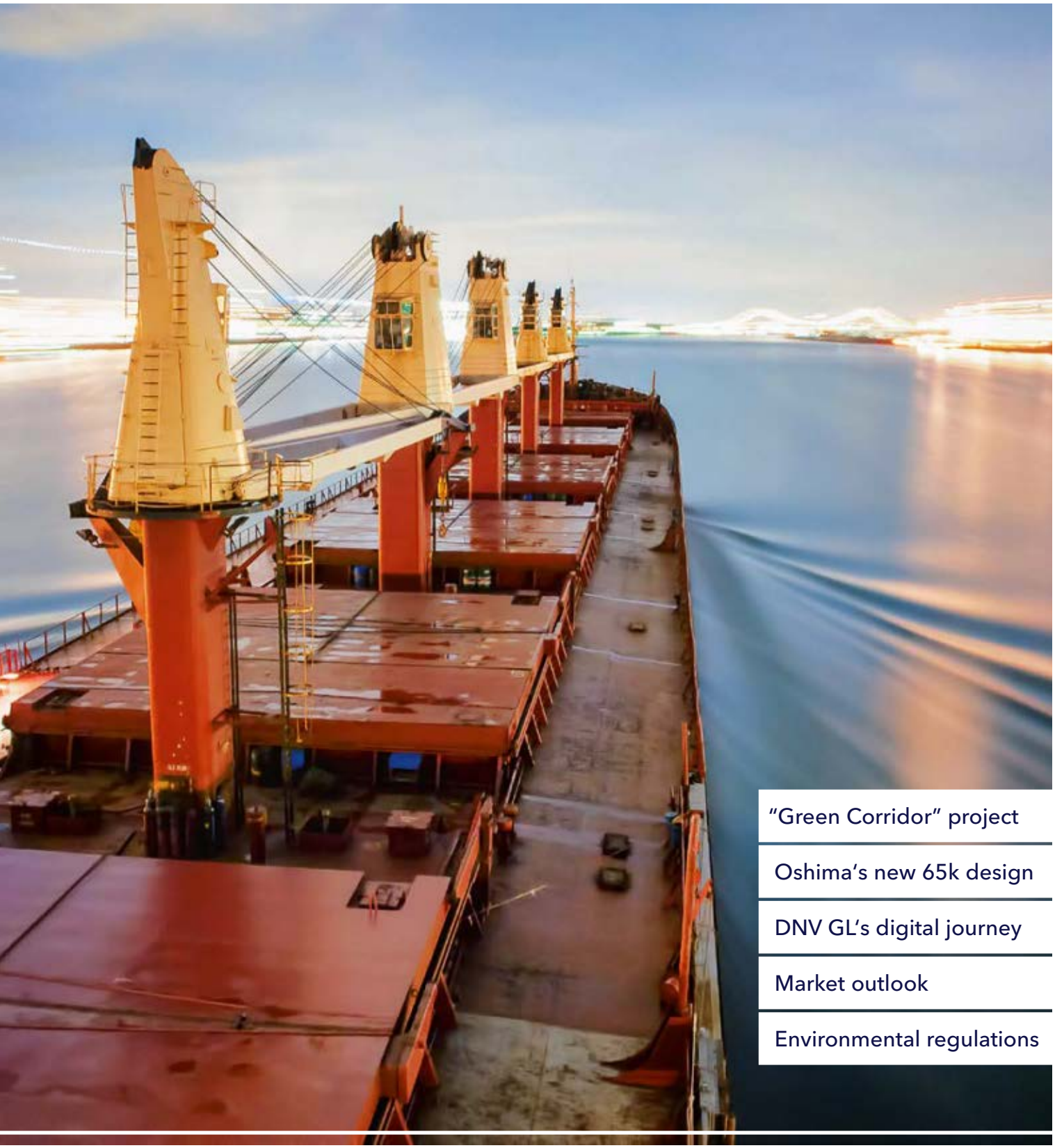
DNV·GL

BULK CARRIER UPDATE

2017



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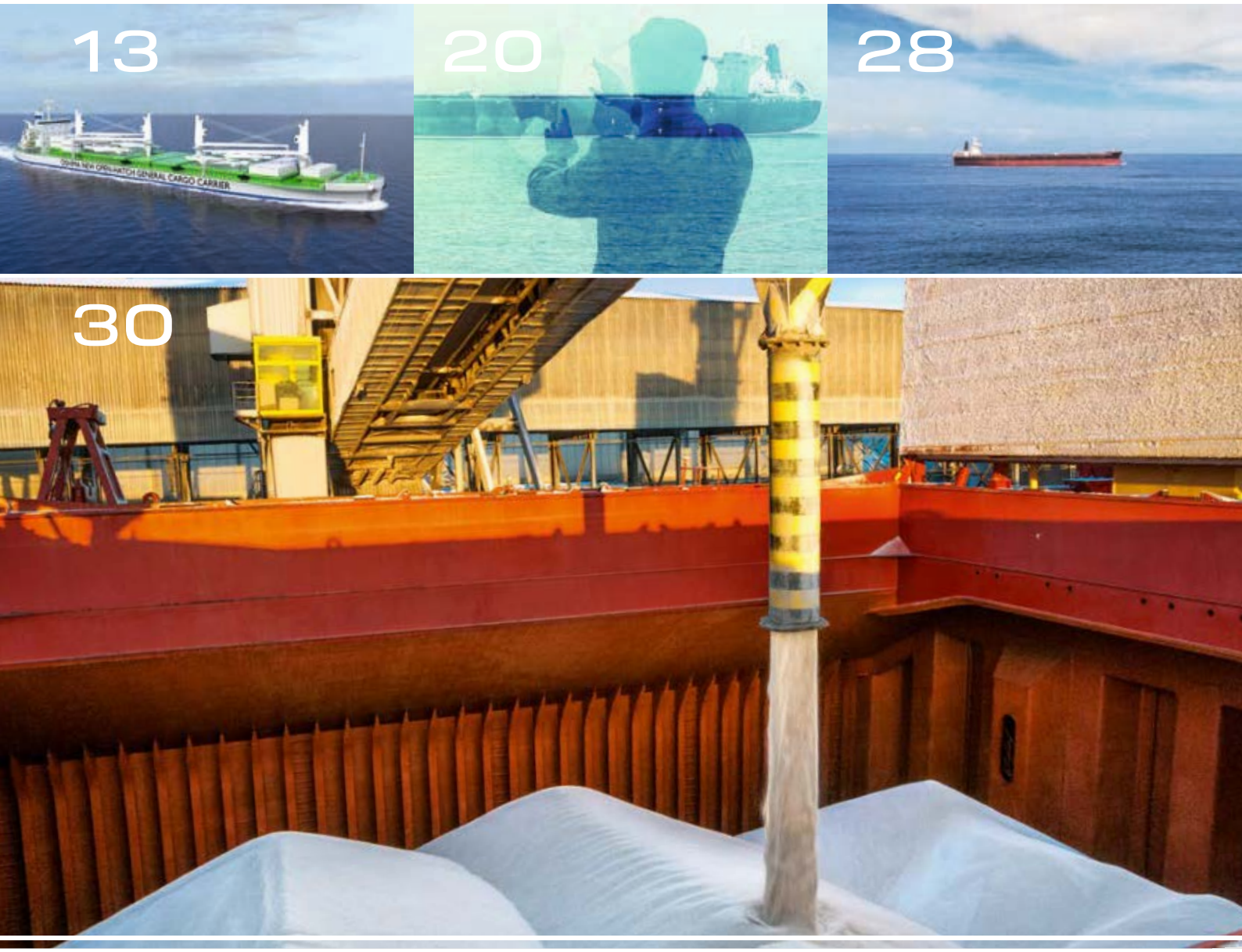

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DEAR READER,

It is a pleasure to welcome you to this new issue of BULK CARRIER UPDATE, which is published concurrently with the Nor-Shipping 2017 exhibition in Oslo, Norway. 2017 started significantly better than 2016 with respect to both freight rates and newbuilding activity. Prices for good, second-hand bulk carriers have increased significantly over the last six months and are now at a level only 20 to 30 per cent below the price of a newbuild. With several new environmental regulations demanding expensive equipment retrofits on board existing vessels, many shipowners have found it more attractive to order new vessels in recent months because the required equipment can be installed at a lower cost while the ship is being built.

To support the industry's efforts to comply with the new environmental regulations, DNV GL has participated in several joint industry projects (JIP) developing new designs that satisfy the expectations of higher energy efficiency (EEDI) while complying with the Ballast Water Convention as well as stricter SO_x and NO_x emission limits. I am pleased to present two of these JIPs in greater detail: the innovative Oshima open-hatch general cargo carrier, which amongst several innovations introduces composite tween decks, and the LNG-fuelled Green Dolphin Newcastlemax, developed by the "Green Corridor" project for the Australia-China trade.

I also recommend to you our articles evaluating some of the technologies that can be applied to ensure compliance with the new environmental regulations. Furthermore, this issue elaborates on innovative design features that help optimize the energy efficiency of newbuilds. Our piece on Berge Bulk, one of the major players in the iron ore trade, describes a new service offered by DNV GL to evaluate the effects of bow retrofits on fuel efficiency.

Our article about DNV GL's digital journey highlights the extensive transformation DNV GL is undergoing to redefine the way we work and interact with you, our customers. Read about digital certificates, machine learning tools and drone surveys as well as the launch of a new industry data platform called Veracity. For those of you who are planning to visit the Nor-Shipping 2017 fair in Oslo, I hope to see you there and have some good conversations with you during that week.

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!

BULK CARRIER UPDATE

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EFFICIENCY CHECK DELIVERS KEY INSIGHTS

Continuing a successful partnership of many years, the Singapore-based Berge Bulk and DNV GL Maritime Advisory conducted a study to evaluate the efficiency improvement potential of a bow retrofit on one of the world's largest ships, the 388k dwt VLOC *Berge Everest*.

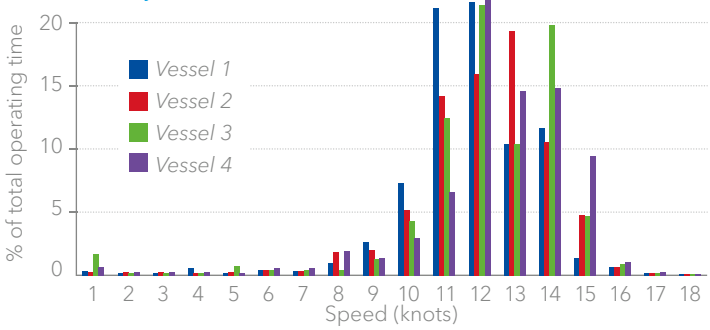
DNV GL evaluated the bow retrofit savings potential of the *Berge Everest*.

In times of intense competition, shipowners want to be sure their vessels are operating as efficiently as possible. DNV GL Maritime Advisory offers CFD-based performance evaluations of ships in service. In a brief, cost-effective feasibility study for Berge Bulk Maritime Pte., DNV GL assessed the energy-saving potential of a bow retrofit on *Berge Everest* and her three sister ships, also known as the Bohai Sisters. Delivered between 2011 and 2012, these DNV GL-classed vessels are 361 metres long and have a capacity of about 388,000 tonnes. "What was special about this project was the lean scope and short delivery time. Thanks to our close collaboration with Berge Bulk, the analysis was completed successfully and on time," says Adam Larsson, Discipline Leader for Resistance and Propulsion at DNV GL – Maritime.

The project resulted in an improved understanding of and increased confidence in the ships' hydrodynamic performance under operating conditions and quantified the potential savings. "The current trend in the industry is to design ships with a straight stem, a result of a better understanding of a vessel's operational profile while accounting for added resistance in waves. We wanted to know if such a design would have any savings potential for some of our largest ships. So we asked if DNV GL could design some radical alternatives for the bow and evaluate the performance," explains Rens Groot, Newbuilding Manager at Berge Bulk. "DNV GL came up with four different bows, each quite spectacular and feasible. Their experience paid off and we were excited about the depth of findings in a short time frame," he adds.

SPEED PROFILES

Berge Aconcagua, Berge Everest, Berge Jay, Berge Neblina, based on 1.5-year AIS data



Loading condition	Speed (kn)	Mean draught (m)	Trim (m)
Ballast	13.5	12.75	0.5 (bow up)
Scantling	11.5	23.00	0

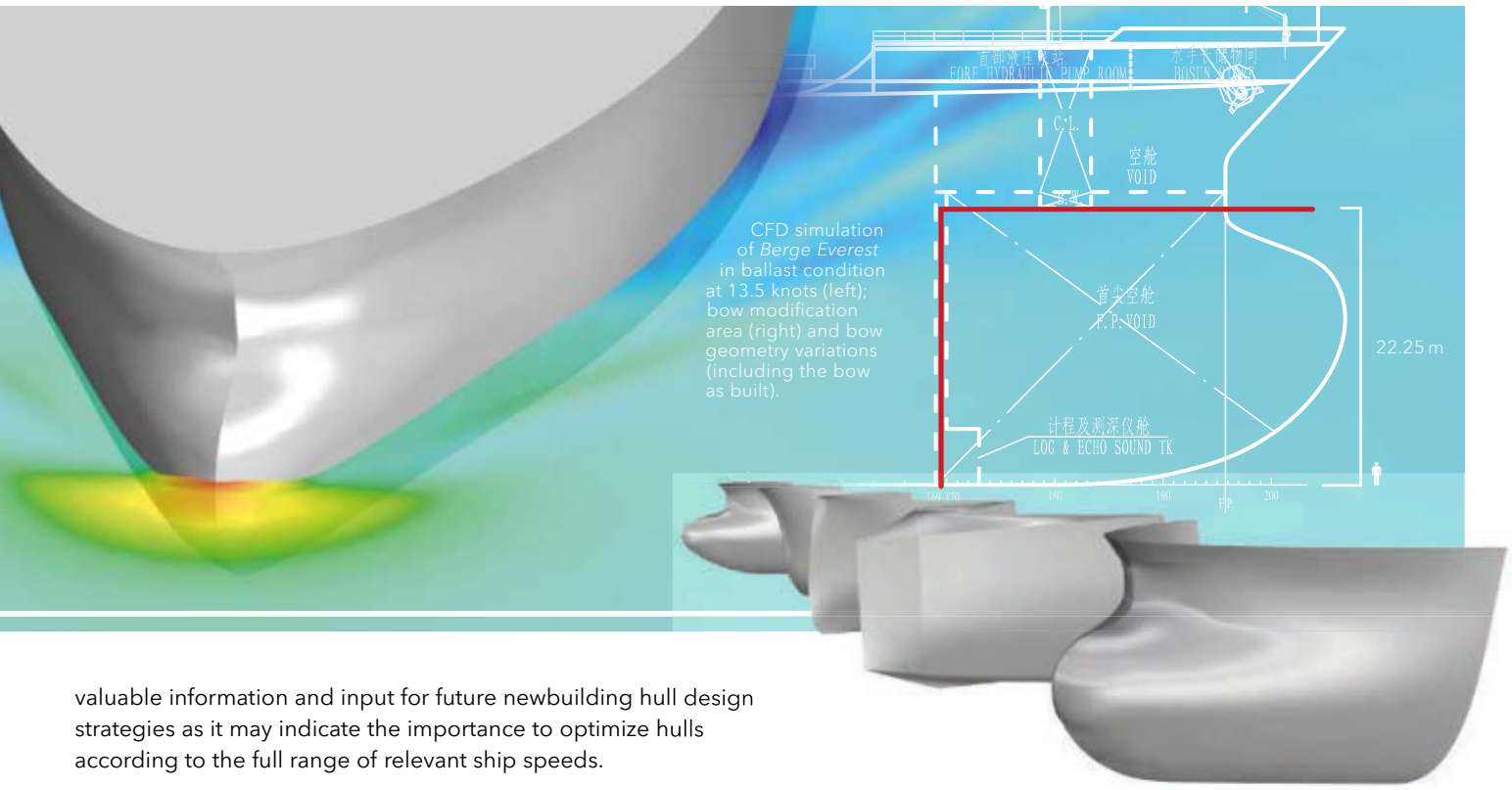
Conditions representing the operating profile during the trade between Brazil and the Far East.

Evaluation of calm-water hull resistance

Rather than focusing on hydrodynamic performance in calm water only, the project also covered actual sea states, which can have a significant impact on the overall performance of bulk carriers. The Bohai Sisters trade between Brazil and the Far East, so the study used sea states for this particular trade. "The speeds included in the evaluation were based on AIS data supplemented by information of historic and intended operation from Berge Bulk. It should be noted that the average sailing speeds are significantly below the design speed of 14.5 knots. The loading conditions that were applied correspond to ballast and scantling draughts," explains Adam Larsson.

Rens Groot continues: "We shared detailed information on all design constraints, primarily the anchor bell mouth and the fore peak bulkhead. We also requested minimizing alteration to the internal structure, longitudinal centre of buoyancy and constant displacement," he adds. The four new bow design concepts were tested using CFD calculations to predict changes in calm-water hull resistance. Performance at ballast draught showed a one per cent improvement potential for the most favourable bow variations whereas performance at scantling draught was slightly reduced.

The overall conclusion was therefore that the existing design is performing well, and that it is indeed a very good design for calm water performance. "The conclusion reassured us that the ships are not prevented from performing well at one speed and one draught only," says Groot. Another observation was a larger than expected wave trough in the way of the bow shoulder about 60 metres aft of the bow and therefore outside the constraints. This is



valuable information and input for future newbuilding hull design strategies as it may indicate the importance to optimize hulls according to the full range of relevant ship speeds.

Evaluation of added resistance in waves

DNV GL then investigated the added resistance in waves based on the conditions along the given trade route. For the short time frame of the project it was decided to consider head sea only and to apply a simplified assessment methodology. For the given project is was sufficient to focus on head sea only, applying a simplified methodology. The best-performing bow variation reduced the added resistance in waves by no less than 14 per cent in ballast and 37 per cent in scantling condition. This is a significant achievement. Nevertheless, extremely high block-coefficient ships with low Froude numbers, such as *Berge Everest*, feature very low wave-making resistance in calm water so the contribution to the overall resistance is limited. Smaller bulk carriers with higher wave-making resistance could still benefit since ship size and speed determines the severity of added resistance. Based on all these findings, the ultimate savings potential from a bow retrofit was estimated to be one to two per cent, which would not justify the investment.

Lessons learned

"As we continuously strive to improve the performance of our ships, it is encouraging to come to the conclusion that the hull lines on our largest ships are already well optimized," says Claus Jensen, Technical Director at Berge Bulk. The results of the study showed that retrofit measures would not have led to significant fuel savings, and that the payback period would have outlasted the ships' lifetime. "As such, even a significant 14 to 37 per cent improvement in added wave resistance proves to be insignificant in the bigger picture. Nevertheless, I have no doubt that we will build on these findings and come up with innovations better suited for VLOCs with the help of DNV GL," he adds.

"It is rewarding to see the great value provided by our experts in a quick and tailored approach. This project proves that key insights into ship performance and improvement potential can be derived at low cost based on our clients' needs," says Adam Larsson. "We will continue our research to lead the way in hull optimization and performance verification in calm water and actual sea states." **AL**

Photos: Berge Bulk, DNV GL

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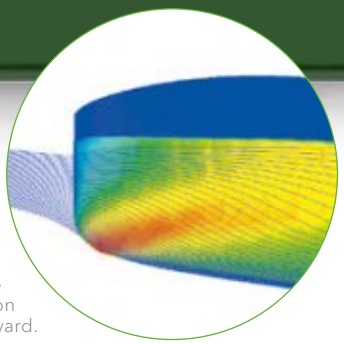
BENEFICIAL COOPERATION

Berge Bulk is a leading independent dry bulk owner with an outstanding reputation for the reliable, safe and efficient delivery of commodities around the world. It is a young, dynamic company with a strong commitment to innovative growth and development. The company's diverse fleet of over 50 high-performing ships (totalling over ten million dwt) ranges from flexible handysize vessels to some of the world's largest VLOCs.

Berge Bulk and DNV GL have collaborated successfully on various projects over the years. In addition to the current performance evaluation project DNV GL Maritime Advisory undertook a study into the feasibility of increasing the summer draught to better balance the restrictions in cargo intake and reduce discounted cargo intake when the ship sags. With a slight increase in summer draught the payload can be maximized without compromising the safety of the ship. Initial experiences have confirmed the benefits of this approach.

The Green Dolphin 38 handysize type was developed by SDARI with technical input from DNV GL.

GETTING WHAT YOU PAID FOR



To reap the full benefit of the fuel-efficient hull design, care must be taken to ensure precise execution at the shipyard.

No matter how perfect a ship design may be, much of the ultimate performance and fuel efficiency of the vessel depends on the way the design is carried out at the yard. In response to surprising findings, DNV GL developed a special service to improve quality control.

Modern ship design can rely on powerful computational fluid dynamics (CFD) software to optimize hull, rudder and propeller efficiency. The more stunning it can be to discover that a finished ship does not exactly conform to design specifications or that sister vessels which are identical by design behave quite differently under comparable conditions. Even seemingly minor differences in the way a design is implemented by the yard can have surprising effects, as DNV GL found out. When fuel economy predictions miss the mark, the owner will incur higher costs than expected.

As Morten Lovstad, Business Director Bulk Carriers at DNV GL Maritime, explains, the classification society has studied aggregated data revealing substantial fuel consumption variations between identical sister ships. The reason, he says, is a less than desirable accuracy in the way design drawings are carried out during the construction process.

So in 2013 DNV GL developed a unique new service to address the quality of the hull fabrication process from a hydrodynamic point of view. By helping yards work more accurately when executing specific hull features, the service ensures that any additional resistance introduced during manufacturing is minimized and the delivered ship is as good as its design.

Drag and turbulence

Fuel efficiency improvements can be achieved primarily in four areas: operation, propulsion, power plant and hull resistance. The area of interest for the Build2Design service is hull resistance. Based on solid shipbuilding science, DNV GL experts compiled a list of roughly 20 parameters that influence water resistance or "drag", and analysed their impact on fuel consumption, bearing in mind the effort and cost involved in making appropriate adjustments. Since every hull form has its unique hydrodynamic flow profile, the parameters to address depend on the given design.

Cosmin Ciortan, Principal Specialist – Hydrodynamics and Stability at DNV GL Maritime Advisory, explains: "DNV GL applies state-of-the-art CFD calculations to obtain ship-specific flow characteristics. This is the basis for our recommendations regarding areas of attention as well as quantified acceptance criteria that can be verified during ship construction." The guiding principle in selecting the parameters to focus on is the cost vs benefit ratio. This ensures that the greatest possible benefit for the owner will be achieved with the least effort at the shipyard. "Quantification of the

Bilge keels positioned on a 210,000 dwt bulk carrier following DNV GL Build2Design assessment.

"Being able to highlight those areas of the hull that were critical in respect of their influence on the overall hull resistance was invaluable to our teams. Armed with this information, they were able to direct resources to pay particular attention to these areas."

Philip Atkinson, Technical Director at Graig Shipping

relative resistance resulting from different approaches should be balanced by the difference in effort and cost," says Ciortan.

Benefits immediately realized

Build2Design is a consultancy service offered to owners for newbuilds of any type and built to any class. It includes a quality control survey at the yard to verify accurate execution of specific hull design aspects known to increase resistance in water: the height and grinding of weld seams, the position of bilge keels, the implementation of draught marks and anodes, and other features such as bow thruster tunnels and hull roughness. CFD calculations performed by DNV GL showed that insufficient control of welding quality, especially in the forward area, causes significant efficiency losses.

A particularly interesting area of attention is the bilge keels customarily put on ships to reduce rolling. "DNV GL discovered that proper bilge keel placement based on hydrodynamic criteria can achieve fuel savings of up to two per cent by minimizing drag," explains Ciortan. "This is an area that has been neglected in resistance calculations in the past, and we were able to show it makes quite a difference." It was also found that bevelling draught marks and carefully choosing the placement of anodes can reduce resistance and turbulence caused by these features.

Upon completion of the Build2Design survey, a statement of compliance is issued to the shipowner. DNV GL began rolling out its new service on the bulk carrier design Green Dolphin 38, a joint development by the Chinese designer SDARI and DNV GL which was first built for the owners Goldenport Shipmanagement and Pioneer Marine. As many as 40 ships of this highly successful design have been delivered to date.

Goldenport Newbuilding Technical Manager Anastasios Proakis describes how Build2Design worked out for his company: "The DNV GL surveyors made sure our ships were built as designed, including the smoothness of the vessel surface. We saw the effects immediately during sea trials. The calculated fuel efficiency benefits of the hull shape, which is very sleek, were fully realized. We are very satisfied with this outcome. The ship has been in service for about 18 months now, and we can say our expectations have been fulfilled." This pilot project was soon followed by several Seahorse 35-type newbuilds for the Graig Group. Philip Atkinson, Technical Director at Graig Shipping, confirms: "Being able to highlight those areas of the hull that were critical in respect of their influence on overall resistance was invaluable to our teams. Armed with this information, they were able to direct resources to pay particular attention to these areas. Correct plate alignment and weld profiles in particular was most influential on the operational efficiency of the completed vessel."

Build2Design not only benefits the owner but also the yard. The builder of Goldenport's Green Dolphin 38 bulk carriers, China Shipping Industry (Jiangsu) Co., says this unique service adds value to the yard in terms of differentiation and improved quality control. "The optimized bilge keel design is quite challenging to implement due to tight tolerances which require high accuracy control. Therefore a new process during block fabrication and assembly has been devised which eases the process and benefits the yard's quality control," said Mr Zuo Chengkui, Assistant Manager – Shipyard Design Department at Jiangsu Shipyard. ■ **AK**

The Seahorse 35-type vessel *Odelmar* was built at Jiangdong Shipyard for Graig Group and delivered on 27 April 2017.

Photos: DNV GL, Graig Group

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LNG-FUELLED NEW-CASTLEMAX FOR THE "GREEN CORRIDOR"

With DNV GL as project manager, a joint industry project (JIP) between key stakeholders operating in the "Green Corridor" bulk carrier trade between Australia and China has developed an LNG-fuelled Newcastlemax design as well as solutions for possible retrofits of dual fuel onto existing Newcastlemaxes. The solutions in this design are state of the art, yet well proven to make the design possible to order and build before the new sulphur limit of 0.5 per cent enters into force in 2020. The design will be presented at the Nor-Shipping exhibition in Oslo, Norway, in June 2017.

"GREEN CORRIDOR" JIP OBJECTIVES

The key project objectives were:

- To assess the business case of LNG as fuel for Capesize bulkers operating in Australia under various pricing scenarios including alignment of the bunker supply chain
- To develop an efficient and practical LNG-fuelled Capesize concept design to a level where it will get an Approval in Principle (AiP) and where owners may start to negotiate orders from yards based on this design
- To bring together key stakeholders to address common challenges and position Australia at the forefront of developments in LNG fueled shipping

Various possible routes from Australia to East Asian destinations were included in the business cases considered for the project.

On 27 October 2016, IMO's Marine Environment Protection Committee (MEPC) agreed to reduce the global sulphur emissions limit down to 0.5 per cent (from today's 3.5 per cent) in year 2020, thus pushing global shipowners to make informed decisions on their fuel choice in the future in order to meet the stringent requirements. Among all possible fuel solutions that comply with the global sulphur emission requirements, many see LNG as the most forward-looking and practical fuel switch option.

The major charterers, shipowners and operators plying the Australia–China iron ore and coal trade route have for a while been contemplating the idea of developing the infrastructure for LNG as a marine fuel for the vessels operating this trade. With the IMO confirming its decision, these stakeholders, together with Australia's major LNG supplier Woodside, as well as ship designer SDARI and class society DNV GL, decided to come together to develop a suitable LNG-fuelled bulk carrier solution.

To enable the quick ordering of these vessels, possibly for delivery already before the IMO sulphur requirement enters into force in 2020, the project partners decided on an evolutionary approach rather than a far-fetched, revolutionary approach. For example, the choice of engine type would therefore be of the rather conventional type, albeit dual fuel, having capability to carry both conventional fuels as well as LNG, as opposed to relying on less-tested technologies such as gas turbines or similar options.

Since LNG is known to be a substantially cleaner fuel option than most other options presently available, the LNG-fueled vessels operating between Australia and China will market the trade route as the "Green Corridor".

"Green corridor" JIP partners

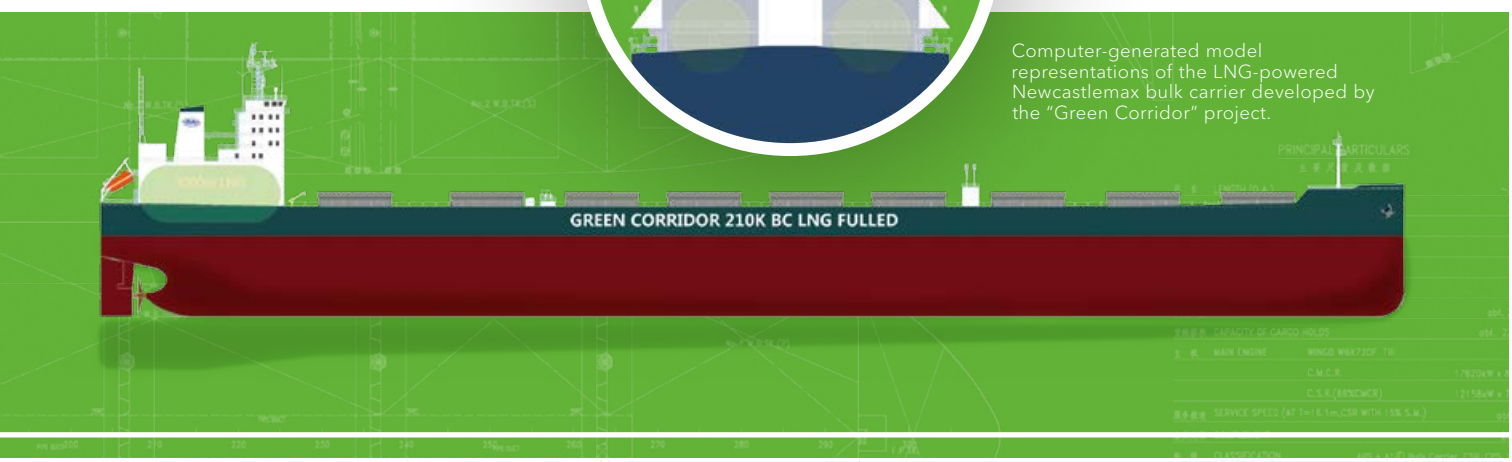
The stakeholders active in developing the LNG-fuelled infrastructure in the iron ore and coal trade between Australia and China came together to conceptualize an LNG fuelled Newcastlemax bulk carrier. The partners represent the whole value chain around the "Green Corridor", including energy supplier Woodside, mining majors and cargo owners/charterers Rio Tinto, BHP and FMG, major shipowners MOL and U-Ming, and finally ship designer SDARI and classification society DNV GL:

- BHP
- DNV GL
- Fortescue Metals Group Ltd (FMG)
- Mitsui O.S.K. Lines, Ltd.
- Rio Tinto
- Shanghai Merchant Ship Design And Research Institute (SDARI)
- U-Ming Marine Transport Corp.
- Woodside Energy Ltd.

Each partner participating in the JIP benefits from working together. Importantly the partners are shaping the future of bulk carriers that will trade in this route. Shipowners and operators MOL and U-Ming provide design inputs through fleet operation experience. Charterers BHP, FMG and Rio Tinto want their supply chain to be robust and sustainable and thus influence the size and scale of fleet operations as well as the suitability of the ships to fit their terminal capacities and constraints in an optimal way. Designer SDARI gets direct feedback from the end users not only on the efficiency of their design, but also helps make their design more viable for actual operations. Based on the operational feedback, LNG bunker supplier Woodside can make informed decisions for their own bunkering development as well as help the other partners design ships that will fit optimally with the available bunkering facilities.

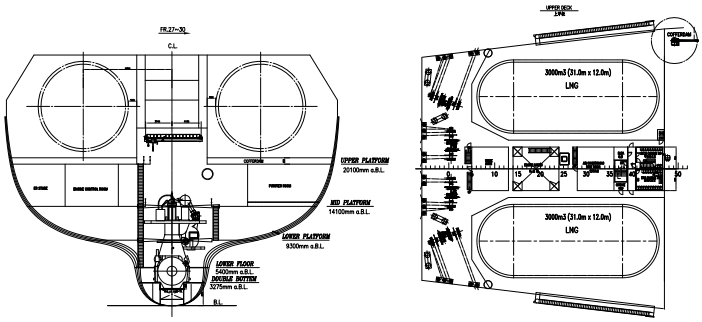
DNV GL has for many years built up its competence and capacity as a thought leader in LNG as fuel for the maritime industry, and now further expands on this in its capacity as both project manager and one of the key contributors to the "Green Corridor" JIP. In its role as a classification society, it is imperative for DNV GL to work closely with key industry partners to get first-hand feedback on its rules and design standards, and to help shape the future world fleet towards a greener footprint.

"The JIP partners decided early on that a Newcastlemax bulk carrier (about 210,000 dwt) would be the most flexible design >



Computer-generated model representations of the LNG-powered Newcastlemax bulk carrier developed by the "Green Corridor" project.

Photos: bahram7 - Fotolia; DNV GL



The innovative arrangement of the LNG fuel tanks at the upper deck level close to the engine room minimizes the risks associated with long cryogenic pipelines.

> for the trade route between Australia and China, since it would cater for both iron ore and coal as cargo.

LNG-fuelled bulk carrier – retrofit or newbuild?

The first question raised in the JIP was: "What would be more cost-effective – having an existing bulk carrier retrofitted to run on dual fuel (conventional as well as LNG fuel), or to build a new, dual-fuelled bulk carrier?" Hence, a study was conducted to compare the cost implications of both these options.

The study resulted in quantifying the actual difference in opting for retrofit versus newbuild as a solution for the "Green Corridor".

The study revealed that a retrofit option is possible from a technical point of view, but would allow less capacity for the LNG fuel tanks, and hence less operational flexibility, and the retrofit option is also significantly more expensive due to the higher capex in the engine installation and the corresponding shipyard costs in comparison to a newbuild. Also, from an operational and cost point of view, the location of LNG fuel tanks is more challenging for the retrofit option, as the tanks would need to be placed on the aft deck. Hence, the question is omit rather whether there is need for more vessels operating this route or whether there already exists enough capacity for this trade. Taking into account other environmental regulations that have already or will soon enter into force, such as the Ballast Water Convention and NO_x Tier III requirements, the partners find it likely that a newbuilding option may be attractive. The following therefore focus mainly on the evaluations done for the newbuilding design, although a concept design for a retrofit option was also developed as part of the JIP.

Design considerations

The LNG fuel tank is the single most expensive component of an LNG fuel system, and so the optimal selection of tank size is of vital importance. The larger size the more flexibility in trade route and bunkering options, but it also results in the highest investment cost and the biggest technical challenges (such as finding space on board the vessel, trim and stability challenges, structural reinforcement to take the load of the tank and fuel, etc.).

Operational trade routes between Australia and China were analysed for the cruising distance, typical ports called, weather impact (based on AIS data from vessels trading the route over the last years), safety margin, engine efficiency, etc. Based on the analyses of the listed factors that typically affect fuel consumption, a cruising range from 10,000 nautical miles to 24,000 nautical miles was studied.

A mid cruising range of 14,000 to 18,000 nautical miles showed the highest number of runs for a round trip i.e. from the load port to discharge port and back. LNG fuel tank size of about 6,000 m^3 was found to be optimal for the said cruising range, with bunkering in Australia for the round trip. The analyses were carried out mainly for the iron ore trade, but also allow for the flexibility on some of the major coal trading routes. The said tank size not only caters for the Australia-China trade, but also has built-in flexibility for some occasional longer voyages.

Several locations for the LNG fuel tank were considered: midships, in front of the engine room, on the aft deck, etc. After several iterations and comparisons, locating the An LNG tanks as close to the engine as possible was found to reduce the risk induced by long cryogenic pipelines and pressure drop. It also reduces the need for building other additional risk mitigation options and, last but not least, it reduces the costs of the cryogenic systems.

With due considerations on operational flexibility as well as trim and stability and structural strength (longitudinal bending moment and shear forces), an optimal solution was found to

Signing ceremony for the "Green Corridor" joint industry project (f. l.): Chen Gang, Technical Manager at SDARI; Toshiaki Tanaka, Executive Officer, Deputy Director General, Dry Bulk Business Unit at Mitsui O.S.K. Lines; Steen Lund, Regional Manager South East Asia, India and Pacific, DNV GL – Maritime; Mike Utsler, Chief Operating Officer at Woodside Energy; Abdes Karimi, Freight Operations Manager at BHP Billiton; and David O'Brien, Freight Manager at Rio Tinto Marine.

LNG TANK TYPES – PROS AND CONS

Different LNG fuel tank types are available and their pros and cons were studied carefully in the project. Mainly due to the more attractive investment cost as well as operational flexibility, technical maturity and availability of more suppliers, a Type C tank was chosen for the "Green Corridor" design.

Tank type	Pros	Cons or areas to consider
Type C	■ Allows pressure increase ■ No need for external BOG handling ■ No sloshing effect ■ Simple fuel system ■ Robust technology ■ Little maintenance ■ Easy installation ■ Good track record on both LNG-fuelled shipping and LNG containment on land	■ To allow proper protection, a steel shield needs to be considered ■ Less flexibility on location, and so increased bending moment may result in additional cost (more steel in vessel design) ■ If located on the aft deck, mooring deck modification may be required (lifeboat, mooring lines, etc). In general, the aft deck is crowded, posing challenges for the arrangement of bunkering station, fuel gas preparation room, ventilation systems, etc. (separation between hazardous area and safe areas).
Type B	■ Space-efficient ■ Minimum sloshing effect ■ Easy to operate in terms of leak detection	■ Boil-off gas handling required ■ Pumps needed ■ Design and approval process much more extensive ■ If the tank is designed to be midships: much longer double-walled piping ■ Midships design: the ventilation ducts and openings related to LNG spaces are to be protected from damage due to cargo operations ■ If located aft of No. 9 cargo hold, it will need a steel shield, water spray and A-60 protection on accommodation forward of the bulkhead; accommodation window to be arranged on side
Membrane	■ Space-efficient ■ Low weight ■ Proven technology in LNGC market	■ Boil-off gas handling required ■ Pumps needed ■ Most complicated in the leak detection operation ■ Risk of sloshing effect (not known, as no ships in operation yet) ■ More yard work due to the alignment and welding of hull lines and membrane system ■ Longer building time, as built with ships's hull, but could be solved by "block" solution

place the two LNG fuel tanks under the superstructure of the accommodation area, where it would be surrounded by steel structure and A-60 insulation, and of course completely separated from the accommodation area and cabins. This way, the fuel tanks will be partly submerged into the engine room. This is a rather innovative design, which caters both for proper protection of the fuel tanks, while also ensuring proper fire protection towards the accommodation, and at the same time it utilizes the engine room space so that it does not reduce the cargo carrying capacity (not even for volumetric cargoes such as coal).

Dual-fuel engines were quickly decided upon by the JIP partners, due to their robustness in offering operational redundancy, combined with sturdiness and several suppliers offering mature solutions.

Both low-pressure and high-pressure engine types have been included into the design to allow for maximum flexibility, since both options have their own pros and cons. However, it is important to note that the design is fully NO_x Tier III-compliant, and thus the high-pressure engine option is also fitted with an exhaust gas recirculation (EGR) system.

Economic considerations

One key driver for the "Green Corridor" is of course to provide more environmentally sustainable transportation in compliance with future environmental regulations. However, it also needs to be sustainable from a commercial point of view, and therefore the operational costs for an LNG-fuelled solution was investigated in detail in the JIP. The main conclusion is that in the long term, the operating costs are predicted to be substantially lower than for a conventional solution. The expected reduced fuel costs and longer overhaul intervals are the main contributor for reduced OPEX, and indicate a quite attractive payback period of less than ten years.

An important part of the JIP has been to conduct a financial feasibility study for the LNG-fuelled Newcastelemax design. It was carried out based on a wide range of possible capital cost, operational cost and sensitivities to LNG prices and that of low-sulphur marine fuel oils as well as a high-level bunker supply chain assessment.

It devised the most cost-efficient solutions for the design and mapped out payback periods under different pricing conditions, and showed an encouraging payback period of less than ten years in the scenario deemed most realistic, whereas a payback period down to six to seven years was predicted in a more optimistic scenario.

The outcome of the study reinforced the belief in LNG as marine fuel for the vessels operating in the identified trade route, and it also helped understand key issues that impact vessel design and the business model for both ship operators and the LNG bunkering suppliers.

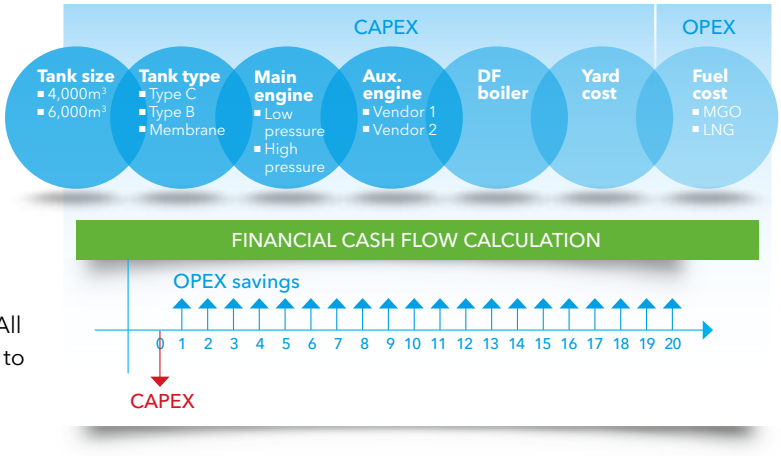
Newcastlemax concept design

World-famous Chinese ship designer SDARI developed the design of the 210,000 dwt Newcastlemax bulk carrier based on their highly energy-efficient Green Dolphin design. This design has already been highly optimized for minimum hull resistance under various realistic operating conditions, including operating profiles considering realistic combinations of speed, trim, draught, etc.

As mentioned, the selection of engine type, LNG fuel tank size/capacity, location and tank type were some of the main decisions carefully reviewed in the project. Whereas an evolutionary approach was selected, one of the key innovations involved in this design was the position of the Type C tanks. Through several iterations, it was identified that two tanks, each placed above the engine room but submerged from the main deck, would >

Photos: DNV GL

While the initial capital expenditure for the engine and fuel system is comparatively high, the operating costs can be expected to be substantially lower than for a conventional solution.



> give an optimal balance between cost, operational flexibility and safety.

A future-proof design

A high-level hazard identification (Hazid) exercise was carried out as a risk assessment approach to identify the key hazards that may occur due to on-board LNG storage and operations. All partners participated in this exercise, which proved very useful to share a common understanding of the challenges at hand and what technical solutions could mitigate the risks.

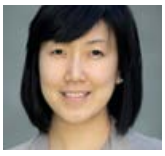
Major incidents that can cause potential hazards, their frequency of occurrence and consequences were mapped out. A list of actions which could be mitigation measures, recommendations or considerations were tabulated for each of the potential hazards.

These action items were later taken into consideration by SDARI in their proposed design to enhance the safety of the design against different elements. The refined design developed by SDARI is now in the process of being submitted to DNV GL for a thorough review according to class rules and applicable regulations. Provided all factors have been satisfactorily considered, DNV GL will issue so-called Approval in Principal for the design.

Thus, in this manner, the JIP aims to arrive at a Newcastlemax design which is in line with charterers' requirements, shipowners' and operators' requirements as well as in full compliance with international rules and regulations.

All vessels sailing in designated emission control areas (ECAs) currently need to comply with the 0.1 per cent sulphur regulation, and after 2020 all vessels sailing globally will need to comply with the 0.5 per cent sulphur regulation. Some ECAs also impose strict regulations on NO_x emissions. All the above urge shipowners to investigate alternative options for compliance for their vessels based on the operational profile, trade pattern and investment cost. LNG as a fuel is a single-system solution for emission regulation compliance, ensuring compliance with both the SO_x and NO_x regulations.

The new, innovative Newcastlemax design developed in the "Green Corridor" JIP, offers unique solutions for cost-efficient, safe and flexible operations. By gathering key stakeholders representing the wider value chain of iron ore and coal transportation, a more robust, commercially viable and safe LNG-fuelled bulk carrier design has been developed to a stage where it is ready to serve as the outline specification for newbuilding orders already in 2017. ■ **AL**



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VESSEL SPECIFICATIONS

Main particulars
- Length overall: 300.0 m
- Breadth: 50.0 m
- Depth: 25.2 m
- Scantling draught: 18.5 m
- Deadweight at scantling draught: 210,000 t
- Cargo holds volume: 225,000 m³
- LNG tank volume: 6,000 m³
- Number of cargo holds: 9 cargo holds
- kind of cargo: grain, coal, ore

Machinery
- Main engine: WINGD 6X72 DF MAN B&W 6G70ME-C9.5-GI

Speed
- Service speed at design draught and CSR with 15% sea margin 14.4 k

EEDI
- 35% below IMO reference line for bulk carriers, complies with EEDI PHASE 3

Class notation
- DNVGL, +A1 BULKCARRIER ESP BC-A GRAB[35] CSR, Holds 2, 4 ,6 and 8 may be empty, COAT-PSPC(B) GAS FUELLED

DESIGN FEATURES

Dual-fuel system
- Dual-fuel system of LNG and HFO to be applied for main engine, auxiliary engines and boiler
- Endurance of 18,000 nm in GAS Mode

Fuel- and energy-efficient
- Hull lines optimized for an operating profile including ballast, design and scantling draughts and speeds in the range of 10–15 kn
- No-bulb concept for a flexible design with improved overall performance, including operation in realistic sea states
- Added resistance in waves calculated numerically and compared to tank test results

Environmentally friendly
- Designed to comply with current and future expected local and global emission regulations
- Efficient main engine with low fuel consumption and emission levels, IMO NO_x Tier III-compliant
- No SO_x or PM emission in GAS Mode
- GHG emission 20% less in GAS Mode

Photos: DNV GL

FLEXIBILITY MAKES THE DIFFERENCE

Continuing a long-standing, highly productive working relationship, Oshima Shipbuilding and DNV GL have developed a state-of-the-art design for a 65k, open-hatch general cargo carrier.

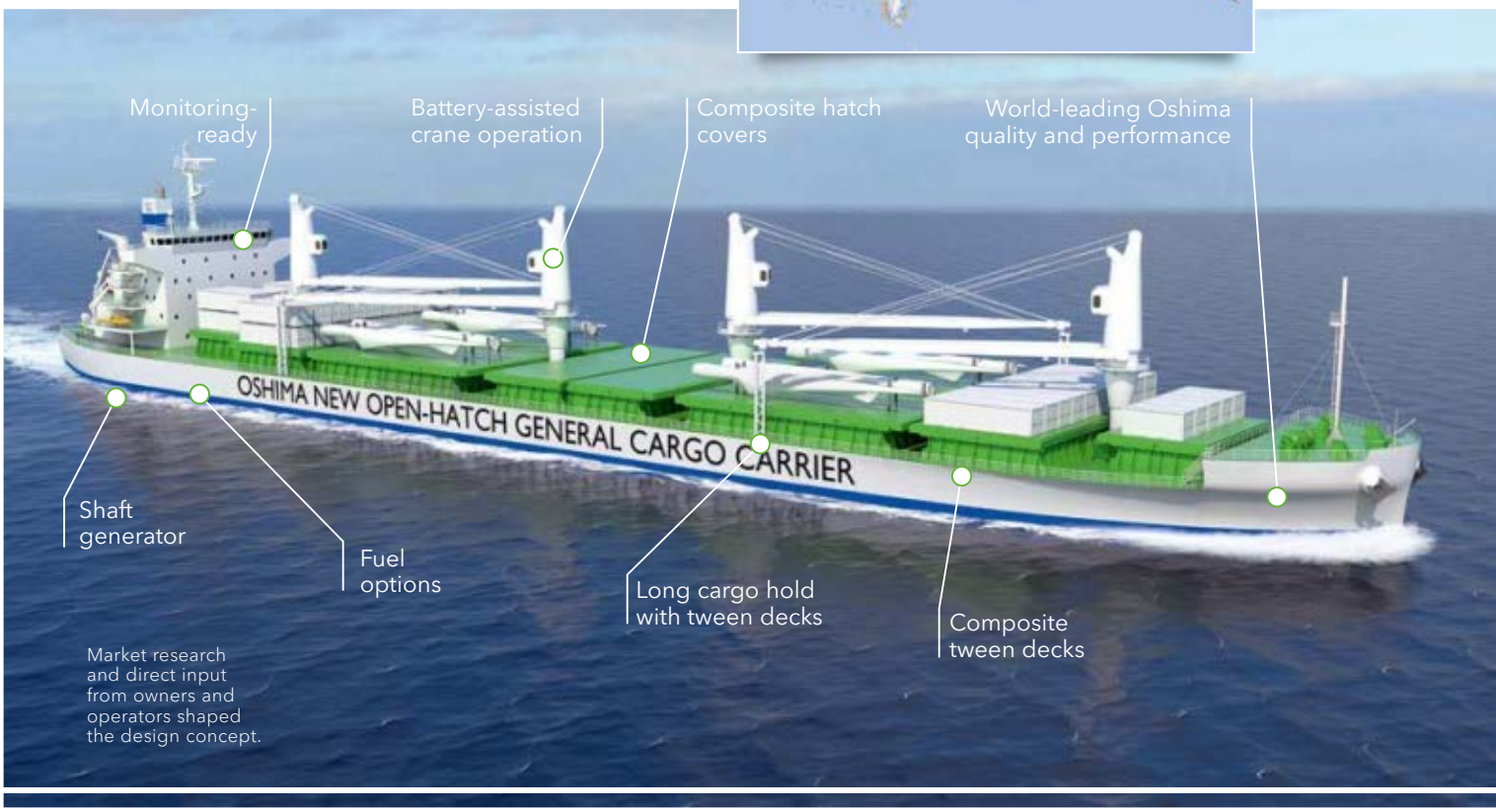
High efficiency and flexibility are the keywords that best describe the purpose of a new joint development project between Oshima Shipbuilding and DNV GL. Oshima, well known as a specialist in open-hatch carrier design, was envisioning a modern, high-performance ship utilizing the best available technologies and adapted perfectly to current market demand. In addition to their extensive combined experience, Oshima and DNV GL used input from major owners as well as extensive market research accounting for fleet profiles, trades and cargoes.

Ship size and cargo hold configuration

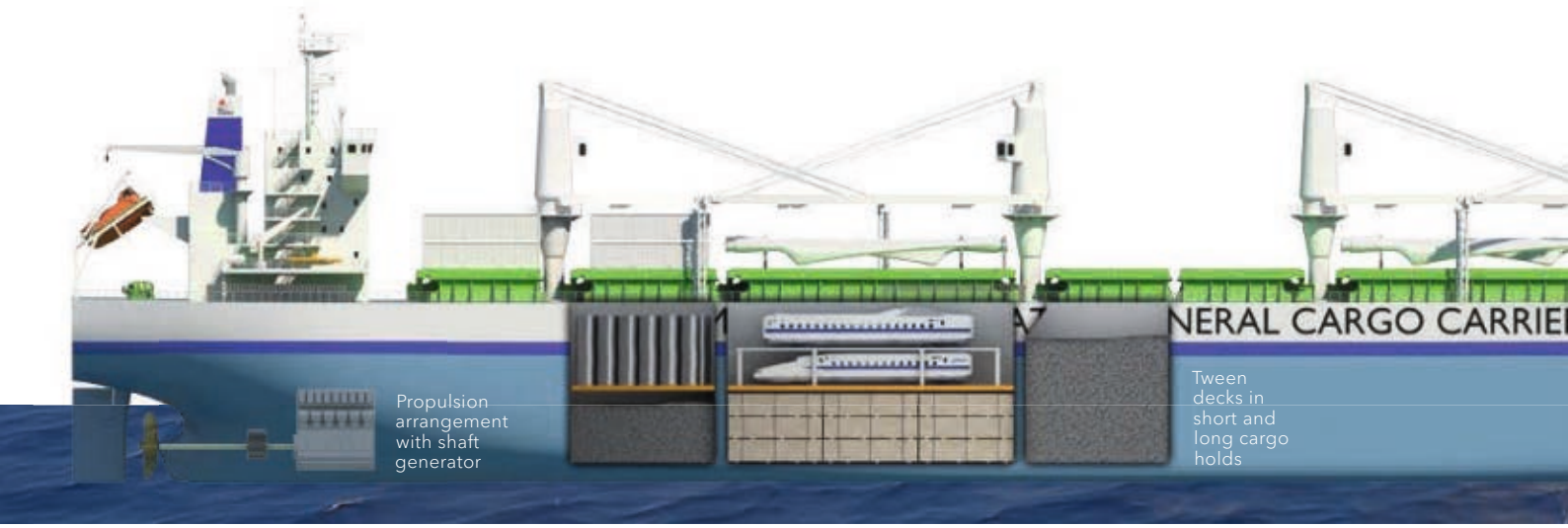
The design is intended for a wide range of project cargoes and packaged goods, such as the carriage of lumber, wood pulp, coils, ingots and carriage of other major and minor bulk cargoes. As cargoes increase in quantity, diversity and size, open-hatch general cargo carriers often carry a variety of goods during the same voyage, which requires many port calls along the route. Flexible loading options and excellent utilization of the available cargo space were therefore top items on the project agenda, along with high operational efficiency and emission compliance.

The deadweight and main dimensions were chosen based on market demand and an assessment of the current fleet and order book, accounting for port limitations, trade patterns >

Trade patterns analysed for determination of ship size and operating profiles.



Photos: DNV GL, Oshima Shipbuilding



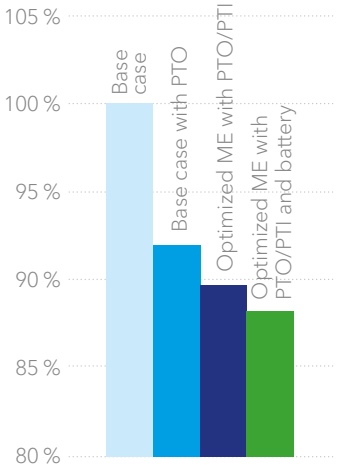
> and cargoes. Considerations were also made as to find the optimal hydrodynamic performance for the given size. The design features a high cubic and deadweight capacity at a shallow draught, enabled by an increased breadth without compromising performance. This allows the ship to enter a large number of ports. It has eight box-shaped cargo holds with full-width hatch openings, including two long holds for larger project cargoes. Holds No. 2 to No. 7 have piggyback-type hatch covers while holds No. 1 and 8 feature folding covers. Rapid cargo handling is ensured by four all-electric jib cranes, a cost-effective selection offering flexible loading compared to the more expensive gantry cranes.

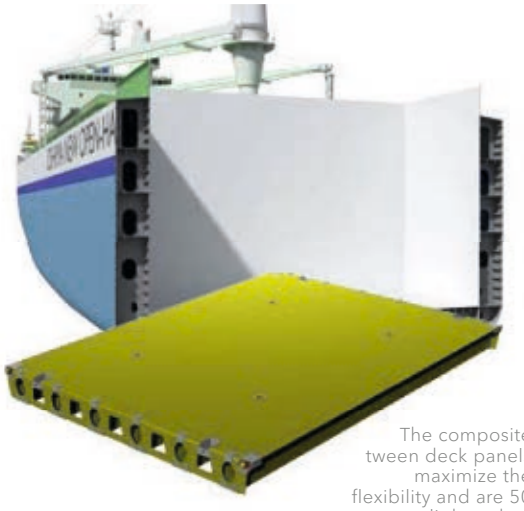
Composite tween decks

The ship is specifically designed for the use of tween decks to maximize space utilization. Holds 2, 3, 6 and 7 can be compartmentalized in this manner. For weight reduction Oshima, DNV GL, COMPOCEAN and IKNOW Machinery jointly developed innovative composite tween deck panels, each made of a single-skin GFRP (glass-fibre-reinforced plastic) top plate bonded to corrugations, which in turn are bolted to the end plates. These composite tween decks are 50 per cent lighter than steel versions without sacrificing any of the functionality, service or safety. The developers accounted for load carrying capacity, dimensional stability, impact resistance, reparability, environmental effects, vibrations, wear and fire safety. Benefits include significantly shorter port handling time, reduced maintenance costs and a simple, cost-effective manufacturing process. A full-size prototype was produced and tested and the design concept has received approval in principle (AiP) from DNV GL. The AiP confirms that, while some details and design solutions need further clarifications, the innovative composite design concept is feasible for application in bulk carriers and cargo carriers.

A similar approach was taken for the hatch cover design where an existing joint development of DNV GL and Oshima was adapted for the current project. In 2013 DNV issued an AiP for the

FUEL COST PER YEAR COMPARED TO CONVENTIONAL SYSTEM

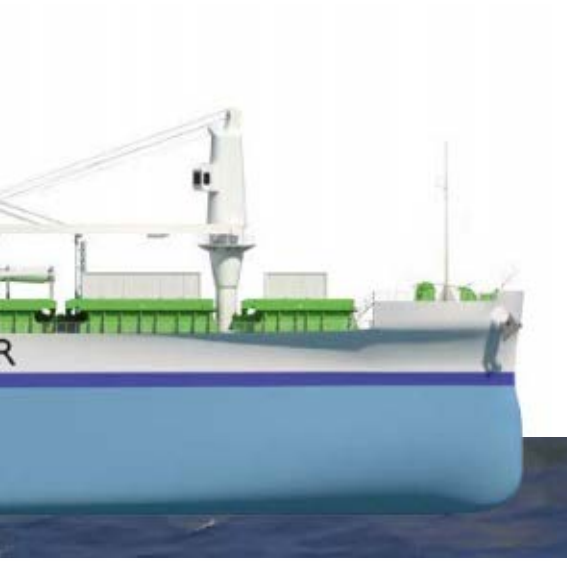




The composite tween deck panels maximize the flexibility and are 50 per cent lighter than their conventional steel equivalents.

"We believe this new ship design will be very useful for our customers. The ship has great cargo flexibility and several new technologies for general cargo carriers have been implemented, such as composite tween decks, a PTO/PTI shaft generator and batteries."

Tatsurou Iwashita, Deputy Yard General Manager



A full-size tween deck prototype was produced and tested and the design concept has received approval in principle (AiP) from DNV GL.

KEY FACTS

Trade and cargo flexibility
- Ship size and cargo hold arrangement adapted to market demands for trades and cargoes
- Application of new technologies and materials little used for general dry cargo ships
- High cargo utilization and flexible loading with tween decks

Energy efficiency
- Fuel-efficient operations with new propulsion configuration
- Energy-efficient crane operations with hybridization

Fuel alternatives
- Several options for emission compliance

composite hatch covers followed by Panama flag approval for fire safety.

Energy-efficient power supply system

A feasibility study by DNV GL has investigated the fuel-saving potential of battery pack-assisted crane operation. This found that a hybrid system can save up to 20 per cent of annual fuel costs for crane operations, resulting in an estimated six- to nine-year investment payback time where the range depends on if the auxiliary engines are run with LSFO or MGO as fuel. With the battery pack absorbing peak loads, one or two auxiliary engines running close to optimal load – instead of the usual two or three – can supply enough power for crane operation. This result in a potential reduction of genset running hours of 50 per cent. When lowering cargo, the cranes can regenerate energy and feed it back into the batteries. An additional DC/AC inverter will allow the batteries to be connected to the main switchboard.

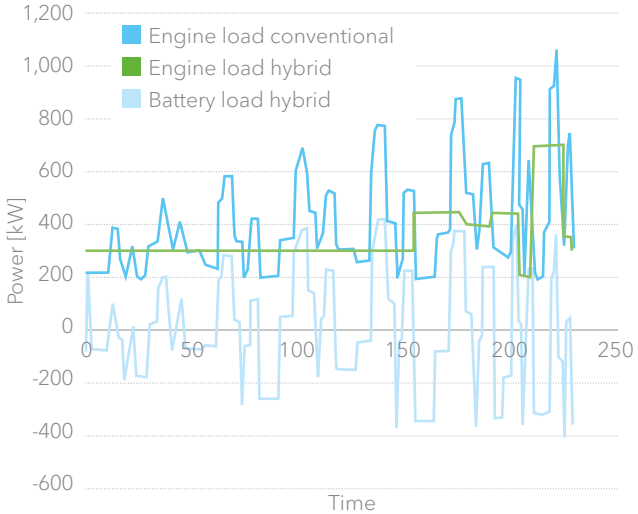
Furthermore, investigations of a large number of comparable vessels revealed frequent operation at low loads, confirming the opportunity to improve the overall main engine running performance and thus potential to improve the annual fuel consumption. DNV GL has found that an optimized six-cylinder, two-stroke main engine running on LSFO in combination with a PTO/PTI (power take-off/power take-in) shaft generator could reduce annual fuel costs by up to 10 per cent and maintenance costs by more than 30 per cent. An additional 1.5 per cent savings can be achieved through utilizing the battery in operations where generator sets are kept running at low load due to redundancy. The additional investment will pay for itself within a period of four to eight years, depending on auxiliary engine fuel type and price.

Fuel alternatives

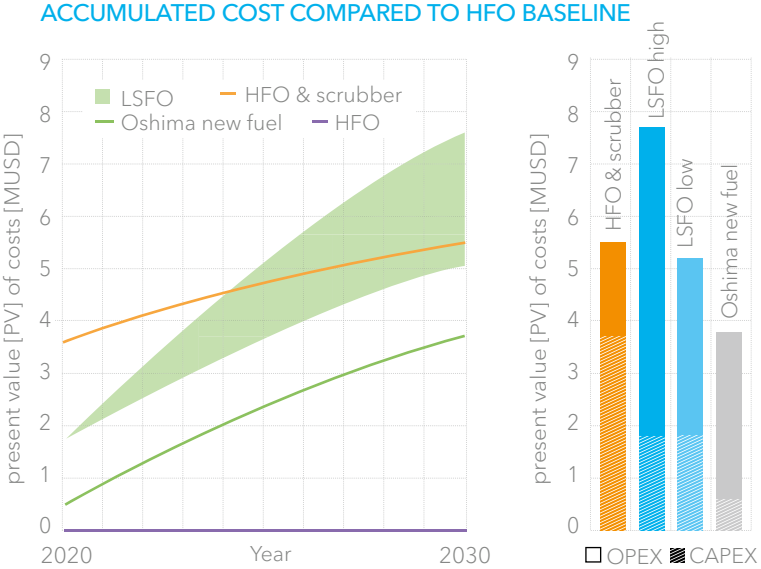
To meet current and future emission limits, the Oshima design offers various options for different fuel strategies. Apart from the baseline LSFO version with exhaust gas recirculation (EGR), available >

Photos: DNV GL, Oshima Shipbuilding

ENGINE LOAD PROFILE – CONVENTIONAL AND HYBRID



ACCUMULATED COST COMPARED TO HFO BASELINE



"This new concept design of an innovative, open-hatch general cargo carrier is a good example of how co-operation between industry partners can benefit the maritime industry."

Morten Løvstad, DNV GL Business Director Bulk Carriers

> options include HFO with a SO_x scrubber and EGR/SCR, LNG, and an innovative Super Eco Fuel which is currently being developed by Oshima and several industry partners. A financial comparison of the available options has been done, giving an initial indication if, or under which conditions a scrubber and the new fuel type are financially attractive compared to the LSFO option. Within the assumptions of the comparison, the scrubber solution provides shipowners with a positive outlook for a return on investment. The new fuel type option also seems favourable from an economic point of view.

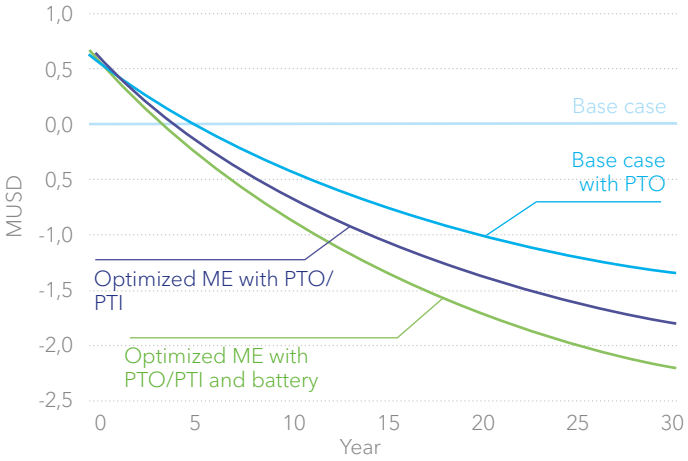
Significant potential

This new Oshima concept design delivers an excellent combination of characteristics for the varying trade and cargo requirements representative for the open-hatch general cargo segment. "We believe this new ship design will be very useful for our customers. The ship has great cargo flexibility and several new technologies for general cargo carriers have been implemented, such as composite tween decks, a PTO/PTI shaft generator and batteries," says Tatsurou Iwashita, Deputy Yard General Manager at Oshima. Both Oshima and DNV GL agree the design offers a highly attractive option to owners and operators in the open-hatch segment, combining well-known technologies that are currently available, making this a design ready to order while it includes features little used today but with significant potentials.

Says Morten Løvstad, DNV GL's Global Business Director for Bulk Carriers: "This new concept design of an innovative, open-hatch general cargo carrier is a good example of how co-operation between industry partners can benefit the maritime industry. The use of low-weight composite material for bulk carriers and general cargo carriers has been an area where both DNV GL and Oshima have done R&D for many years already, and I am pleased to see that this concept has now reached a level where it can be applied in commercial design, ready for order. Also, the use of hybrid solutions for the crane operations is a technology I think will be common in most of the future bulk carrier designs. Finally, I am excited about the new "Super Eco Fuel" developed by Oshima – provided sufficient availability of bunkering and technical feasibility of engine performance can be assured, this new fuel may have a significant potential as marine fuel!" **AL**

Photos: DNV GL, Oshima Shipbuilding

CUMULATIVE DISCOUNTED CASH FLOW FOR CONVENTIONAL VS OPTIMIZED SYSTEM



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OSHIMA NEW 65K OPEN-HATCH GENERAL CARGO CARRIER

The ship size and main dimensions were selected based on an assessment of the current fleet and order book, trade patterns and port limitations, cargoes and vessel performance considerations.

Main particulars
- Length: 210 m
- Breadth: 35 m
- Max draught: 13.1 m
- Deadweight: 65,000 mt
- Cubic capacity: 77,000 m^3

Major equipment
- Composite tween decks
- Fully electric JIB deck cranes
- Shaft generator
- Battery pack

Speed
- Service speed at design draught, NCR with 15% sea margin: 14.5 kn

Daily fuel consumption, service speed at design draught
- 25.1 t (Tier III mode)

DNV GL class notations
- ✠1A, General dry cargo ship, HC(A), Holds 3 & 6 may be empty, Grab(3-20), Strengthened(HA, DK, IB), COAT-PSPC(B), E0, LCS, BWM(T), BIS, TMON(X), Container, DG(B, P), Clean, Recyclable, Battery

DAWN OF A NEW FUEL

A new fuel being developed by Oshima Shipbuilding aims to meet all air emission regulations while simplifying the fuel system and reducing investment costs significantly.

The ideal solution to the new environmental regulations for emissions to air is a fuel that is compliant with these regulations without requiring spacious, complex and expensive equipment to be installed on board. Oshima has taken steps to create such a solution and, together with industry partners, a new fuel type is being developed and tested that will help both shipowners and shipyards overcome many challenges they face. With the production title Super Eco Fuel, this new fuel type is produced by mixing LCO (light cycle oil, a secondary refinery product) with GTL (gas-to-liquid, a liquid fuel made from natural gas) and water. The result is a fuel that requires no installation of new equipment while meeting the most stringent NO_x and SO_x requirements.

An innovative fuel mix

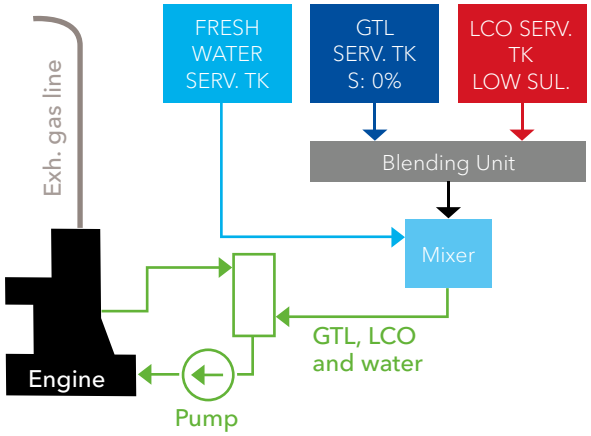
LCO has a low sulphur content but poor ignition performance. On the other hand, GTL contains almost no sulphur or other impurities, features high ignition performance and a complete combustion process. When mixed in the right quantities the result is a fuel that meets the 2020 0.5% global sulphur cap. As a second step, adding water and adjusting the fuel mix results in a fuel that satisfies both the 0.1% ECA sulphur limit and is NO_x Tier III-compliant. In addition, the specific fuel oil consumption is slightly lower. CO_2 emissions and soot formation are reduced as well.

LCO and GTL can be stored separately in the normal fuel tanks. In addition, the fuel can be used in existing engines without modifications, making it relevant for retrofitting to existing ships. The fuel is mixed on board by a mixing unit.

Preliminary tests of the fuel characteristics, engine performance and reliability have yielded satisfactory results. Further tests are planned. The largest challenges are the supply and bunkering of the individual fuel components, which must be addressed before the fuel will be accepted and used widely. Similar to other fuels there are uncertainties with price fluctuations over time. The cost of the new fuel mix is expected to be higher than standard HFO at current rates but lower than for other LSFO options, making it an attractive potential fuel alternative with marginal additional investment costs. ■ **AL**

Photo: Oshima Shipbuilding

SYSTEM OUTLINE



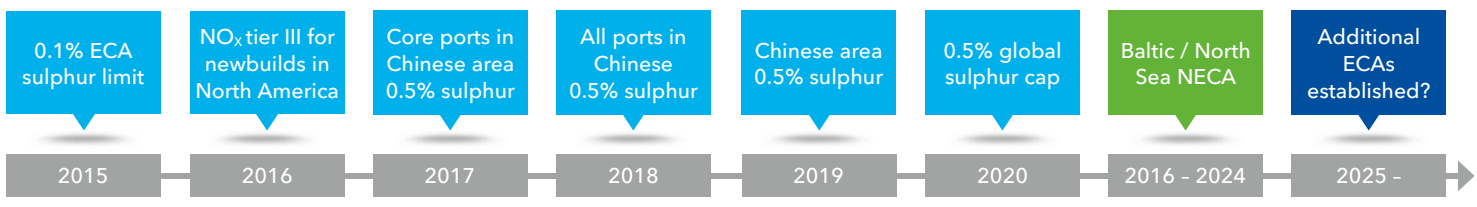
YARD AND SHIPOWNER BENEFITS

- Simple system
- Low initial investment
- Small installation footprint
- Low maintenance need
- Easy to retrofit

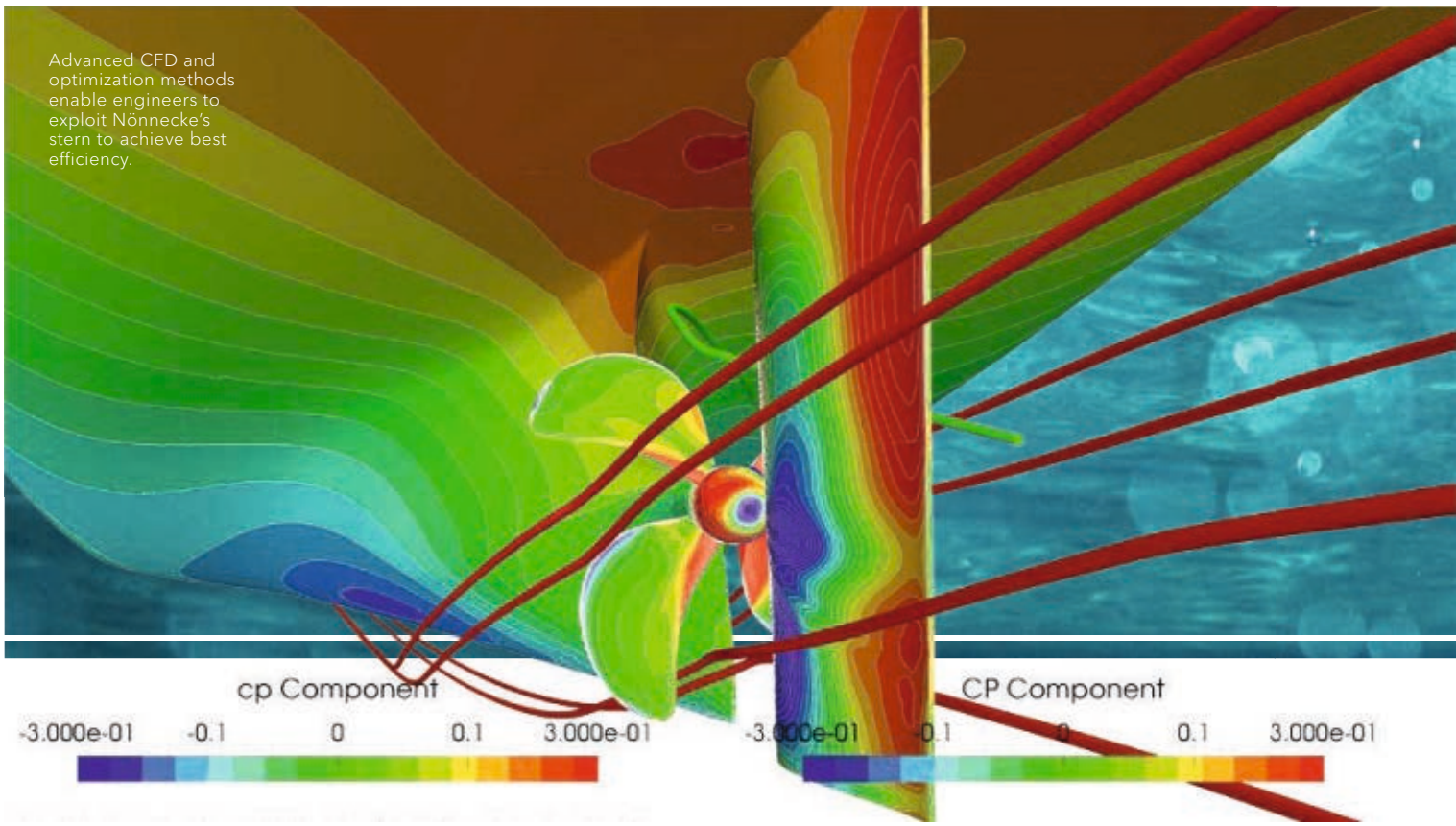
"This new fuel makes compliance with both SO_x and NO_x regulations possible without investments in expensive and complex equipment on board."

Tatsurou Iwashita, Deputy Yard General Manager, Oshima Shipbuilding

SO_x AND NO_x EMISSION REQUIREMENTS



■ adopted ■ in the pipeline ■ possible



Advanced CFD and optimization methods enable engineers to exploit Nönnecke's stern to achieve best efficiency.

HOW TO SCULPT AN ASYMMETRIC STERN

Advanced computer technology and modelling techniques are helping revive an old idea: twisting the stern section of the hull to optimize flow and save fuel.

The history of shipbuilding harbours many surprises, and the biography of Ernst A. Nönnecke is one example: a trained shipbuilding engineer and an accomplished opera singer at the same time, Nönnecke, born in Hamburg in 1921, had a reputation for his intuitive, rather artistic approach to shipbuilding; was also a sculptor. In the late 1960s he came up with the brilliant idea of designing a ship with an asymmetric stern to account for the different flow conditions to the right versus left side of the propeller. His concept for optimizing flow and propulsion efficiency came more than a generation too early, however: the manual calculations proved to be extremely tedious, and implementing the design at the yard was even more tricky – and costly.

IT brings the breakthrough

But Nönnecke's invention was by no means a wasted effort. It was implemented various times during the following decades, if with great effort, and the few ships built with twisted aft sections did prove the merits of the concept as an elegant alternative to retrofitting so-called pre-swirl devices such as fins or ducts to optimize the utilization of the propulsion systems' rotational losses.

But the real breakthrough came more recently, enabled by high-performing computers and advanced software. "What computers can do so much better than people," explains Dr Karsten Hochkirch, Head of Department – Fluid Engineering at DNV GL, "is find the right balance between improved propulsion efficiency and increased resistance." This can be accomplished only by performing complex iterative calculations for a large number of design variants – a perfect job for computers.

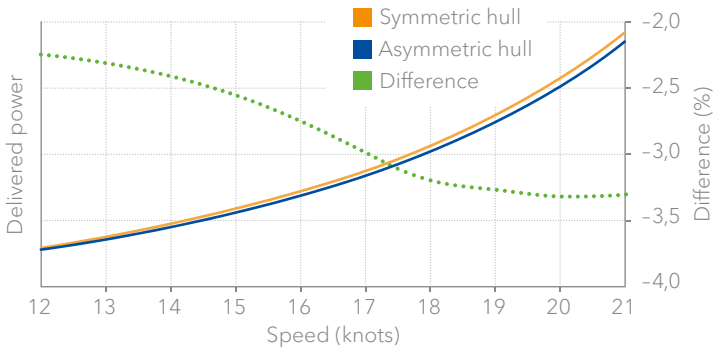
High-fidelity computational fluid dynamics (CFD) today provides the right toolset for designing complex shapes efficiently. Used in combination with the formal parametric optimization procedure developed by DNV GL, this approach makes design optimization much more manageable and efficient. Within the scope of its ECO Lines hull design optimization services, DNV GL now offers

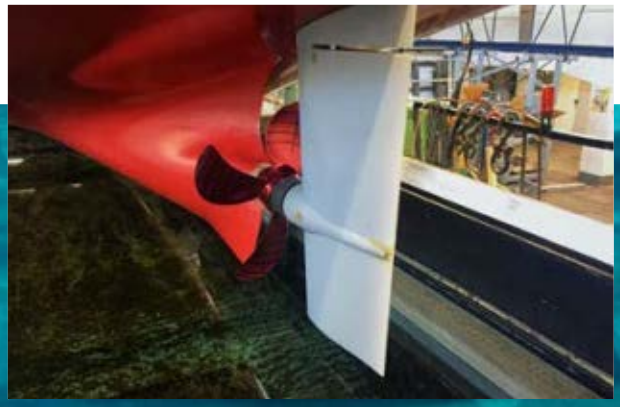
asymmetric stern optimization. The procedure gives significant freedom in shape variation without altering the key design requirements. Using special CFD tools and custom-developed code tested and proven in hundreds of towing tank trials, the DNV GL experts combine ship and propulsion simulation techniques based on viscous Reynolds-averaged Navier–Stokes (RANS) equations with dedicated, state-of-the-art propeller analysis code to determine the propulsion efficiency of a given model with high accuracy.

The formal hull shape optimization procedure begins by defining the objectives and optimizing the parametric model of the ship. What follows is a cyclic, iterative process to select the best-performing solution out of thousands of virtual model variations. In the RANS cycle, which is part of the routine, the results of the viscous flow calculations are used as input to the propeller

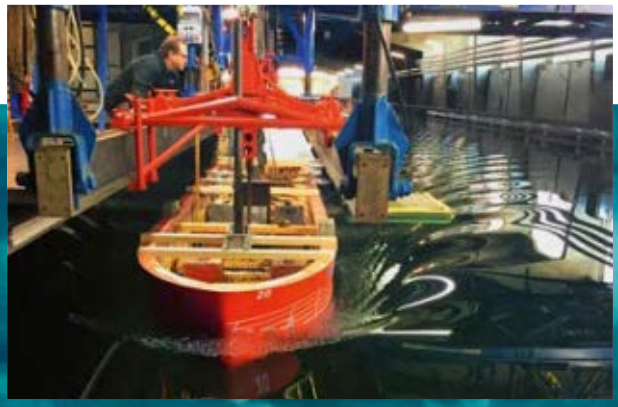
PROPULSION POWER REQUIRED FOR VARIOUS HULL FORMS

Model test predictions for an optimized symmetric hull vs its asymmetric version show a 3 per cent improvement for the latter near the 17 kn design speed.





Tank test model of a handymax bulk asymmetric stern shape.



The traditional towing tank test confirms the improved propulsive efficiency.

computation tool, whose output is then fed back into the next round of viscous flow calculations. In a final stage, the most efficient models undergo virtual towing tank tests until the best variant has been identified. This entire process requires enormous computing power: "There are around 7,000 CPUs in the basement of the DNV GL building doing the work Nönnecke did by himself," Hochkirch points out. When all computer work is done, a real-life scale model of the final design is built and taken to a traditional towing tank to verify the data.

The actual production processes at the yard have become much simpler as well thanks to advanced CAD/CAM techniques and modern, CNC-controlled fabrication methods.

Considerable fuel savings

Several projects have demonstrated the potential of the DNV GL approach. In the case of a handymax bulk carrier design, the resulting twisted stern enabled a four per cent decrease in propulsion power compared to the original design. In another project, a 3,000 TEU container ship was to be modified to minimize power consumption. Starting from a well-optimized symmetric baseline design, the asymmetric aft ship reduced propulsion power by three per cent, a result confirmed in model tests.

These and other examples have shown that the achievable gains in propulsion efficiency are generally higher for bulk carriers and tankers than for container ships. Depending on vessel design and operating profile, fuel efficiency improvements of up to five per cent are possible when starting from a well-designed symmetric baseline. Added benefits of a twisted stern include higher structural robustness and minimized vibration and fatigue.

The Fluid Engineering team at DNV GL can draw on decades of experience pioneering parametric hull line optimization. Implemented in close cooperation with both the customer and the yard, its ECO Lines asymmetric stern optimization service ensures reliable calculations, confirmed results from proven experts, and accurate execution at the yard. Ernst A. Nönnecke's ingenious idea is finally coming to full fruition. ■ **AK**

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DNV GL'S DIGITAL JOURNEY

From electronic certificates, machine learning tools and drone surveys to the launch of a new industry data platform, DNV GL is embracing digitalization to enhance class services and improve communication with customers.

Shipping has undergone a remarkable transformation over the past few decades. Advances in technology, new materials and new insights into the design, construction and operation of vessels mean that they are more complex, more efficient and larger than ever before. While the use of ship-to-shore data and greater digitalization is improving operations and performance, reducing maintenance and operational costs, as well as enhancing safety. DNV GL has been at the heart of this transformation for more than 150 years.

"For us, digitalization is not an end in itself, we see it as another means to fulfil our main purpose: ensuring safe operations at sea and protecting life, property and the environment," says Knut Ørbeck-Nilssen, CEO of DNV GL – Maritime. "The role of class in ensuring the integrity of the vessel and safety of the crew will continue, but the way surveys are conducted may change significantly. Furthermore, digitalization enables us to become more efficient and improve our level of service," he adds.

Single access point to all digital services

When our customers interact with classification, they want this to be as simple and efficient as possible. To help, we launched My DNV GL. This is a single access point for all of our digital services, with many applications designed to support our customers in areas such as port state control inspections (see info box – PSC Planner), cybersecurity preparedness and regulatory compliance. To provide worldwide access to class documentation,

ELECTRONIC CERTIFICATES

Starting in September 2017, DNV GL will introduce electronic certificates for the class and statutory regimes. Accessible from anywhere in the world, electronic certificates bring many advantages to both DNV GL and its customers. By eliminating paper handling, they reduce the administrative burden on all stakeholders. A validation solution ensures that electronic certificates are just as safe as paper. In addition, electronic certificates are easy and convenient to share.

Compiling them in My DNV GL provides a comprehensive overview of key ship data that cannot get lost and is just a few clicks away. For DNV GL, electronic certificates help make processes more efficient, and they provide experts with easy access to certificates when they need to check up on something, be it during a survey or at a customer meeting. Electronic certificates will be rolled out gradually and will be implemented with a vessel's next annual survey.

Digitalization is enhancing our understanding of maritime operations, improving efficiency and helping to reduce costs.

"For us at DNV GL, digitalization is not an end in itself, we see it as another means to fulfil our main purpose: ensuring safe operations at sea and protecting life, property and the environment."

Knut Ørbeck-Nilssen, CEO of DNV GL – Maritime

SMART SURVEY BOOKING

The Smart Survey Booking tool will be launched towards the end of the year. It simplifies survey booking, fitting inspections into the customers' schedule while saving time and costs. This is how it works:

- Customers are notified about the best time to order surveys and audits and notified shortly before the due date of the next survey.
- The tool proposes the scope of the survey and states how long a survey of this scope would take.
- A list of approved service suppliers in each port is provided, and helps operators to find out whether an in-water survey can be performed in a specific port.
- The tool offers up-front cost estimates including travel and overtime charges for survey combinations during any given port stays based on ETA (estimated time of arrival) and ETD (estimated time of departure).
- Based on automatically calculated cost estimates and the possible scope of the inspection in each port, customers can compare and benchmark various port-stay options.
- Once the date is set, the tool attaches relevant survey preparation notes to the booking confirmation to help the operator prepare for the inspection.

Photos: DNV GL, momentscatcher/zinkevych - Fotolia

DNV GL customers will soon be able to use electronic certificates. This means their documentation never gets lost, is always up to date and is accessible from any device (see info box – Electronic Certificates).

"And with the introduction of our new simple survey booking tool towards the end of the year, we will also start using intelligent software agents to help customers find the best time and place to book a survey," adds Ørbeck-Nilssen (see info box – Simple Survey Booking). When customers have questions or run into a problem, they can get in touch with one of DNV GL's technical experts through the DATE service. "This service has been a great success and now, to make it even better, we have introduced a tool that uses machine learning to automatically match our customers with the right expert for their question," says Ørbeck- Nilssen. The tool has already analysed more than 200,000 requests and is continuing to learn (see info box – Machine Learning). "Soon, we expect it will be able to answer simple questions on its own," he adds.

Modern survey methods

One of the most important ways we work to keep shipping safe is by conducting annual surveys on all of the vessels in our class. So far this has meant a surveyor needs to crawl and climb to reach every remote corner inside a ship. But new technologies are changing even how DNV GL does this. Already, surveyors have used camera-equipped drones to visually inspect large cargo holds and tanks. Using a drone opens up a lot of new possibilities. "In the future, drones could eventually be piloted remotely or even autonomously, meaning the surveyors could work from their >

> desk thousands of miles away from the ship and inspect the vessel in virtual reality (VR)," says Ørbeck-Nilssen.

For our customers, the successful delivery and regular inspections of a vessel as well as interactions with class are just one part of a bigger puzzle. The other big questions are: How does the design perform in daily operations? Is the engine achieving optimal fuel consumption? And are the safety systems reliable at sea?

Turning data into business intelligence

Today, advanced sensor technology and powerful satellite connections have opened up a new range of possibilities for understanding more about vessels and their operation. Everything on board, from the engines, the propeller and the safety systems to the containers themselves can be fitted with smart sensors to monitor performance and catch irregularities early on. This information can then be fed into the DNV GL performance management platform ECO Insight, which can check the quality of the data before analysing it. "This lets operators benchmark their vessels against the world fleet, turning their data into valuable business intelligence," says Ørbeck-Nilssen.

DNV GL can also take this data and combine it with information from inspections and a 3D model of the ship to build a "digital twin" – a digital copy of a real object, modelled to exactly represent its properties. DNV GL experts can use the digital twin to find the best design, see how the networks on board respond to cyberattacks, test measures to improve performance and identify when vital equipment needs maintenance or replacement – throughout the lifetime of the vessel. Ultimately, digital systems could end up controlling ships entirely – without the need for a human crew. An autonomous ship would use advanced navigation software and smart control systems to follow a course, avoid obstacles and safely deliver its cargo. Of course, if the industry is going to rely on these systems, they need to be as reliable and secure as possible. With software-in-the-loop testing and a digital twin, DNV GL can check and correct weaknesses in the system.

The broader view

These new digital solutions are not confined to the world of shipping. "It doesn't matter where you look in DNV GL, our customers are using data analytics to improve safety, gain efficiencies, reduce environmental impacts and evolve new business models," says Remi Eriksen, Group President & CEO at DNV GL. "On drill ships, we've seen how sensor data and advanced data analytics are helping our customers save millions of dollars in downtime. In the renewables industry, power cybernetics is helping to integrate variable wind and solar power safely into the grid, while machine learning helps oil and gas pipelines become safer by drawing insights from previously unconnected data sets," he explains.

A new industry data platform

All of these advances need many different project partners working together with accurate, reliable and secure data from multiple sources. And as decision-making and business models become more data-driven, trustworthy data becomes even more valuable. "Without trust in this data, truly cooperative projects cannot deliver the progress we hope for. At DNV GL, we have always been trusted with data, trusted to give an independent expert view and trusted to connect different industry players. That is why we have created a place for industry experts and data to come together

MACHINE LEARNING

DNV GL has introduced a new machine learning tool to the Direct Access to Technical Experts service (DATE). When customers have a query, this service connects them to one of more than 400 technical experts located at five support hubs worldwide. DATE was used more than 20,000 times in 2016, with over 97 per cent of requests being completed within the customer's deadline. Matching every request with the right expert as quickly as possible is essential. DNV GL's new machine learning tool searches for key words in a customer enquiry to create a profile for each request. Then it sends the request to an appropriate expert. After a piloting phase the machine learning tool went live for all DATE requests at the beginning of May 2017. It has viewed about 200,000 requests already and is learning continually. In the future, it could even answer simple questions on its own.

DNV GL surveyors perform a final check on one of the custom-built DNV GL drones, before using it to inspect a cargo tank.

Advanced technology is helping to modernize communication with class and is changing the way DNV GL conducts surveys.

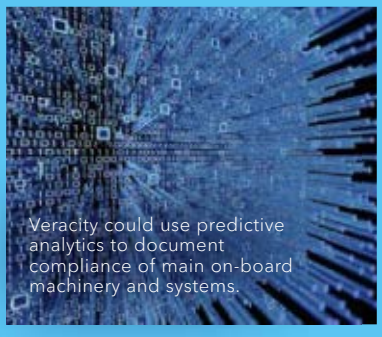
securely: our new, multi-sided industry data platform called Veracity," says Remi Eriksen.

Veracity is a meeting ground for co-innovation and co-creation between multiple industry stakeholders, playing a key role by assuring data quality, data security and access. It is an open platform for qualifying, unlocking and improving data from sensors and other sources. Customers stay in control in this secure environment, and can trust domain experts, algorithms and analytics to combine and transform their data into real value. And Veracity could be a key component of a class-concept built around sensor-based data: securing and assuring data for use in the condition assessment of the hull and critical components.

"The digital transformation cannot be realized with one solution or one service. It is a journey," says Knut Ørbeck-Nilssen. "By working together with us, customers can capitalize on these new opportunities – to make the world safer, smarter and greener."

VERACITY

The Veracity industry data platform is designed to help companies improve data quality and manage the ownership, security, sharing and use of data. One area where the maritime industry could benefit from the Veracity data platform in the future could be allowing DNV GL's maritime customers to document compliance of main on-board machinery and systems through predictive analytics, removing the need for calendar-based inspections. In one of DNV GL's first pilot projects a drilling operator embarked on a project to explore predictive analytics with a components vendor and an analytics services company. Working with DNV GL to see if this approach could gain class approval, an analysis of the data revealed severe quality issues that none of the partners were previously aware of. Once the data was quality-assured, machine learning algorithms could be applied to the data with success. A key learning from the project was that it demonstrated the need for continuous data management and quality assurance to reap the benefits of a data-driven approach.



Veracity could use predictive analytics to document compliance of main on-board machinery and systems.

PSC PLANNER

Launched in April 2017, the Port State Control (PSC) Planner is one of the most recent additions to the My DNV GL customer portal. Designed to help shipowners, managers and operators increase operational efficiency, the PSC Planner gives an overview of vessel or fleetwide PSC performance, which can then be benchmarked against the IACS-classed world fleet. The tool also assists the crew on board by highlighting specific areas to focus on when preparing for the next inspection.

Find out more at:
www.dnvgl.com/maritime/mydnvgl-service-overview/psc-planner.html

Photos: DNV GL, Devrimb-Thinkstock, donvictorio – Fotolia

TREAT HER RIGHT

With the ratification of the Ballast Water Management Convention, shipowners are pressed to decide which treatment systems to choose. For manufacturers keen to be selected, attaining type approval by the U.S. Coast Guard can be a deciding factor. DNV GL provides comprehensive support.

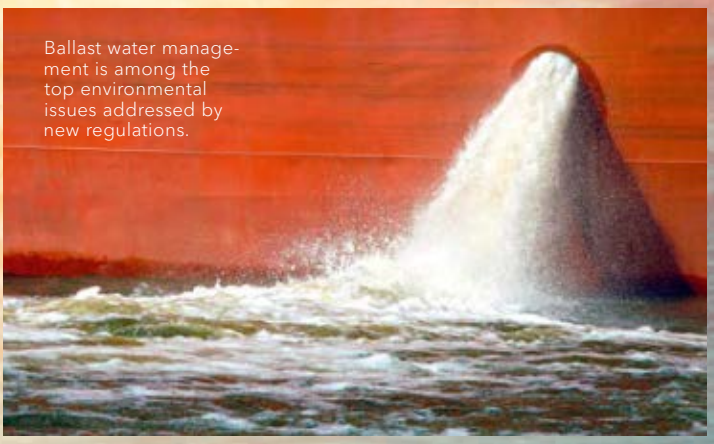
After many years of discussions, the date is set. The IMO's Ballast Water Management Convention will enter into force on 8 September 2017. For operators with vessels that discharge ballast water in international waters, this means that they must have a treatment system installed on their vessels within five years. The specific deadline depends on the next renewal survey of a vessel's International Oil Pollution Prevention (IOPP) certificate.

For many operators trying to decide which type of system to install, one of the most important questions is: Does the system meet the U.S. Coast Guard (USCG) requirements? In late 2016, the manufacturers Alfa Laval, Optimarin and OceanSaver became the first to be awarded U.S. Coast Guard type approval certificates for their ballast water treatment systems. "We are proud to have worked with all three of these successful applicants from the very beginning," says Martin Olofsson, Senior Principal Engineer, Environmental Protection DNV GL – Maritime Approval of Ship Systems and Components.

More systems close to approval

In the first quarter of 2017, DNV GL submitted two further applications to the U.S. Coast Guard, for manufacturers Sunrui and Ecochlor. "Currently, we have also completed land-based testing cycles for four further manufacturers. Successfully passing land-based testing is a good indication that the systems could also meet the U.S. Coast Guard's requirements, once they have undergone shipboard testing," says Olofsson. "Land-based testing really challenges the efficacy of these systems. In 15 test cycles, they expose the systems to 1,000 times more large organisms and ten times more medium-sized organisms than shipboard testing." If all goes to plan, another four systems could be approved in the first half of 2018.

The USCG officially appointed DNV GL as an Independent Laboratory (IL) to perform type approval testing of ballast water treatment systems (BWTS) in 2013. "DNV GL and its associated sub-laboratories DHI Denmark, NIVA (Norway), Golden Bear Facility (USA) and DHI Singapore have been deep into the details of USCG testing for three years and have gained substantial experience in what is practical and possible to achieve in compliance with the regulation," says Olofsson. There are now five



Ballast water management is among the top environmental issues addressed by new regulations.

"Independent Laboratory" accreditations for BWTS. Out of 45 BWTS manufacturers who have signed a letter of intent for having their systems approved by the USCG, DNV GL is currently handling 25, making it the largest independent provider of laboratory services by far.

The choice of the best-suited treatment system for a particular vessel depends on a number of factors: What ship type is it? Does the vessel operate in fresh or brackish water? Does it primarily sail in cold or temperate waters? Will the system have to work in high-turbidity conditions, meaning water that contains a lot of clay, algae or silt? All these questions are very important for making the right choice. The five treatment systems which already hold or are soon expected to hold a USCG type approval certificate include UV systems, electrolytic systems and chemical injection systems. Read on to see how these types of systems work, which operational profiles they can handle and their advantages and drawbacks (see next page). **AJO/HH**

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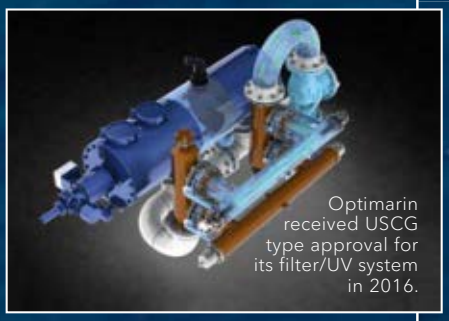
SELECTED BWT SYSTEMS AT A GLANCE

UV SYSTEMS

- **How it works:** With a market share of 50 per cent, UV systems are the most popular option at present. They use a two-step process of filtration and ultraviolet (UV) irradiation to sterilize organisms and stop their reproduction.
- **Suitable for:** UV systems are suitable for any vessel in theory, but primarily for those which do not take in too much ballast water and have flow rates of up to around 1,000 cubic metres per hour. This includes ro-ro vessels, container ships, offshore supply vessels and ferries.
- **Advantages/Challenges:** UV systems are easy to install and retrofit, and have few safety concerns from a class point of view. They also operate independently, no matter what the water salinity and temperature are. However, they are dependent on the water transmittance (UV-T) and work less well in turbid water. The U.S. Coast Guard's interpretation that any organisms released into US waters should be dead before leaving the vessel, rather than just made infertile, means that a type-approved filter+UV system becomes more sensitive to water turbidity and may require longer holding times to ensure mortality.



Optimarin received USCG type approval for its filter/UV system in 2016.

ELECTROLYTIC SYSTEMS

- **How it works:** Electrolytic treatment systems have a market share of around 35 per cent and therefore come second in the treatment systems' ranking. Many of these systems also use a filter as a pretreatment. By passing an electric current through a small side-stream of seawater, they use the salt and the water molecules in a chemical reaction to generate sodium hypochlorite, a disinfectant, which is then reinjected into the ballast water to kill all organisms.
- **Suitable for:** Electrolytic treatment systems are more suited for larger vessels such as tankers and bulk carriers, which have large ballast water volumes and high flow rates in the range of up to 8,000 cubic metres per hour.
- **Advantages/Challenges:** As well as being able to handle large capacities, electrolysis-based systems are very efficient and the treatment of the water is done on the intake only (possible neutralization on discharge). This means they provide on-board disinfection, and some systems even provide in-tank circulation treatment during the voyage, when treatment in the port is not feasible. One of the disadvantages is that the electrolytic reaction generates small amounts of hydrogen gas, a factor which needs to be accounted for in safety considerations. In addition, electrolytic systems are sensitive to low salinity and low temperatures, so salt or a heating system must be added where necessary. Finally, they are more complex to install, control and maintain compared to UV filter systems.

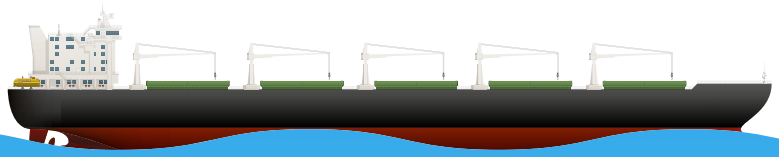
CHEMICAL INJECTION SYSTEMS

- **How it works:** These systems are often used in combination with filtration. A chemical solution is injected into the ballast water to ensure disinfection. The disinfectant may be liquid or granular and will sometimes require neutralization prior to discharge overboard. Some of the active substances which are commonly used include sodium hypochlorite, peracetic acid and chlorine dioxide.
- **Suitable for:** Chemical injection systems are deemed appropriate for most ballast flow capacities ranging up to 16,000 cubic metres per hour and are mostly used to treat ballast water on vessels with larger capacities and flow rates, such as tankers and bulkers. The technology also makes it suitable for infrequent usage and is also good for disinfecting tanks that have been used without treating the ballast water during ballasting and deballasting in local waters.
- **Advantages/Challenges:** Chemical injection systems generally have low power requirements, because their only energy consumption comes from distributing the chemicals into the ballast water. With the dosing pump as their main component these systems require less space on board, making them easier to install than other technologies. However, the chemicals which are used, such as Peraclean or Purate, are trademarked, and supply might be limited to specific ports. In addition, the chemicals must be stored on board in closed containers and may be hazardous. The use of chemicals requires implementation of strict safety provisions and crew training. Having to stock up the supply of chemicals regularly also generates additional operational costs compared to UV or electrolysis systems, which have electricity as their main cost item.

Photos: Dudarev Mikhail - Fotolia, Hasenpusch, Optimarin

PREPARING FOR MRV COMPLIANCE

The European Union's Monitoring, Reporting and Verification (MRV) regulation requires, as a first step towards compliance, monitoring plans for every ship to be submitted to independent verifiers by 31 August 2017 at the latest. This overview helps owners and operators get ready.



YOUR FOCUS/ CHALLENGES

Study the EU MRV regulation – familiarize yourself with the "M" (monitoring) and "R" (reporting") in particular. Identify challenges such as how to monitor cargo for particular vessels etc.

Assess your **reporting system** and decide whether it satisfies the MRV regulation. In case the system needs an extension or replacement, allocate resources to decide on the right system, its distribution and implementation on board your vessels.

Gain confidence in data reported by your crew by assessing the related data quality. This enables you to take corrective measures before reporting commences in 2018.

DNV GL SUPPORT

DNV GL has published an MRV guidance paper and offers webinars, regional meetings and seminars throughout 2017.

Should you have specific questions or need clarification on the regulation, please see the FAQs at **www.dnvgl.com/mrv** or contact your local DNV GL office directly.

DNV GL's MRV Readiness Check app provides a first assessment of whether you are EU MRV-ready or not. It guides you through a condensed checklist covering all aspects of the regulation, giving you a clear picture of your present preparation status and leaving you with a to-do list to plan your next steps. The app is available to our customers through *My DNV GL* free of charge.

Should more detailed support be required, DNV GL offers a tailored **MRV Ready service** through our Advisory department.

Navigator Insight is the DNV GL solution for ship-to-shore reporting. It comes with an on-board reporting tool for manual input of all the parameters required by the MRV regulation and can be extended to cover all aspects of daily ship operations. More than 450 plausibility checks enhance data quality before the data is sent ashore. More information can be found at **www.dnvgl.com/navigator-insight**.

MY DNV GL APP: MRVMP

The app

- The application will help users generate an MRV monitoring plan and hand it in for approval

Features

- Provides an easy-to-use, step-by-step template that helps with pre-filled technical information of the particular vessel to generate the MRV monitoring plan
- Smooth 1-click transition from plan to approval with discounted pricing for verification

Benefits

- Informs about the upcoming MRV regulation
- Saves time and effort on both the customer and DNV GL side
- All relevant vessel data is stored and accessible via *My DNV GL*
- Avoids the need for iterative clarifications

The upcoming EU MRV regulation requires careful attention. As a very first step, companies should assess whether tools already in place today will suffice for the MRV regulation and its reporting needs or whether they need to be extended or maybe even replaced by a new solution. Important questions to ask include:

- Is my system capturing all the required data? Is it also capable of differentiating between EU ports and non-EU ports, while reflecting on the different fuels and emissions at berth as well as many additional details such as anchoring time? Does it allow for repair calls in ports not subject to reporting requirements and so forth?
- Will I be able to efficiently extract and aggregate all the required data as necessary for the emissions report and corresponding verification?
- Is the system sufficiently implemented within the company to ensure a certain data quality which matters for MRV reporting, as data will be made publically available?

Once assessed and decided, companies will need to establish management procedures to ensure successful implementation of their monitoring systems and their proper usage on board. On the way towards compliance, we propose the following actions:

Companies have until 31 August 2017 to create and submit a ship-specific **monitoring plan** to the contracted verifiers indicating the method chosen to monitor and report emissions and other relevant information for each vessel over 5,000 GT that calls at EU and EFTA ports.

Preparing the monitoring plan can be a time-consuming task. Its content is specified in detail by the EU MRV regulation. Requirements include ship-specific data, such as emission sources, as well as information about the development and implementation of additional management procedures.

The first **reporting** period commences at the start of 2018. Based on your individual monitoring plans, your vessels will collect all the necessary data and transfer them ashore.

We suggest you initiate the processing of data in 2017 so there is still time to take corrective action in case any system or process shortcomings are discovered.

Prepare the emissions report and submit it to the contracted verifier. DNV GL has incorporated the guideline on verification for its verification activities.

DNV GL's MRV monitoring plan app supports you in preparing your monitoring plans for your entire fleet – semi-automatically and efficiently. The app pre-populates technical input fields in advance where data is already available from external data sources such as vessel particulars. It supports the definition of management procedures by offering predefined text blocks. Upon completion it compiles all information gathered in the correct format. The app is available to our customers through *My DNV GL* free of charge.

DNV GL's monitoring plan verification
We will verify whether your company has compliant monitoring plans and is ready to submit plausible emissions reports. DNV GL will design the verification process as digital as possible to reduce the additional work for you.

Navigator Insight is our suggested tool for ship-to-shore data collection and reporting.

DNV GL's emissions report verification
Verification of your emissions report(s) starts in January 2019. DNV GL will design the verification process as digital as possible to reduce the additional work for you. We will check your emissions report against your voyage log abstract and the external data we require.

Please refer to
www.dnvgl.com/mrv
for a comprehensive overview of all topics regarding the EU MRV regulation.

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Cleaner air comes at a price: in all scenarios foreseeable today shipping becomes more costly.

SULPHUR CAP AHEAD – TIME TO TAKE ACTION

According to IMO estimates, the 0.50 per cent sulphur limit for marine fuels in 2020 will affect as many as 70,000 ships. Choosing the most economically feasible option for compliance is difficult. DNV GL provides decision support.

The introduction of the new global sulphur cap in 2020 is causing nothing short of a paradigm shift in marine fuel. It is more than just another regulation – it is a complex challenge, and how you choose to comply may ultimately impact the future competitiveness of your assets. There is a great deal of uncertainty related to enforcement, fuel availability and technological solutions.

It is challenging to make exact predictions regarding the most cost-efficient approach. DNV GL has compiled and thoroughly analysed available information to give shipowners a comprehensive overview of the various compliance options. Every ship is different and so is its operational profile. The ultimate decision between HFO and scrubber, distillate fuel (MGO), LNG, low-sulphur fuels (0.50 % S) or other, alternative fuels should to be evaluated individually.

Depending on the underlying assumptions, the calculations lead to different conclusions. DNV GL has established scenarios that can be used as a guidance for investment decisions. Needless to say, any unexpected event, such as volatile changes of fossil fuel prices, can substantially change the outcome. It should however be noted that by 2020, a vast majority of ships will continue to run on whichever compliant fuel, that can be supplied in a port. This will be a higher-valued product compared to conventional HFO, thus inevitably will increase the operating costs. It is in owners' best interest to investigate all compliance options which may increase their competitive edge.

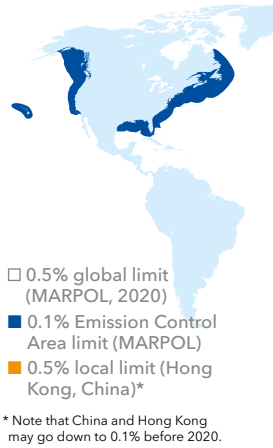
The status quo

Emission Control Areas (ECAs) in European and North American waters already impose a 0.1 per cent sulphur limit today, and new domestic control areas are being established in ports and areas in China. Most ships switch from HFO to MGO to ensure compliance. For alternative means of compliance, regional restrictions and limitations must be taken into consideration. Factors such as suitable scrubber technology, scrubber water disposal or availability of specific fuels need to be evaluated.

Looking towards 2020, it is challenging to make precise predictions of the future fuel availability and its pricing. The refinery industry will carefully evaluate its future production capacity investments by examining the market expectations and the demand. Shipowners on the other side, tend to assume that refineries will be able to provide enough of the compliant fuel

ECA ZONES

Independent of the 0.5 per cent global fuel cap, the emission control areas (ECAs) in Europe and around North America, possibly followed by China in a few years, impose a 0.1 sulphur limit in ship fuel today.



* Note that China and Hong Kong may go down to 0.1% before 2020.

Area	Sulphur limit	Scrubbers
Global	0.5 % (2020)	yes
Sulphur ECA	0.1 %	yes
EU	0.1 % in all ports	open-loop restricted in some countries
China	0.5 % in selected areas	yes
California	0.1 % within 24 nm	no, only through research exemption

POSSIBLE COMPLIANCE SOLUTIONS FOR A BULK CARRIER

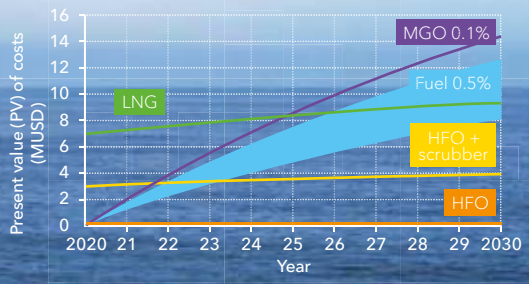
Three possible solutions for various operating profiles, ECA exposures and ship ages

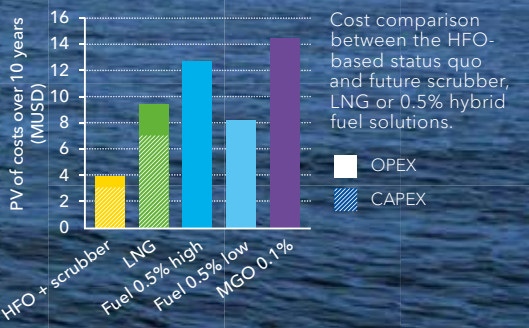
	BULKER I	BULKER II	BULKER III
Age	3	13	to be built
Operating profile	normal speed profile	normal speed profile	medium/high speed
ECA exposure	medium	low	high
North American trade	no	no	yes
SOLUTION #1	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA	**Hybrid fuel** 0.5% outside ECA 0.1% in ECA +EGR/SCR (Tier III)
SOLUTION #2	**HFO + scrubber** 0.5% outside ECA 0.1% in ECA	**HFO + scrubber** 0.5% outside ECA 0.1% in ECA	**HFO + scrubber** 0.5% outside ECA 0.1% in ECA +EGR/SCR (Tier III)
SOLUTION #3			**LNG** +EGR/SCR (Tier III)*

* Using LNG as marine fuel removes 85-90% of NO_x in the case of low-pressure engines (2- and 4-stroke), while for a high-pressure engine without further emission abatement systems, NO_x removal is typically 40% to 50% when operating on LNG, hence requiring EGR or SCR.

ACCUMULATED COSTS RELATIVE TO HFO BASELINE

Hypothetical scenarios for a handymax bulk carrier





to satisfy the increased demand. The researchers and industry experts do not seem to agree either. A 2016 IMO study indicates that the refining capacity will be sufficient to provide adequate quantities of low-sulphur marine fuel by 2020. There are other sources however, which are more sceptical, pointing to the fact that desulphurization is technically difficult, costly and may discourage refineries from such investment. All of those different opinions and strategies trigger off a lot of uncertainty.

Enforcement of the sulphur cap comes with new requirements. EU member states will be obliged to check 10 per cent of all ships calling at their ports for compliance with the EU Sulphur Directive. There are also reporting duties related to fuel sample analyses and surveys. In order to raise awareness of the sulphur control issues, inspectors and crews will have to be appropriately trained. Enforcement on the high seas is still an open question.

The options

It is clear that every owner has an interest in identifying the most economical and competitive strategy for sulphur cap compliance. DNV GL has prepared special evaluation lists presenting all of the available options. These lists are sensitive to various factors such as ship age, operating regions, trade patterns, as well as cost development diagrams accounting for the CAPEX and OPEX of each solution.

It has turned out that based on our assumptions for future cost of fuels and the corresponding investment, a SO_x scrubber installation may prove to be the most cost-efficient choice over a ten-year period. It must be noted however, that the experience with respect to scrubber technology is mainly limited to some passenger and ro-ro vessels operating in ECAs. Retrofitting a scrubber system can be technically challenging. Furthermore, certain local restrictions regarding the discharge of scrubber wash water or sludge disposal may apply in addition.

On the fuel side, it is expected that new 0.50% S-compliant blends will be introduced. Similar to hybrid fuels used in ECAs today, a diligent use and handling of them will be important for safe and successful operation.

Among alternative fuels, LNG will probably get more traction as availability and bunkering infrastructure improve. This however, applies mainly to the newbuild tonnage, especially for ships which will operate extensively within NO_x ECA regions. Beyond being a sulphur-free fuel, LNG also offers a reduction in NO_x emissions particulate matter and CO_2 footprint compared with conventional fuels. Given the present regulatory outlook, these fuel characteristics will probably become more and more attractive in the future.

Another question in the feasibility equation is the proportion of time a vessel spends inside the ECAs. Furthermore, there is also an element of the fuel consumption which partly defines the attractiveness of the ship in the charter market. A free DNV GL guidance paper "Global Sulphur Cap 2020" is available for download. In addition, DNV GL offers a wide range of advisory services to help find the most cost-effective compliance strategy, including ship-specific calculation services and feasibility studies. **AK**

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INDICATIONS OF SLIGHT NEAR-TERM RECOVERY

During the first quarter of 2017 the dry bulk market still showed signs of strain. Whilst there are indications of cautious optimism in the segment, a major market upswing in the near future is unlikely, given the substantial oversupply of tonnage. Nevertheless, average earnings are expected to outperform the levels seen in the last two years.

Following robust activity in 2016, the dry bulk import demand from China continued to grow in the first quarter of 2017. The steady increase of Chinese imports is driven by the availability of very competitively priced iron ore from Australia and Brazil replacing some of the domestic production, along with high demand for imported coal to compensate for domestic production cuts.

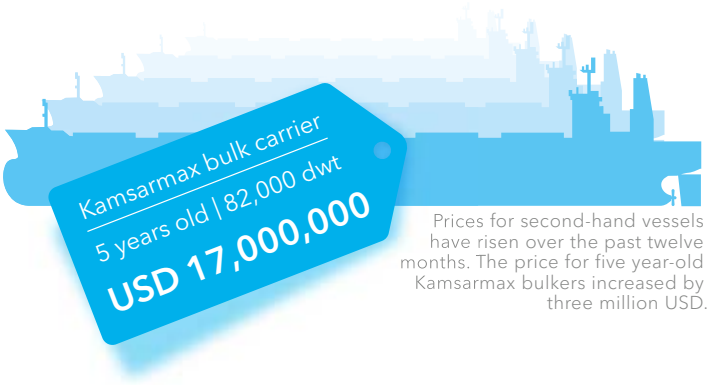
The latest seaborne trade statistics indicate a 13 per cent year-on-year rise in total iron, and an 48 per cent increase in coal imports to China as at end of March 2017. With the overall dry bulk demand firming, average bulker earnings reached 11,133 US dollars (USD) per day in March and the BDI stood at 1,141 points (versus 383 points in March 2016).

Second-hand prices have risen as well and recorded firm gains in the year to date. A five-year-old 82,000 dwt Kamsarmax can be purchased for 17 million US dollars which is three million USD above the 2016 price.

The newbuilding price for a similar-sized ship is estimated to be around 24.5 million US dollars and growing interest has been reported, especially in China. But so far in 2017, the number of signed contracts has remained rather low. Orders for one Capesize and two handysize bulkers, as well as four Panamaxes and one ore carrier were placed. Depressed dry bulk market conditions last year resulted in an increased non-delivery rate of the scheduled order book. In fact, non-deliveries in 2016 reached a rate of 46 per cent, compared to 36 per cent in 2015. Thus overall deliveries dropped to a seven-year low of 47 million dwt in 2016.

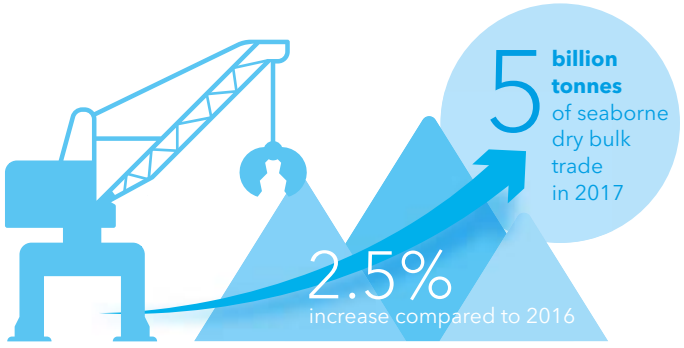
The pace of fleet growth is expected to remain subdued

The pace of fleet growth has fallen sharply since 2010 when the fleet was growing by a record 17 per cent. In 2016, the supply-side response to difficult market conditions caused the bulker fleet to grow at the slowest pace so far this century. Shipowners took drastic measures, including intense scrapping and delivery deferral, which in combination resulted in fleet growth hitting a 16-year low of 2.3 per cent in 2016. Total scrapping reached 29 million dwt last year, the third-highest total on record. We expect scrapping to increase over the next few years due to upcoming



Prices for second-hand vessels have risen over the past twelve months. The price for five year-old Kamsarmax bulkers increased by three million USD.

With the overall dry bulk demand firming, average bulker earnings have improved somewhat.



Strong demand in China is expected to support seaborne trade.

regulations. In many cases installing compliant technologies is not an economical solution, especially for owners of old tonnage. For example, the cost of installing a ballast water management system on a Panamax bulker is estimated to be around USD 800,000 to one million USD, with an additional USD 0.5 million for dry-docking. This is a substantial investment, bearing in mind that a 15-year-old ship is valued around USD 4.5 million, which is only USD 1.5 million above the scrapping price. Therefore current projections indicate a fleet expansion of only two per cent in 2017 on the back of continued high scrapping activities, lower levels of deliveries and continued newbuilding delays.

Market performance still down to China

The latest forecasts for 2017 indicate a global growth in seaborne dry bulk trade of around 2.5 per cent, totalling five billion tonnes. This is somewhat faster than what was recorded last year, but still moderate compared to historic values. The global seaborne iron ore trade is expected to rise by five per cent as Chinese demand continues to rise and the pressure on domestic iron ore mining increases. Global seaborne steam coal imports are projected to increase by around one per cent to reach approximately 899 million tonnes. Chinese steam coal imports are expected to remain highly sensitive to Beijing's policy decisions, given the significant volumes of coal mined domestically.

All in all, the market has gained momentum in recent months and sentiment has improved. Whilst concerns remain over the demand outlook, and improvements in conditions may be limited in scope, it does seem that the market has bottomed out. ■ **PP**

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