days before the landmark International Maritime Organization (IMO) London conference, the chances of an agreement to control shipping's greenhouse gas (GHG) emissions looked unlikely. But then, ironically on Friday 13 April, the members of the Maritime Environment Protection Committee (MEPC) reached a consensus: by 2050 shipping would cut its GHG emissions by at least 50 per cent from 2008 levels. This was the first time emission targets were set for global ocean shipping.

Commercial shipping is getting greener. Both the EU and the IMO are committed to reducing noxious maritime emissions. However, to get a reliable data basis about climate-affecting exhaust gases, a legally binding framework must be established to collect and evaluate relevant information. To that end the EU, and shortly thereafter the IMO, implemented two similar albeit separate regimes: the EU's Monitoring, Reporting and Verification (MRV) of CO₂ Emissions regulation ((EU) 2015/757), and the IMO's Data collecting system on fuel consumption of ships (DCS).

Streamlined reporting service

The primary goal of both regulatory frameworks is to monitor maritime fuel consumption and CO₂ emissions. The aggregated information may eventually be used to cut emissions through a fee scheme, such as emission certificate trading. The EU MRV focuses on ships entering or leaving European ports, whereas the IMO system covers emissions from global shipping.

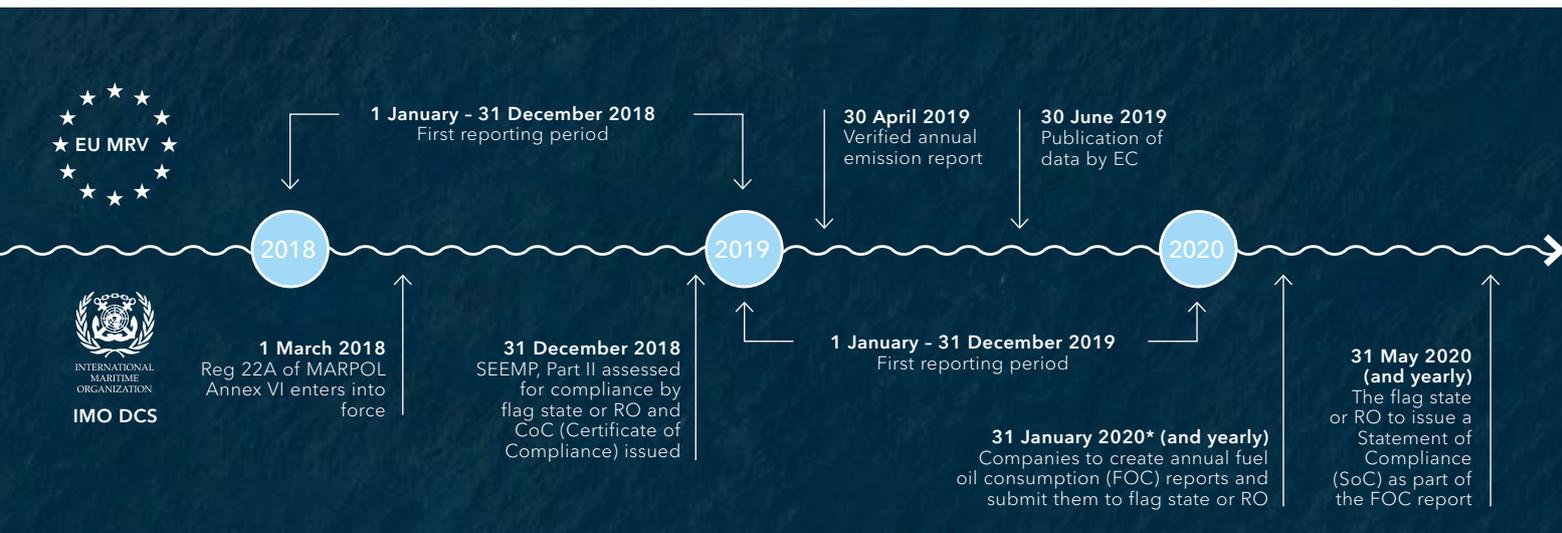
Implementing these regulations is technically complex. DNV GL stands ready to support owners and operators as a reliable and competent partner in both roles: as an accredited verifier for the EU MRV system or as a Recognized Organization (RO) authorized to verify compliance with the IMO DCS on behalf of several flag states. As Sven Dudzus, Head of Section EU Product Certification at DNV GL - Maritime, points out, "DNV GL offers its verification

DNV GL SUPPORTS ITS CUSTOMERS BY:

- **Combining verification** of MRV and DCS - same verifier makes sense
- **Digital reporting** to minimize efforts for the ship operator
- **Providing online tools to:**
 - generate the SEEMP, Part II
 - continuously verify the completeness of reported data
- **A dedicated interface manager** to support implementation of effective reporting
- **Providing reporting formats** to cover the necessary information for verification
- **Minimizing the need for site visits** and requests for more information
- **Offering a flexible and cost-efficient solution** to ensure compliance with IMO DCS at all times - or EU MRV if applicable (depends on trading patterns; but DCS always applies)

Find out more at:
www.dnvgl.com/maritime/imo-dcs





service independently from a ship's classification society to make the process as smooth as possible. For practical purposes we recommend using the same verifier for EU MRV and IMO DCS. If a customer uses another class society for statutory certificates, the flag must accept that another RO is used for DCS."

In effect since 31 August of last year, the MRV regulation requires shipowners to submit a Monitoring Plan, a complete and transparent description of the method used to determine the CO₂ emissions of each vessel from 5,000 GT upwards, similar to the IMO scheme. "All in all some 10,000 ships with continuous EU trades are subject to the EU MRV," says Dudzus. DNV GL has prepared roughly 50 per cent of these documents to date. "This is a great mark of confidence on the part of our customers who benefit from the fact that we are the only verifier in the market to offer the plan review and the emission report for a specified time period as a single-package solution."

Ensuring data integrity

The first MRV reporting period started at the beginning of this year. The aggregated ship emission and efficiency data will be published by the EC every year, starting on 30 June 2019. The IMO DCS process will be launched in January 2019. By that time every ship must present proof of the applied method; the IMO stipulates an updated SEEMP, Part II. The RO or flag state will issue annual DCS statements of compliance to shipowners by 31 May.

DNV GL will provide an electronic reporting form through the My Services customer portal in Veracity. Customers can then submit the completed form to DNV GL for approval of SEEMP Part II. To minimize the effort involved in the reporting process for shipowners and operators, DNV GL covers both the EU MRV and the IMO DCS processes in one tool. Single-source data verification for both annual emission reports is the most common-sense approach, especially for vessels operating on both European and non-European global trades, or changing their region of deployment. Ships can use existing infrastructure on board to capture some of the required information, such as fuel consumption data which is routinely collected anyway.

Data plausibility is checked in a fully digitalized process, making sure the content and reporting parameters comply with the EU and IMO rules and requirements. Data integrity is of the essence. Since many performance and status data points cannot be read electronically but must be logged manually, errors can occur. DNV GL provides specialized tools to help customers check the information prior to transmission.

Defining an interface is all that needs to be done to enable transfer of the data. "We have appointed an Interface Manager who will assist customers in implementing an effective reporting system upon request," says Dudzus. The choice is between automated system-to-system data uploads or manual transmission of fuel consumption data. DNV GL customers subscribing to the ECO Insight service are already covered for their MRV and DCS reporting duties.

DNV GL recommends customers to report their data throughout the year instead of filing a cumulative report at year's end. This will allow DNV GL to perform continuous data quality checks so that by the end of the year all data have been screened for completeness and plausibility.

Operators can upload the annual emission report to the EMSA THETIS database stipulated by the EU, which will be verified by DNV GL. The DCS data will be uploaded to the IMO database either by DNV GL as a designated RO or by the flag state.

DNV GL verifies the data received, whether overall fuel consumption data, log abstracts or fuel balance details (e.g. bunker delivery notes), in an automated process, avoiding time-consuming visits at the ship manager's office for verification or physical documentation. "Our processes will be optimized continuously. Working closely with our customers we will provide the smartest solution in the market," says Dudzus. ■ PL

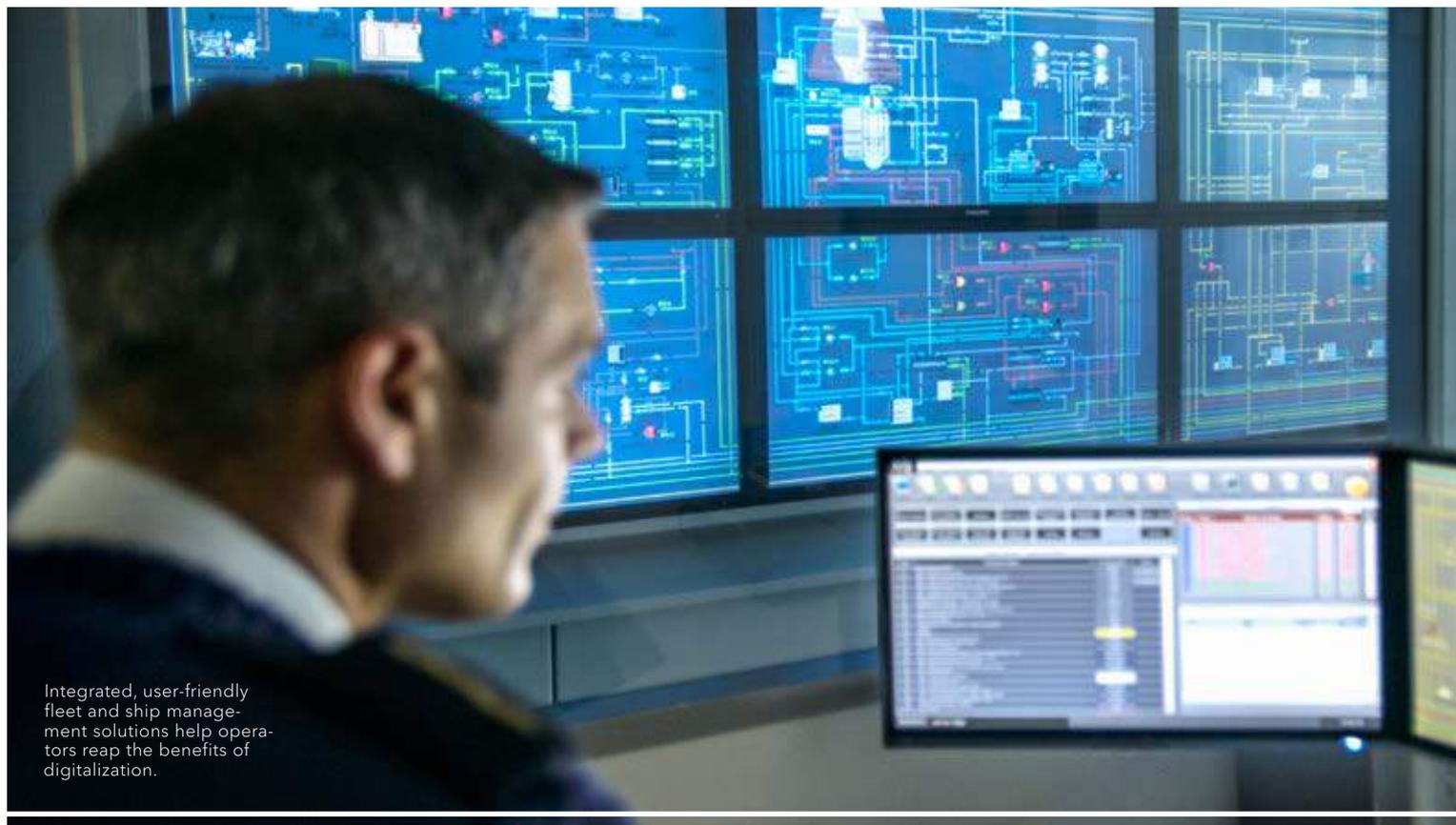


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Integrated, user-friendly fleet and ship management solutions help operators reap the benefits of digitalization.

MINSHIP SHIPMANAGEMENT BOOSTS DIGITALIZATION

MINSHIP Shipmanagement has chosen DNV GL's ShipManager fleet management software solution for its fleet of dry cargo vessels.

As shipowners and managers are under constant pressure to make operations leaner and more efficient, it is essential to get the most operational insight out of the ship management data. Data smart fleet management systems are needed to efficiently manage a modern fleet, whether this means a few or hundreds of vessels. A solution based on an integrated approach can provide the insight that is needed to gain efficiency, reduce operational expenditure (OPEX) and remain competitive in the maritime market.

MINSHIP Shipmanagement is optimizing their processes as they are managing a growing fleet. The currently managed MINSHIP fleet of Handy and Handymax vessels ranges from 30,000 to 38,000 dwt per vessel. The group is responsible for the management of a broad range of vessels owned and controlled by a wide variety of third-party shareholders from Europe, Asia and the Americas. Their services include full ship management, including the commercial, crewing and technical part. It also provides international freight forwarding services. Via affiliated companies the

group provides services in short-sea trade, tanker brokerage and the ship agency sector.

A key part of their optimization process involves the replacement of various separate systems and spreadsheets for ship management activities with a user-friendly and integrated fleet management solution.

User-friendly and data smart fleet management solutions

"Our future outlook focuses on becoming more digitalized," says MINSHIP Deputy Fleet Director Christian Altmann. "We are confident that the ShipManager solution will help to streamline our processes and standardize our data, which is especially important with our growing fleet. Our teams are working closely together, and we're running a well-organized implementation process," he says.

DNV GL's maritime solutions, ShipManager and Navigator, are in use worldwide on more than 6,200 vessels by nearly 300 customers. ShipManager, the fleet management system, covers technical management, procurement, hull integrity management,



Photos: DNV GL, Getty Images/Cultura RF, MINSHIP GmbH & Co. KG (www.minship.com)

dry docking, QHSE (quality, health, safety, environment), crewing and business intelligence. The MINSHIP implementation project includes modules for maintenance, procurement, QHSE, crewing, payroll and also services including database building and data migration.

Implementation support by DNV GL

A fleet management system implementation involves capturing and migrating data from many disparate sources, and it is crucial



DNV GL's comprehensive ship management solutions include data mining and analytics capabilities, create transparency and streamline processes.

INTEGRATED SOLUTIONS

The integrated ShipManager software includes a technical ship management system for planned and unplanned maintenance, defect reporting and technical asset and data management. The procurement system supports purchasing departments and allows them to streamline the complete scope of maritime procurement activities for all spares, services, stores and consumables and other items. Improved information management ensures that crew and office are working with the same information, and always know the status of requisitioned items. The ship safety management system supports compliance and helps to reduce the administrative burden of relevant shipping industry regulations, such as ISM/ ISPS, SOLAS, TMSA, classification rules, vetting inspections and Port State Control. The crewing solution supports the ship crew management process across the entire crew pool for optimal crew deployment, with all key data and reports accessible on board and ashore.

"We are confident that the ShipManager solution will help to streamline our processes and standardize our data, which is especially important with our growing fleet."

Christian Altmann, Deputy Fleet Director, MINSHIP Shipmanagement

to have access to domain expertise and best practices from previous implementations to secure the value of the data and to achieve a successful project. DNV GL supported MINSHIP during the implementation phase.

Ketil Aamnes, Regional Manager for Europe, Middle East and Africa, DNV GL - Digital Solutions, says, "We welcome MINSHIP to our growing user community and look forward to implementing ShipManager. With the digitalization of their fleet management, they can enhance transparency and streamline processes and operations. The trend in shipping is towards steadily increased focus on digitalization, where data mining and analytics improve performance and optimize operations."

"MINSHIP's tender process was prepared in an extremely professional way," says Sebastian Eggert, Principal Specialist, Ship Management & Operation, DNV GL - Digital Solutions. "Their sophisticated evaluation process took business processes and many aspects of the daily operation into consideration," he says. "Our customers are able to take advantage of a complete solution, improving efficiency in a competitive market, with immediate access to centralized data and operational insight," he adds. ■ RB



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After the record-low levels reached in 2016, expectations of a better dry bulk market rose in 2017. So far in 2018 the market has certainly improved and year-on-year earnings across all major segments grew significantly, with average bulk earnings 24 per cent higher in 1Q 2018 compared to 1Q 2017. Asset prices are also going up. The five-year-old second-hand ship price index reached a three-year high at the end of March, reflecting positive market sentiment. Earnings are expected to continue to rise this year as fleet growth is set to be the lowest in a decade. However, downside risks remain amid growing fears over a potential global trade war as well as concerns over China's future demand for raw materials.

Fundamentals improve but demand-side risk factors remain

The latest forecasts expect dry bulk shipping demand to grow by three per cent to 5.24 billion tonnes in 2018, which means it will outstrip the predicted two per cent supply growth, leading to an improved market balance. Apart from iron ore and grains, minor bulks from bauxite to cement and scrap are expected to contribute to healthy demand growth. Chinese iron ore imports are forecasted to grow strongly at around four per cent while grains trades are seen expanding by two per cent. Coal will probably see the lowest trade growth at just 1.6 per cent to 1.2 billion tonnes. Tariffs on steel and aluminium imports recently announced by the US administration are not expected to have a significant impact on minor bulk trade, although there are some

CLEAR SIGNS OF HOPE

Rising demand for raw materials and other dry bulk, increasing rates and earnings, and a sharp drop in scrapping activities are all positive signs the bulk sector has been waiting for. As the market normalizes, new risks of a trade war are emerging.

potential risks. Emerging restrictive trade policies are not good for the industry and a potential trade war could put the market on its knees, although such a scenario is unlikely, at least in the short term. In addition, China's deleveraging economy could potentially see more conservative investment decisions. This could have a direct impact on the nation's industrial activities and infrastructure growth as China would consume less industrial materials.

5.24 billion
tonnes

Expected dry bulk
shipping demand in
2018 - a growth by
three per cent.

12,482
USD/day

Panamax rates grew
by 38 per cent.

A return to stable and profitable freight earnings

The firm demand for dry bulk transport has given a substantial boost to earnings. Although the Capesize market is currently showing signs of seasonal weakness, earnings have increased by six per cent in 1Q 2018 compared to 1Q 2017 and stood at 14,284 US dollars (USD) per day at the end of April. Panamax rates grew by 38 per cent to an average of 12,482 USD/day in 1Q 2018 and the BDI during the first quarter of 2018 averaged 1,175 points which is 230 points above the previous year's figure.

Healthier rates have had an impact on second-hand prices which have increased by around 16 per cent over the last twelve months. A five-year-old 82,000 dwt Kamsarmax can be purchased for USD 23.5 million which is USD 6.5 million above the January 2017 price. A five-year-old Capesize bulk carrier currently sells for USD 34 million which is nine million US dollars more than at the beginning of last year.

Slow expansion of the dry bulk fleet

The limited contracting activity in recent years is expected to see the pace of deliveries slow and fleet growth to ease in 2018. The fleet is currently projected to expand by two per cent to 834 million dwt. Shipowners started to turn towards the newbuilding market again last year, where a total of 325 bulkers (37.5 million dwt) were ordered, compared to only 62 contracts in 2016. Kamsarmaxes and Ultramaxers were the most popular sizes with 126 and 68 ships contracted

respectively. 28 per cent of the total tonnage contracted came from 32 ore carrier orders. As of May 2018, 57 bulkers have been ordered including 16 Kamsarmaxes, 14 Newcastlemaxes and ten ore carriers.

In line with improving market conditions, scrapping slowed down last year, with 217 ships demolished at an average age of 24.5 years, representing a total of 14.6 million dwt. This is a major slowdown compared to 2016, when 408 ships were scrapped representing almost 30 million dwt.

Last but not least, the order book declined to less than 1,000 ships in 2017. A total of 723 bulkers are under construction today totalling 81.4 million dwt. This is equivalent to ten per cent of the total existing dry bulk tonnage.

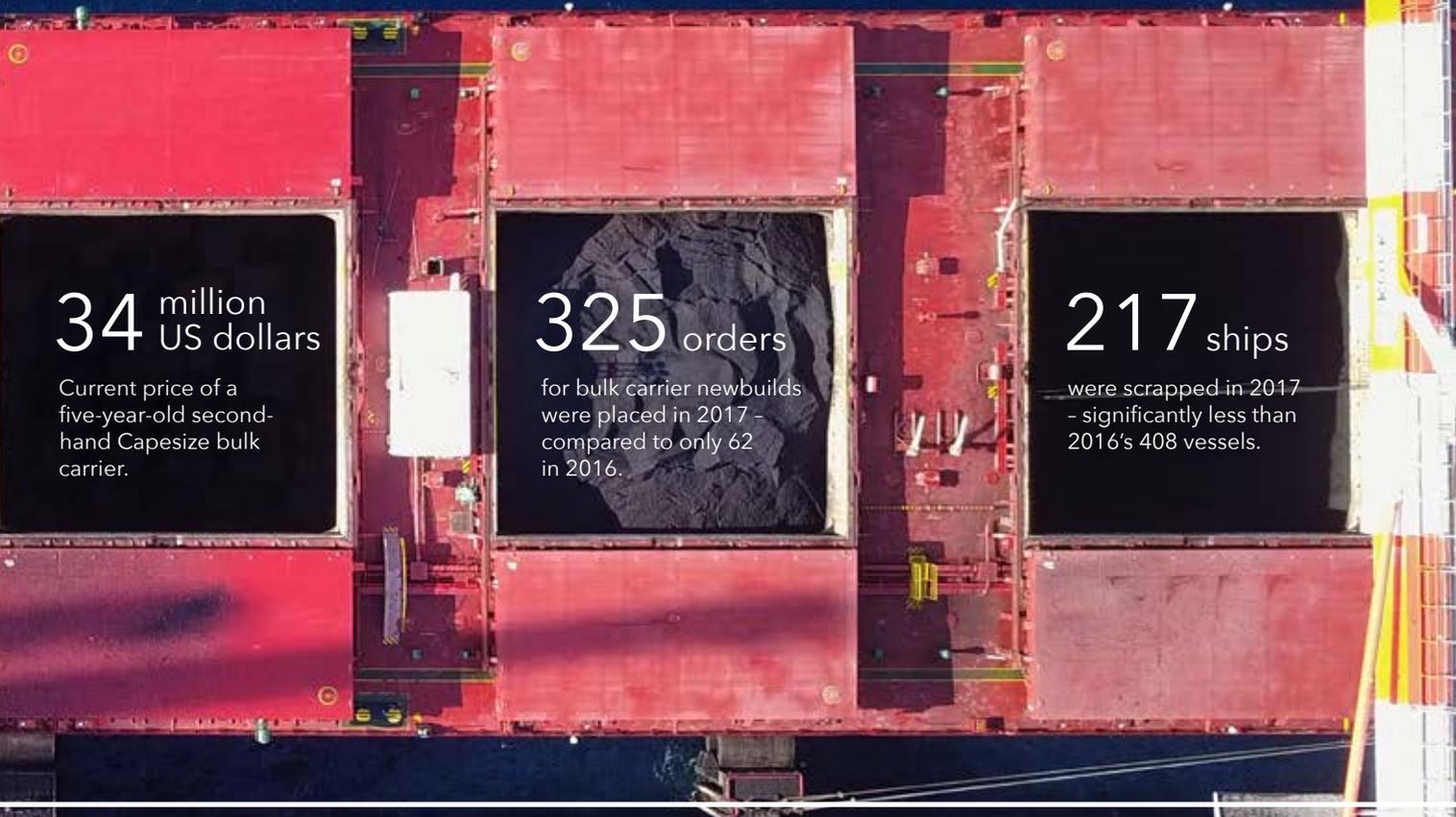
The overall sentiment has certainly improved and the outlook for this year as well as next year is generally positive. Nevertheless some risk factors should to be taken into consideration, such as global trade wars or China's deleveraging economy causing industrial material imports to drop. ■ PP



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Photo: DNV GL, yanhv - stock.adobe.com



34 million US dollars

Current price of a five-year-old second-hand Capesize bulk carrier.

325 orders

for bulk carrier newbuilds were placed in 2017 - compared to only 62 in 2016.

217 ships

were scrapped in 2017 - significantly less than 2016's 408 vessels.

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DNV GL is the world's leading classification society and a recognized advisor for the maritime industry. We enhance safety, quality, energy efficiency and environmental performance of the global shipping industry - across all vessel types and offshore structures. We invest heavily in research and development to find solutions, together with the industry, that address strategic, operational or regulatory challenges.

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