MARITIME IMPACT

ISSUE 02–14

THE MAGAZINE FOR CUSTOMERS AND BUSINESS PARTNERS

THE FUTURE OF SHIPPING

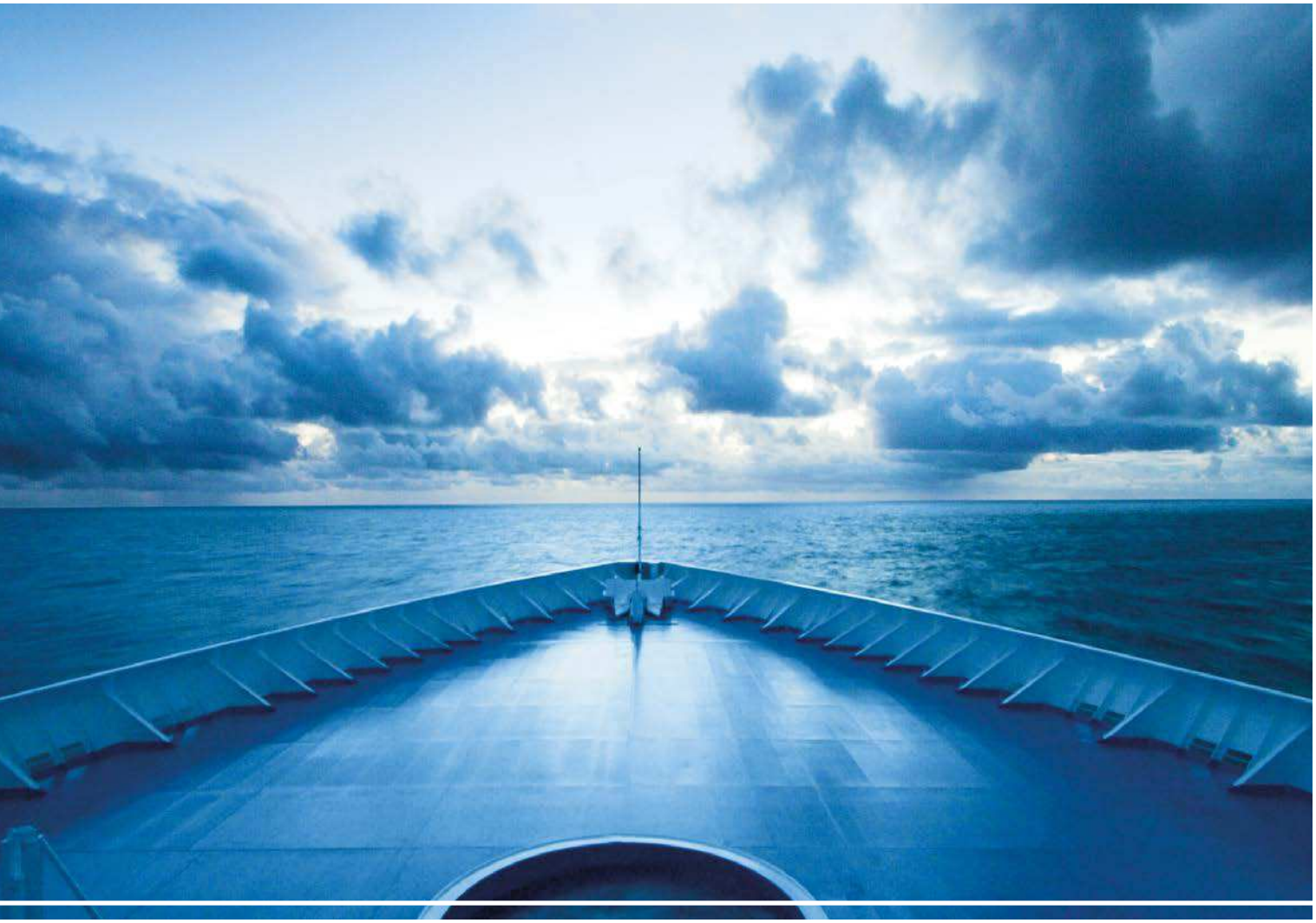
SETTING THE COURSE

SHIP DESIGN
Size matters – the limits for future container vessels

LOW CARBON
New concepts for optimising LNG propulsion systems

ZERO EMISSIONS
Fully battery-powered vessels to revolutionise short-sea shipping

DNV·GL



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As your classification and advisory partner, we provide you with the latest technical developments and future solutions for today's challenges.

Visit our **Stand No. 207** in **Hall B4** on the **ground floor** – and be sure to join our talks and presentations at the **DNV GL Forum, East Entrance:**

Tuesday, 9 September

13.30 **Efficient designs and optimisation**

15.30 **Next-generation bulk carrier concepts**

16.00 **Technology update for gas carriers**

Wednesday, 10 September

11.00 **Cost-efficient operation**

13.30 **LNG solutions / emissions control**

15.30 **Environmental regulations**

Thursday, 11 September

10.30 **Technology and innovation**

13.00 **Naval classification** (classification societies – trusted partners to navies)

14.30 **Market and design developments for MPVs**

16.00 **Containership design and performance**

Friday, 12 September

11.00 **Offshore support vessels**

MORE DETAILS

dnvgl.com/forum

SAFER, SMARTER, GREENER

DNV·GL

Tor E. Svensen
CEO of DNV GL Maritime

Dear Reader,

Every two years in September the city of Hamburg stops, as all eyes are on your industry. SMM is not only the leading international trade fair for the maritime world, it is very much an important part of our history and our business at DNV GL, bringing us closer to our customers and allowing us to share our ideas, and our vision for the future.

This year we have decided, in recognition of the anniversary of our foundation, to raise our involvement with SMM to the next level, acting for the first time as the main sponsor of the whole fair. This will allow us some extra opportunities of connecting with our customers, the most notable being the DNV GL Forum, where we will hold presentations throughout the week of the fair. The Forum will be a true showcase of our broader view for the industry and I hope that many of you will be able to attend and participate.

The theme for this year's fair is "keeping the course". Over the last 150 years, DNV GL has worked very hard together with our partners in the business to remain true to our course – to improve safety and to spur innovation for the benefit of our customers and the environment.

In the maritime world as a whole we should stick to our course. However, in the business and regulatory climate we face today, to get there we may have to adjust course. The recognition that some aspects of our business must change has never been so strong and we can see this in the shift towards alternative fuels and the central role of energy management.

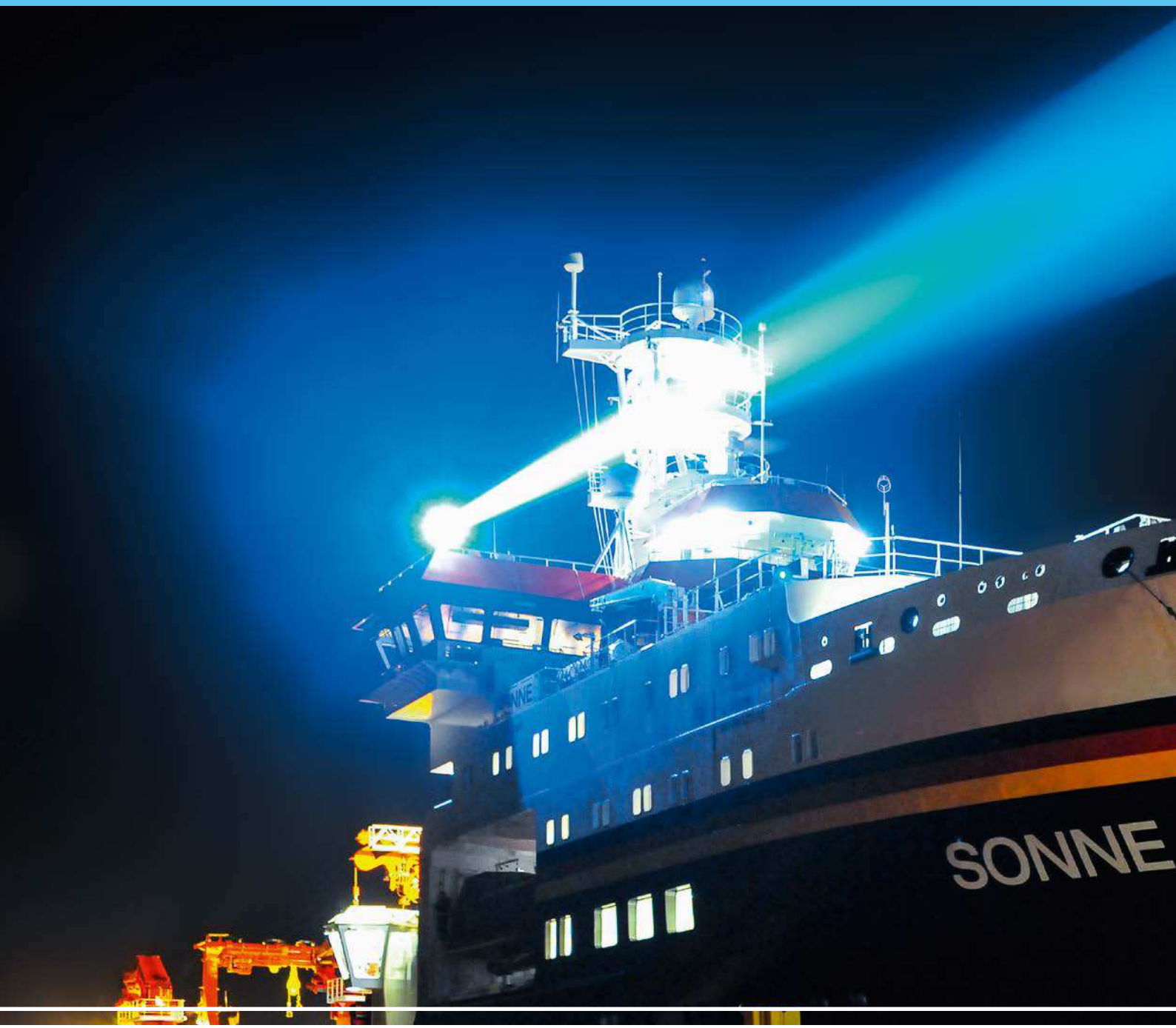
Many of the stories in this issue of Maritime Impact illustrate these trends, whether it is the adoption of LNG as a ship fuel, new designs that point the way to a zero-carbon future, or the new ECO Insight service.

The course we strike in the maritime world is one that we take together. In partnership we can ensure that on this journey shipping remains a vital and thriving part of our global economy, is safe for all, and continues to improve its environmental record.

Tor E. Svensen

HERE COMES THE SUN

German marine and atmospheric scientists can look forward to working on board one of the world's most advanced research vessels, which will be handed over in November.



She is a beauty of a ship, she has everything you could want from a research vessel, and one can only envy the scientists who will be able to work on board "Sonne" (sun), the new flagship of Germany's research fleet. Built with DNV GL class by MEYER WERFT, "Sonne" is 116 metres long, 20.6 metres wide, has a 700-square-metre-working deck and 550 square metres of laboratory space, can accommodate 40 scientists and is designed for a crew of 35. Chancellor Angela Merkel who christened the ship in July called her "an impressive masterpiece of German shipbuilding and engineering – truly a high-tech ship that fully satisfies the requirements of advanced oceanic research".

"Sonne" will explore the deep sea of the Indian and Pacific Ocean to expand our understanding of climate change, marine resources and the impact of humans on marine ecosystems. "It is an honour for us at DNV GL to be watching over this very special ship," said Knut Ørbeck-Nilssen, President of DNV GL Maritime.

Photo: Ingrid Fiebak-Kremer

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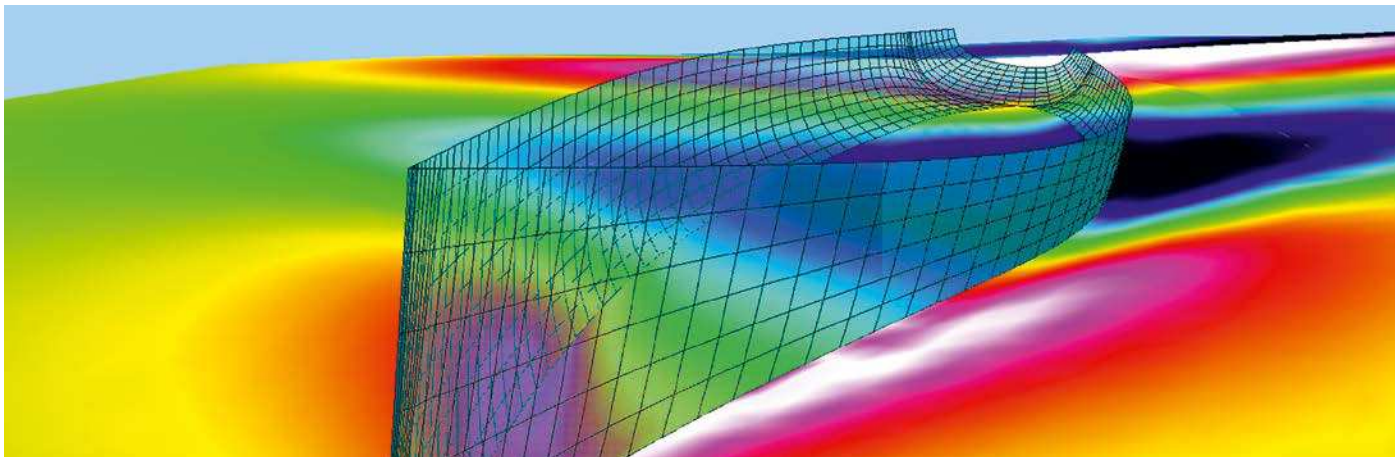

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Standards

IN BRIEF

From left:
Knut Ørbeck-Nilssen (President of DNV GL Maritime), Narish Nathan (CEO of Eversendai Offshore) and Kenneth Vareide (DNV GL Director of Division Offshore Class).

DNV GL wins class contracts for two new jack-ups

DNV GL has signed agreements for the classification of two new jack-up vessels equipped with dynamic positioning: Vahana Aryan and Vahana Arjun. The units, designed for Vahana Offshore (S) Private Limited of Singapore by GustoMSC, will be built by Eversendai Offshore RMC FZE, Dubai.

The agreements were signed at the DNV GL head office in Høvik by Knut Ørbeck-Nilssen, President of Maritime, and Narish Nathan, CEO of Eversendai Offshore, in the presence of Kenneth Vareide, Director of Division Offshore Class, Erik Henriksen, Director of Business Development, Bas Veerman, DNV GL Customer Service Manager for Gusto MSC; and M.P. Bijali, Regional Offshore Class Manager Middle East & India.

"We are entering into a long-term partnership with DNV GL and planning for many more newbuilding projects," said Narish Nathan of Eversendai.

"These are the first NG-2500X designs to be constructed to DNV GL class," added DNV GL's M.P. Bijali. "We will carry out the approvals at our Dubai Jack-up Service Centre where we have local experts on site to assist our customers in the region."

The 61 m x 36 m units have four triangular truss-type legs for operating depths of up to 70m, and four thrusters for transit, station keeping and offshore positioning. They will have a 800 m^2 clear deck area with a 1,300 t variable load and be equipped with two cranes. Class notations include 1A1 Self-Elevating Support Unit., E0, DPS2, HELDK, SELF-PROPELLED.

DNV GL boosts simulation-driven design with upfront CAE design optimisation software

DNV GL continues to develop its design and engineering software. A recent addition to its "Sesam" portfolio is Sesam CAESES, an application for upfront design optimisation in the maritime, offshore and mechanical industries.

Sesam CAESES is a computer-aided engineering system supporting simulation (Upfront CAD). It allows users to improve the hydrodynamic or aerodynamic properties of designs such as ship hulls, propellers, engines and turbo-machinery to optimise their energy efficiency and their environmental and business performance. Sesam CAESES was previously marketed as FRIENDSHIP-Framework, part of GL's software portfolio.

"FRIENDSHIP-Framework has long been recognised as a leading product in its field," says DNV GL's Software Managing Director Are Føllesdal Tjønn. "We are proud to now include it as Sesam CAESES into the Sesam family of products for design and engineering."

Maersk Line switches to DNV GL´s ShipManager

Maersk Line has begun implementing DNV GL's ShipManager software with pilot tests on five vessels. Installation of ShipManager on their self-owned fleet of 250 vessels is scheduled for next year.

Maersk chose DNV GL's ShipManager following a thorough review of available options including 26 other ship management solutions. By switching to the leading off-the-shelf ship management system, the world's largest container shipping company will benefit from increased process efficiency and improved information accessibility and analysis.

"The implementation of ShipManager on the pilot vessels is a major milestone in the project," says Are Føllesdal Tjønn, Managing Director at DNV GL Software. "We have an entire, dedicated implementation team working at Maersk Line. All configurations and settings have been agreed," he says.

"The feedback we have received so far from Ebba Maersk, a 15,500 TEU containership, has been very positive. The application is performing well, and the users have praised the application for its user-friendliness and the self-explanatory nature of the modules," says Sebastiaan Van den Wijngaert, Senior Project Manager at Maersk Line IT.

Headquartered in Copenhagen, Maersk Line has 33,000 employees worldwide and makes 35,000 port calls annually. "ShipManager will replace nine applications we have had in use, giving us one integrated, easy-to-learn, user-friendly and technically up-to-date application," says Van den Wijngaert. "It will make on-boarding of new people a lot easier."

Maersk Line will be using six integrated ShipManager modules: Technical, Procurement, Project, Crewing, QHSE and Analyzer. ShipManager Analyzer extracts information from all other modules for analysis. "This will give our fleet managers a transparency they have never had before," says Van den Wijngaert.

"We are very proud that our investments in our ship management software portfolio over the last five years stand up to the highest industry requirements," says DNV GL's Tjønn.

Photo: Maersk Line

ShipManager, DNV GL's popular software suite, was chosen by Maersk Line following a rigorous selection process.

Industry asks DNV GL to explore risks at small-scale LNG bunkering and filling stations

Dr M. Ahmad, Multiphase Flow Specialist – Gas Quality and Flow, DNV GL Oil & Gas

Photos: DNV GL

To better understand the consequences of an accidental liquefied natural gas (LNG) release, DNV GL has been asked by the industry to initiate a joint industry project (JIP) to be run in collaboration with E&P companies and LNG market stakeholders. The JIP will contribute to the development of rigorous safety standards and guidelines for small-scale LNG bunkering and filling stations.

"DNV GL is teaming up with industry partners to simulate several credible failure scenarios at small-scale LNG bunkering and filling stations at our Spadeadam test centre in the UK. This will generate valuable data to create well-verified and approved models for accurate predictions of LNG behaviour in any type of system failure," says Mohammad Ahmad, Project Manager, DNV GL. "The experiments will provide information needed to carry out a quantitative risk assessment. This JIP will contribute to the development of rigorous safety standards and guidelines for small-scale LNG bunkering and filling stations," says Ahmad.

HAMBURG KEEPS THE PARTY ROLLING

Hamburg took up the baton to carry on DNV GL's 150-year anniversary and Year-One celebrations at the historic Fish Auction Hall on 24 June. Dignitaries, customers and industry leaders reflected on DNV GL's proud history and bright future.

Positive impact of the merger: Key guest speaker Olaf Scholz, Mayor of Hamburg, called DNV GL an important pillar of Hamburg's maritime community.

In his welcome address, Henrik O. Madsen, President and CEO at DNV GL, stressed the merged company's mission and values: "Our ambition has been to explore where we can leverage our history and expertise to translate our vision into impact. Through these projects we take a broader view on society. We sincerely hope that our work can inspire and promote new and radical forms of collaboration between authorities, civil society, academia and business."

DNV GL's 150-year anniversary gala and first birthday party as a merged company in Hamburg was a lavish celebration of an impressive success story, as all speakers agreed. Leading industry and political figures paid tribute to the sustained positive impact of DNV GL. The key guest speakers, Olaf Scholz, First Mayor of the Free and Hanseatic City of Hamburg, and Michael Behrendt, Chairman of the Executive Board of Hapag-Lloyd AG, spoke engagingly of their experience with DNV GL throughout the years.

Mayor Scholz noted: "The city of Hamburg acknowledges that a major global player has been created by this successful fusion, one which is a substantial pillar in the maritime community in Hamburg. This means that the important tasks for the development of the technical solutions needed for the future can be tackled in Hamburg with even greater determination."

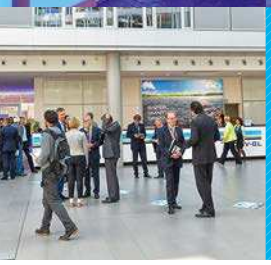
The key to success

Mr Behrendt praised the values that have ensured DNV GL's continued success: "This mixture of courage and business consideration, of a will to innovate, of corporate responsibility and collective values and convictions within the company characterises the centennial champions who have been successful for over a century and a half. It is values that belong to

A brilliant mixture of entertainment, speeches and discussions: About 650 guests joined the party at Hamburg's historic Fish Auction Hall.

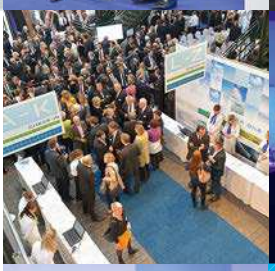
On the same wavelength: Ralf Nagel (l.), CEO of the German Shipowners' Association, and DNV GL's Henrik O. Madsen were both in a great mood.

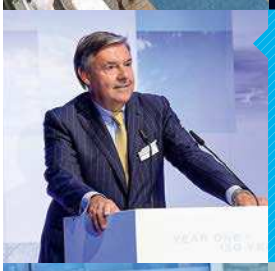


Celebration of 150 years of DNV GL and one year as a merged company: Henrik O. Madsen welcoming guest keynote speakers Olaf Scholz and Michael Behrendt.


At home in Hamburg: Henrik O. Madsen, President and CEO of DNV GL, and Tor E. Svensen, CEO of DNV GL Maritime.

Guest speaker Michael Behrendt, CEO of Hapag-Lloyd, highlighted the values that have ensured DNV GL's continued success – and need to be cared for.





The themes of the day were discussed by DNV GL experts including Dr Pierre C. Sames and Lutz Wittenberg (r.), led by moderator Saya Kitasei.



Open house event at the headquarters of DNV GL's maritime business: Tor E. Svensen, CEO of DNV GL Maritime set the scene for Innovation Day.

Photos: DNV GL

the DNA of a centennial company like yours – values you cannot buy for all the money in the world. But above all, values that need to be cared for."

Throughout the night there was music and entertainment on three stages, including a DNV GL-themed sand art performance and songs from Madeline Juno, a young star finalist from Germany's Eurovision Song Contest.

Starting into the future

For the following day the Hamburg team had organised "Innovation Day", an open-house event for customers and international media representatives. Throughout the day a group of experts held presentations on strategic topics, while the exhibition area presented some of DNV GL's latest innovations.

Tor E. Svensen, President of DNV GL Maritime, and Dr Joachim Segatz, Global Shared Services Officer, met with media representatives to give an overview of the Group and the innovation themes of the day. A Q&A session and several interviews followed.

A talk-show-style panel discussion led by moderator Saya Kitasei tied the themes of the event together. Dr Pierre C. Sames, Director of Technology and R&D, Lutz Wittenberg, Director of Division Technology Services R&D and Chief Technology Officer, Andreas Schröter, EVP Renewables Certification, Philipp Schwarmann, Product Manager Energy Management Worldwide, reflected on new risks and challenges within each business area, and in particular the impact of the changing energy landscape and the emergence of big data.

To cap the day, all of the guests and participants were invited to relax at a casual barbeque on the patio outside the Head Office. The weather cooperated perfectly, a great end to a very interesting and successful day.

TOWARDS A NEW ERA OF SHIP DESIGN

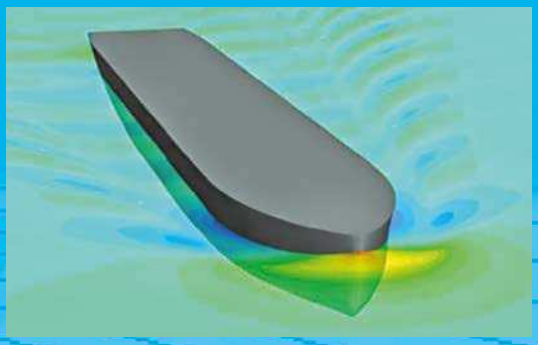
Advances in computer technology and software engineering are creating a far more powerful environment for ship design than ever thought possible.

A 21st century ship is an extremely complex system. This is not only due to all the state-of-the-art propulsion and control technology on board. A far greater challenge results from the multitude of economic and regulatory pressures in a highly competitive, globalised shipping market, along with a heightened sense of environmental responsibility. Today's ships must be designed to operate at the highest possible efficiency under all conceivable circumstances. From the hull shape to the propulsion system and from loading patterns to navigating and operating parameters, ships must be optimised to carry as much cargo as possible while minimising costs, energy consumption, safety risks and emissions to the environment. This requires extensive advance testing and evaluation even before work begins at the shipyard.

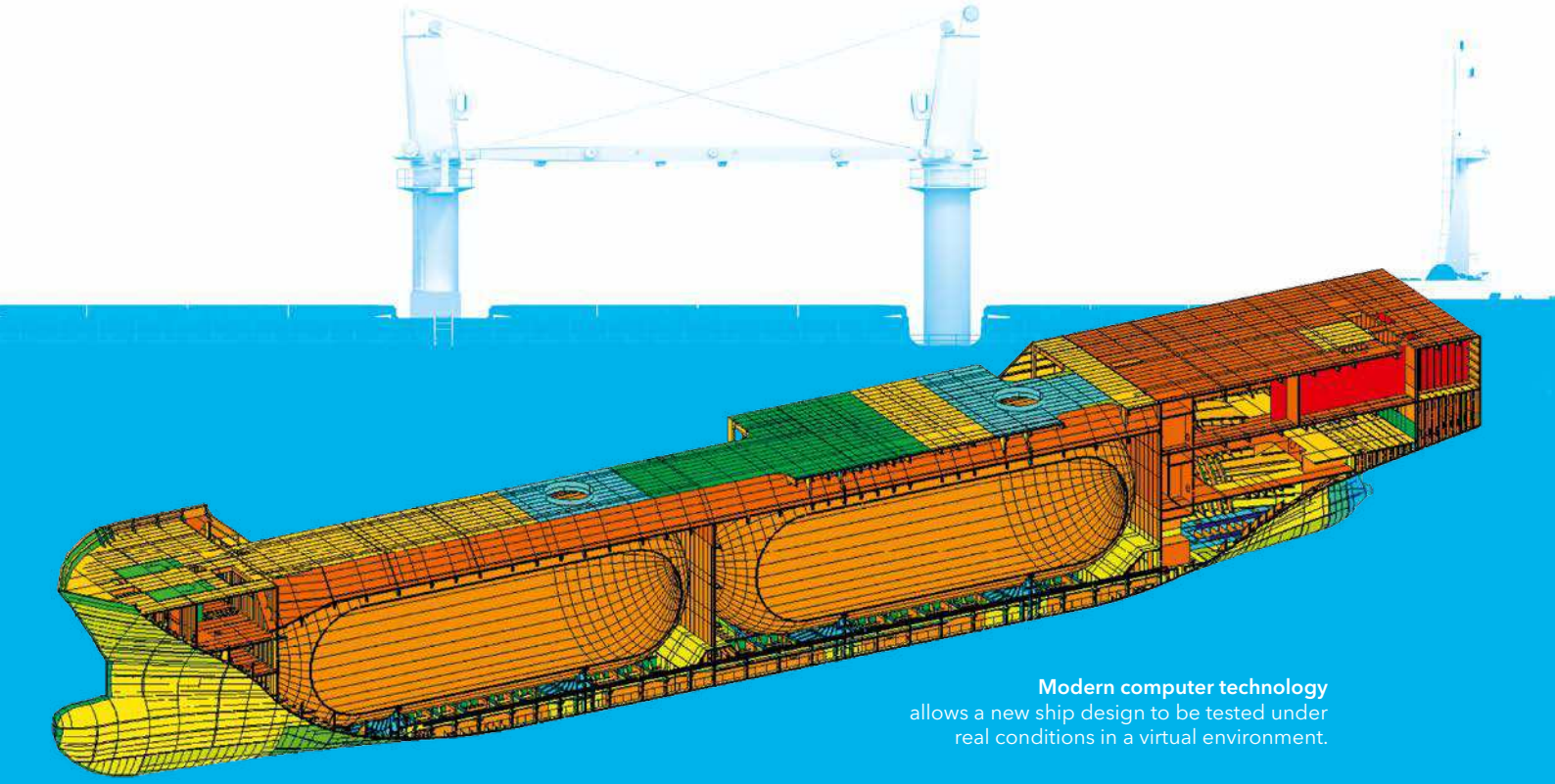
Three approaches

Advances in computer and software technology have created an entirely new playing field for ship design. Today, ship designers can rely on sophisticated engineering and simulation software to anticipate the behaviour of a planned ship under many different operating conditions, and optimise their designs accordingly. As technology continues to evolve, the breadth and depth of engineering applications expand, enabling ships that are safer, smarter and greener than ever before.

In the context of advanced ship design, DNV GL has identified three approaches which are of pivotal importance for progress into a new era of ship design:



Hydrodynamic efficiency reduces operational costs. CFD analysis helps optimise the hull.



Modern computer technology
allows a new ship design to be tested under real conditions in a virtual environment.

- Virtual Ship Laboratory
- Energy-efficient design
- Next Generation Emulation

Virtual Ship Laboratory is a virtual design environment allowing a virtual model of a new ship to be tested and evaluated under diverse conditions. Advanced computational fluid dynamics (CFD) will further expand the range of wind and wave parameters, allowing more realistic testing scenarios. New software generations will lead to a more holistic approach to ship design, replacing today's sectional concept. A detailed virtual model created for each individual vessel will be available throughout its lifetime to assist in condition-based maintenance and optimisation measures.

Increasing number of options

For years, shipowners have been investing in measures to improve the energy efficiency of their ships in service. While modern vessels operate much more efficiently than their predecessors, thanks to improved machinery, propellers and hull forms, advanced design concepts and innovative technology can achieve even more, from optimised hydrodynamic properties to bio-inspired design approaches, electrification and on-board energy recycling.

In the past, ship design was a matter of experience based on trial-and-error: a method far too expensive for today's ships. Modern computer technology allows engineers to mimic the behaviour of ships in water under precisely defined conditions. Emulating real-life conditions accelerates the design, testing and evaluation of new ships and allows planners to simulate critical conditions such as fatigue, corrosion and vibration, as well as situations such as evacuations, maintenance operations and system monitoring. Furthermore, emulation plays a key role in crew training and bridge operations, in engineering collaboration and decision-making.

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Photos: DNV GL

SIZE MATTERS

The freight rate per TEU has driven the trend towards larger ships, contributing to the great success of post-Panamax designs. Vessels capable of carrying close to 18,000 TEU are in operation, and 20,000 TEU giants are under development. But before continuing this trend, several important questions must be answered.

The sheer dimensions of these behemoths are breathtaking. And there are bigger ones still to come. Container vessels have grown beyond imagination in recent years. Will the trend continue, or is there some kind of natural limit beyond which they would simply break apart?

The answer is much more complex than that. First of all, today's giant vessels can only sail on certain routes because factors such as the present and future widths of the locks in the Panama Canal, draught and length limitations in South American ports or the air draught limit in the Port of New York would make it impossible for them to travel to those locations. Then there are physical criteria to consider before attempting to build bigger ships. It takes some in-depth investigations to determine just where to put the limits.

Parameter no. 1: ship length

The length of a standard container defines the incremental steps for the potential enlargement of containerships. The clearance in the cargo hold and the typical transverse bulkhead width are further factors. All these structural characteristics increase the wave and still-water bending moments caused by the enlargement by a power of two. This in turn has consequences for the steel plates used in the upper hull girder because of the open, U-shaped cross section of containerships. In the case of an 18,000 TEU vessel, the material scantlings are 80 to 95 millimetres thick. However, there are technical limits for the possible thickness of high-tensile steel plates, and global strength rules for the bottom area limit the use of 470 N/mm^2 steel.

Assuming an 18,000 TEU containership with a single main engine, four 40' bays behind the funnel, and eleven 40' bays between the funnel and deck house, a practicable elongation would be to add one 40' bay forward of the engine room. Combining this with the small cargo hold above the engine room would form two standard 40' cargo holds. This arrangement would result in a vessel with twenty-five 40' bays and a length overall of approximately 411.50 metres. This could still be achieved based on standard practice. To exceed this length one

Photo: anekoho - Fotolia

would have to develop and investigate an innovative cross-sectional arrangement. Furthermore, a ship of such dimensions might not be able to berth or turn around in some ports.

Parameter no. 2: ship breadth

For today's slow-steaming ships the engine power considerations limiting ship breadth in the past are no longer a concern, and new length-to-breadth ratios are now feasible. Many yards have begun building shorter, wider ships while maintaining the nominal capacity. This cuts the building costs, an important factor considering today's cost pressures.

Again, the dimensions of a standard container including the cell guides and clearances dictates the increment for widening the beam: 2.5 metres. From a strength perspective the influence of the enlargement on the wave and still-water bending moments would only be linear. In other words, widening an existing design has a much less significant impact on global longitudinal strength than elongating the vessel. Besides, widening a vessel increases the nominal capacity more than stretching it.

However, there are setbacks: widening the vessel will worsen its so-called warping deformation, which occurs on both sides of the vessel but in different longitudinal directions. It intensifies the movements of the hatch covers, and thereby the wear and tear on the bearing pads, which in turn increases maintenance costs or requires stronger hatch panels. In addition, warping deformation affects the containers in the cargo hold as well as the interaction between the containers sitting on top of the hatch cover and the lashing bridge. To curb this effect, designers have shifted the deck house to the forward area so as to achieve a closed strength member below the deck house, resulting in a twin-island design. Compared to present, elongated designs, widening is a more feasible solution from a strength perspective.

The rolling and transverse acceleration forces occurring on a container ship depend on the width of the vessel. They affect the permissible loads on the lashing equipment as well as the crew required on the bridge deck. Designers have therefore increased the height of lashing bridges to either allow heavier containers to be stowed in higher tiers or reduce the racking loads on lower containers caused by transverse forces during rolling. Increasing a ship's beam ultimately means that the nominal container intake is not the same as the number of containers that >

The height and reach of gantry cranes can limit ship dimensions.

> can actually be taken in. Furthermore, the gantry cranes in some container terminals have an outreach of 60 metres, a fact to remember before widening current designs, especially for the Asia-to-Europe trade where very large vessels are deployed.

Parameter no. 3: ship depth

The depth of a vessel depends on the number of containers it carries in the cargo hold, the height of the hatch cover and the space between the top of the containers and the lower side of the hatch cover. In addition, a passageway at least two metres high must be kept free above the upper deck and on top of the hatch cover. A modern 40′ high-cube container is 9′ 6″ tall, but the 8′ 6″ standard size is still most common. More importantly, the nominal container capacity of a containership is always expressed in 8′ 6″ tall TEUs (twenty-foot equivalent units). There are consequently two possible container arrangements: either ten tiers of 9′ 6″ high-cube containers with a combined height of 28.96 metres, or eleven tiers of 8′ 6″ standard containers rising to 28.50 metres. The resulting difference in side depth is as little as 459 millimetres, which means that most designs could accommodate ten tiers of high-cube containers in the cargo hold.

According to ISO 1496/1, the lowest container in the hold may be over-stowed by 192 t (based on a maximum vertical acceleration of 1.8 grams), which would result in an average container weight of around 31 tons for 40′ containers, or 28 tonnes in the case of 11 tiers, which is equivalent to the typical 14-tonne homogeneous loading condition. However, this loading condition is typically a key item in contracts between shipowners and building yards. Therefore yards and designers are hesitant to enlarge the number of tiers in the cargo hold or the ship depth because that would cause the maximum container load to differ from the maximum 14-tonne homogenous loading condition in the cargo hold, leading to interpretation difficulties.

Three different draught concepts can be evaluated for a containership: the design draught, the scantling draught or the operational draught. Traditionally, the design draught is used for contractual items such as speed and cargo capacity, while the scantling draught is the basis of all international regulations and class rules. Today the different operational draughts are used to calculate the specific fuel oil consumption at various loading conditions. The design draught of a 13,000 TEU container ship is between 14.0 and 14.5 metres, while the scantling draught is in generally 15.5 to 16.5 metres.

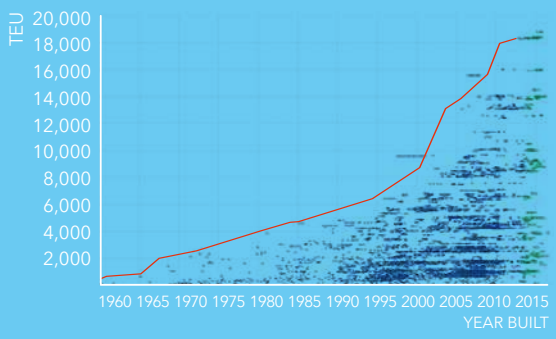
However, widening the vessel while maintaining its depth and draught will reduce the additional freeboard. This could make it necessary to install weathertight hatch covers, which in turn would cause extra maintenance work and costs. Shipowners should carefully consider whether a large scantling draught is needed or whether the same deadweight could pos-

SHIP LENGTH VS SHIP STRENGTH

- Delta length has a square effect on bending moments
- Delta length is approximately 14.60 m (one bay)
- Delta width has a linear effect on bending moments
- Delta width is approximately 2.50 m

Other criteria for ship length
- Port restrictions
- Turning basin diameter
- Quay length, etc.

Containerships then and now
The evolution of the containership 1960–2015



ECONOMIES OF SCALE – WHERE IS THE END?

Size is the key: The table on the right shows the scale effects of containership size and capacity utilisation in terms of cost per unit of cargo. The reference is a 14,000 TEU vessel loaded to full capacity (100%, top left). The economies of scale increase steadily across the capacity range. A 21,000 TEU vessel at 90% utilisation operates more profitably than the reference vessel at 100% utilisation.

Utilisation	Vessel size: 14,000 TEU	16,000 TEU	18,000 TEU	21,000 TEU
100%	100%	97%	91%	89%
95%	105%	101%	96%	94%
90%	110%	106%	101%	98%
85%	117%	112%	106%	103%
80%	123%	119%	112%	109%
75%	131%	126%	119%	116%

sibly be achieved by reducing the draught and having a larger block coefficient typical of a fatter vessel.

Another aspect to be considered when contemplating various draught-to-beam ratios is the specific limitations imposed by the Suez Canal. A draught of 16.8 metres would allow for a maximum beam of 60 metres, which is consistent with current designs. However, should the beam increase to 65 metres, then the corresponding draught limitation to 15 metres could compromise the flexibility of new designs.

Parameter no. 4: air draught

The maximum number of containers above the hatch cover is restricted by the strength of a container, similar to the depth of the vessel. The major difference is the racking load due to the rolling action of the vessel – which does not exist within the cargo hold because of the cell guides. This effect can be compensated by higher lashing bridges, which are today up to three tiers high, and different stowage devices. Over the years the number of tiers on the hatch cover has increased stepwise to 8, 9 and 10, respectively, by installing 1-, 2- and 3-tier lashing bridges. It is important to note that the total stack load can only be slightly increased due to the limited strength of the lowest container, but the weight distribution in the stack can be influenced. There are designs and ships waiting to be delivered that have 11 tiers on the hatch cover. Another factor is that the number of tiers on the hatch cover will further raise the deck house and therefore the height of the bridge deck. This will have an impact on the transverse acceleration and therefore on the safety of the crew. It may be necessary to install protective structures for the conning position as used on VLCCs.

Port restrictions such as the bridges in Osaka, Hong Kong and Hamburg, as well as air draught limitations below the gantry cranes of some harbours on the Asia-to-Europe trade, may also be limiting factors that should be taken into account.

Conclusion

While there is a demand for container liners exceeding 20,000 TEU, technical challenges remain, in particular those relating to the maximum steel plate thickness in the upper hull girder. Present designs could be elongated or widened within certain limits. Further enlargements would require an innovative layout. In addition, port facilities and canal limitations are important criteria to consider.

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EVOLUTION OF CONTAINERSHIP SIZES

A representation of bay/row layouts for common containership sizes from 3,500 TEU through to (hypothetical) 22,750 TEU. The ship size increments are pre-determined by the size of a standard container.

Bay Row	13	14	15	16	17	18	19	20	21	22	23	24	25	26
13 (32.25 m)	3,500 TEU (212 m)	3,500 TEU (225.5 m)	3,650 TEU (254 m)	4,300 TEU (262 m)	4,900 TEU (275 m)	5,060 TEU (283 m)								
14 (35.0 m)			4,250 TEU (253.4 m)	4,500 TEU (268.5 m)										
15 (37.5 m)	3,600 TEU (219 m)	4,500 TEU (249 m)	4,600 TEU (254.7 m)	4,900 TEU (269.2 m)										
16 (40.0 m)				5,500 TEU (257.4 m)	5,900 TEU (273.45 m)	6,800 TEU (300 m)								
17 (42.8 m)						7,090 TEU (300 m)	8,063 TEU (323 m)	8,600 TEU (334 m)						
18 (45.6 m)						8000 TEU (300 m)	9,000 TEU (320 m)	9,200 TEU (336.7 m)	10,000 TEU (349.7 m)					
19 (48.2 m)						8,800 TEU (300 m)			11,500 TEU (349.7 m)	12,600 TEU (366 m)				
20 (51.2 m)										13,300 TEU (366 m)	14,000 TEU (383 m)			
21 (54.0 m)											14,800 TEU (383 m)	16,000 TEU (399 m)		
22 (56.2 m)											Emma M (397m)	CMA CGM (399 m)		
23 (58.6 m)												19,000 TEU (400 m)	20,250 TEU (414 m)	20,800 TEU (429 m)
24 (61.2 m)												20,750 TEU (400 m)	21,250 TEU (414 m)	21,750 TEU (429 m)
25 (63,8 m)												21,700 TEU (400 m)	22,200 TEU (414 m)	22,750 TEU (429 m)

THE NEXT REVOLT

Could present-day technology improve the cost and effectiveness of short-sea shipping while enhancing safety and environmental performance? Yes, it could! Taking current technology to the extreme, DNV GL has developed a revolutionary concept for an unmanned, zero-emission short-sea vessel.

REVOLT IN BRIEF

Specifications
- Service speed: 6 knots
- Range: 100 nautical miles
- Cargo capacity: 100 TEU
- Route: coastal traffic
- Port stay: 4 hours on average
- Power demand: 50 kW in calm sea
- Unmanned operation
- Inclined keel
- Straight bow
- High efficiency propulsion system
- 2-blade propellers
- Podded propulsion for increased manoeuvrability
- Retractable bow thruster for port manoeuvring
- Extended cell guides

Economic benefits
- Increased safety
- Increased situational awareness
- Lower operating cost
- No direct emissions
- Ballast-free design
- Smaller wetted surface
- Lower need for rotating machinery
- No cavitation
- Fast cargo handling
- No manual lashing

Power supply
- Requires re-charging facilities in every port

Unmanned and fully battery-powered, DNV GL's zero-emission design could revolutionise short-sea shipping.

The EU's road network suffers from chronic congestion. Yet, road usage for cargo transport is steadily increasing, leading to heavier road wear, more accidents and higher emissions. The population growth in urban areas expected over the next decades will without doubt compound the problem, causing the demand for transport to exceed the capacity of today's roads.

To alleviate these issues, governments all over the EU are trying to move some of the freight volume from the road to waterways and railways. In the short-sea shipping segment however, profit margins are small due to high energy and operating costs as well as high taxes.

These circumstances prompted DNV GL Strategic R&I to design a new ship concept specifically for short-sea shipping with the objective of encouraging a modal shift from road to sea. By taking the design and applied technologies to the extreme, the DNV GL engineers want to launch a new discussion within the community while upholding DNV GL's maxim of a safe and sustainable future for shipping.

The innovative ship concept "ReVolt – the unmanned, zero-emission, short-sea ship of the >

Photos: ©Toftenes Multivisjon

> future" is the result of a multi-disciplinary, team-based development project at DNV GL based on an assessment of current requirements along European short-sea routes. Nevertheless the concept could be implemented in other coastal regions around the globe.

Defining the operational profile

ReVolt's operational profile was established by analysing Automatic Identification System (AIS) data from vessels operating in the Norwegian Economic Zone (NEZ) in 2012. The relevant routes consist of individual legs of less than 100 nautical miles. The ship type and cargo capacity, which is within the 100-TEU range, were obtained by pairing the AIS data with DNV ship register data. From this information the requirements for the ship concept were derived.

The vessels evaluated in the AIS analysis had an average service speed of 8.7 knots. For ReVolt it was decided to reduce the required speed, to 6 knots to allow for more efficient propulsion solutions. As a consequence of this low speed the logistics chain will have to be redesigned entirely to account for longer transit times. However, implementing a "conveyor belt" logistics concept with frequent departures and short, four-hour-average port stays could create the right conditions for transferring appropriate cargo types to this mode of transport.

Design characteristics

The hull of the vessel was designed to optimise ship efficiency, fulfil all applicable safety and operational requirements and enable operation without ballast water.

At the ship's slow cruising speed, the resistance to overcome will consist primarily of hull friction and occasional external forces acting on the vessel. The wave-making resistance will be modest. For this reason a straight vertical bow design was chosen to minimise resistance across the entire operational profile. In addition, a sharp waterline creating a piercing effect is favourable in adverse wave conditions. CFD calculations for the chosen design showed a low calm-water resistance of 50 kilowatts. On the other hand, the added resistance in waves and wind resulting from the low cruising speed was shown to contribute a relatively large portion to the vessel's overall resistance. Resistance calculations incorporating met-ocean data sets from the intended route revealed an average ship resistance of 120 kilowatts.

The ReVolt's battery packs will be a major investment.

An investigation into the possible use of composite materials was also carried out. While the lightweight material would reduce the wetted surface when compared to normal steel, the resulting draught reduction would require a smaller-diameter propeller, thereby compromising the ship's propulsion efficiency. Therefore a steel hull, which is also less costly, proved to be the best solution.

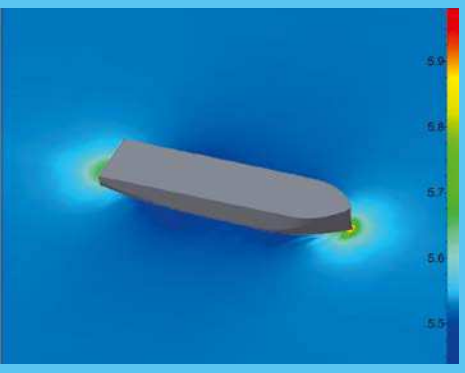
The propeller design for the ReVolt was largely based on efficiency considerations since most of the normal design constraints were irrelevant due to the low vessel speed. Since cavitation will be negligiable, the number of propeller blades was reduced to only two. This in turn reduces viscous losses in the propeller considerably. For the final design a propulsion efficiency of 76 per cent was achieved.

ReVolt will operate independent of tugs and needs good manoeuvrability. Because of her hull shape a podded propulsion system was chosen over conventional shafted propulsion; this also reduces the number of rotating parts on the ship. The design calls for two stern pods as main propulsion units plus one retractable bow thruster for manoeuvring.

A fully battery-powered solution was selected for the ReVolt to maximise efficiency, eliminate emissions and reduce the number of rotating components requiring maintenance. Provided that the batteries can be charged with hydropower, a battery-based propulsion system will be highly efficient and clean. The energy loss from the water reservoir to the propeller is estimated to be as low as 40 per cent. By contrast, comparable diesel-powered ships may suffer well-to-propeller losses of up to 85 per cent. Furthermore, using renewable energy to charge the batteries makes ReVolt a zero-emission ship. And finally, batteries represent a low-maintenance solution for an autonomous vessel designed to require as little human interference as possible.

Autonomy through simplicity

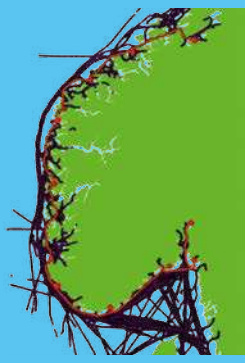
The safety record of the shipping sector today is relatively poor, with 900 fatalities per year on average – a figure 90 per cent higher than for comparable land-based industries. Studies show that as many as 85 per cent of accidents in shipping are the >



CFD analysis of the ship's resistance. (left)

The on-board batteries will need to be recharged at every port (below).

Raised hull sides and cell guides in the cargo hold (above).



AIS plot of the proposed trade route for ReVolt (right).

Photos: DNV GL, ©Toftenes Multivisjon

> result of human error. DNV GL has set the goal of reducing the number of fatalities in this industry to a level equivalent to land-based industries. If this ambition is to be met, the accidents caused by human error must be addressed in multiple ways, for example by introducing automation to support or replace human action.

Ship maintenance chores are a major portion of a ship crew's activities. So when a ship operates with a very small crew or entirely without people on board, how can the vessel be maintained? One strategy is to minimise the required maintenance effort, and this is precisely what the designers of ReVolt did. Since the equipment most prone to technical breakdowns is rotating machinery, ReVolt is a ballast-free, fully battery-powered, unmanned vessel with the smallest possible number of rotating components. In fact, the only rotating machinery on board are the components associated with the propulsion pods and bow thruster and are located outside the ship's hull.

FACTS & FIGURES

Main particulars	
LOA	60.23 m
LPP	57.23 m
Beam	14.5 m
Depth	13.18 m
Draught (full)	5.02 m
Draught (ballast)	3.35 m
Service speed	6 kn
Capacity	
Cargo capacity	100 TEU
Deadweight	1,250 mt
Cruising range	100 nm
Machinery	
Battery	3,000 kWh
Propulsion	
Azimuth pods with 2 blades (3 m diameter)	2
Retractable bow thruster	1

Wireframe image of the loaded vessel.

In terms of autonomous navigation, an integrated system comprising ECDIS, GPS, radar, cameras, LIDAR and other sensory equipment has the potential to create complete situational awareness around the vessel. All of the required technology is available off the shelf today.

ReVolt's autonomy concept takes the applied technologies to the extreme, and DNV GL believes that many intermediate development steps, such as condition and sensor-based monitoring, enhanced navigational assistance and remote operation, will have to be taken before unmanned ships can become a reality.

Operational and cost efficiency

Since ReVolt sails at relatively slow speed it is essential to avoid wasting time in port. By using state-of-the-art technology in automatic mooring systems, such as grip-arm and vacuum-based mooring, ReVolt will be moored quickly without the need for ropes and winches, which are highly dependent on manual assistance and regular maintenance.

By raising the hull sides and cell guides to full container stack height, cargo handling can be accelerated while eliminating the need for stevedores and manual lashing.

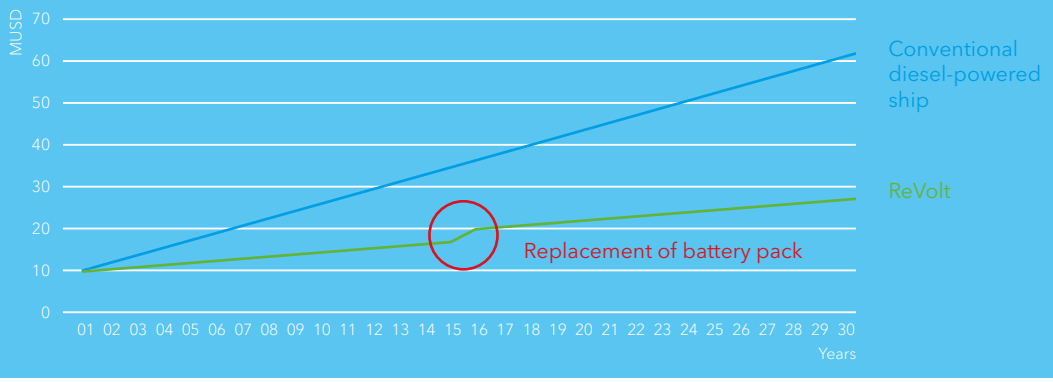
To ensure fast transfer of cargo from the ship to other modes of transportation, the shoreside facilities in ports need to be highly efficient. This can be achieved by building dedicated terminals with easy access for trucks.

The ReVolt is unique in terms of both safety and environmental performance. However, the question remains whether all this can be achieved at a reasonable cost. The autonomous capabilities of ReVolt significantly reduce or even eliminate the need for crew facilities, a superstructure and auxiliary machinery, leaving more space for payload. The battery pack on board ReVolt is, however, extremely capital intensive with an estimated cost of 1,000 US dollars per kWh. And, due to the performance degradation of batteries, the need for a replacement pack means that this cost will be incurred twice over the estimated lifespan of the vessel (30 years).

As battery technology matures, battery costs are likely to drop significantly. Taking into account local incentive programmes such as the Norwegian NO_X-

The ReVolt model demonstrator is used to learn about the possibilities related to autonomous navigation.

ReVolt's lifetime cost will be significantly lower than that of a conventional vessel.



fund, the CAPEX of ReVolt is estimated to be equal to that of a conventional ship with equivalent cargo capacity.

But where ReVolt will truly excel is the cost of operation. Her energy, maintenance and crewing costs will be far below those of a diesel-powered ship; how much, will depend on the shoreside infrastructure needed to enable autonomous operation.

As a result, ReVolt will be profitable from day one. Over her lifetime the ship will save about 34 million US dollars in operating costs compared to a conventional vessel. Future governmental emission reduction incentives may further increase the margin. A detailed 1 : 20 scale model of ReVolt has been built to demonstrate the ship's autonomous capabilities and test other design features.

DNV GL uses this scale model to learn about the challenges and opportunities of autonomous navigation and pave the way to a future where autonomy is part of the solution for better safety at sea.

A vision for the future

ReVolt is a vision for the future and will not be built until several of the technologies involved have matured. However, the vessel could conceivably be built and operated using current technology. ReVolt is intended to serve as an inspiration for equipment manufacturers, shipyards and shipowners as they endeavour to develop new solutions towards a safer, more sustainable future.

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THE RETURN OF FLAMINIA

Like a phoenix from the ashes, "MSC Flaminia" has recovered from the severe fire incident two years ago and is now back in liner service. In the course of the repair work the containership was turned into a state-of-the-art "eco"-vessel.

23 July 2014 was a very special day for German shipowner Reederei NSB. At the Italian port of La Spezia, an NSB containership resumed its liner service for the shipping company MSC after having suffered severe damage two years earlier when crossing the Atlantic. A fire had broken out in one of "MSC Flaminia's" cargo holds, followed by several explosions. Two crew members died fighting the flames, and a third one was reported missing.

The heavily damaged "MSC Flaminia" was not only saved and repaired but actually totally overhauled and converted into a state-of-the-art, eco-friendly vessel. So what her owner, NSB, finally handed over to charterer MSC that day was a ship that may still bear the original name but has in fact been refitted and optimised for today's shipping market requirements in every conceivable respect.

Tuned for efficiency

"MSC Flaminia" has been repaired and modernised in a single process at the Daewoo-Mangalia shipyard in Romania since February 2014. Her design was modified to cut fuel consumption and make her operate more efficiently and generally more cost-effectively.

Owner NSB had analysed the ship performance data and sat together with several partner companies to develop a comprehensive, eco-friendly redesign package. "The technical know-how for the refits was ours," says Bozidar Petrovic, Vice President of NSB, and head of the rebuilding project. But experts from DNV GL contributed to the development and subsequent implementation as well. "Ultimately all repairs and modifications had to be approved by DNV GL," confirms Petrovic.

From a classification point of view, every repair, alteration or conversion is a challenge, especially in combination. "We are very proud to have been part of the repair and re-launch of 'MSC Flaminia'," says Martin Grieger, Project Manager at DNV GL. "It is a gratifying experience to see the ship return to service, and beyond that, to see how the owner, NSB, has been able to transform 'Flaminia' by enhancing her efficiency and minimising her environmental footprint."

Successful salvage operation

The experts from the classification society were involved in the "MSC Flaminia" drama from its beginning until the happy end. The vessel was enrolled

The fire and subsequent explosions caused severe damage to "MSC Flaminia" in the July 2012 accident.

Photo: Reederei NSB

Through the Bosporus and back to liner service: The 6,750 TEU containership "MSC Flaminia".

in former GL's Emergency Response Service (ERS). Therefore the ERS team in Hamburg was alerted immediately after the first explosion on board and began simulating the condition of the vessel to assess her stability and strength. Working closely with the salvage company and the owner, the GL ERS team carefully studied the consequences of potential fire fighting and cooling measures, reports Henning Schier, Naval Architect on the ERS team.

Bozidar Petrovic agrees that the cooperation between DNV GL and NSB in the follow-up to the fire disaster on board "MSC Flaminia" could not have been better. "The ERS team's repeated ship stability calculations were an essential prerequisite for towing the ship safely to Wilhelmshaven, and later on to Romania," he says. "It was always reassuring to have this team of experts by our side."

The ship was taken to Wilhelmshaven's Jade Weser Port for retrieving the damaged cargo and contaminated fire extinguishing water. The ERS team first worked out a detailed unloading plan accounting for each individual item to be removed (refer to box insert). Again the ERS experts from GL and the NSB staff teamed up to support every step of the process, which was successfully completed in January 2014.

A greener ship

Just a few weeks later the Daewoo-Mangalia shipyard began repairing and retrofitting the damaged vessel. Apart from hundreds of smaller repairs, the badly damaged midship sections were exchanged >

THE "FLAMINIA" ACCIDENT

On 14 July 2012 a fire broke out in one of "MSC Flaminia's" cargo holds. Several explosions followed. The containership was operating in liner service between Charleston, USA and Antwerp. At the time of the accident she was roughly 100 nautical miles away from the closest shore. Two crew members died in the accident, and a third one was reported missing. Legacy GL's Emergency Response Service assisted in the rescue and salvage operations. Using detailed data models of the vessels on file at the ERS, the team calculated the structural effects of the fire and concluded that the ship was safe and stable enough for towage to Wilhelmshaven, Germany, for discharging operations.

Photo: Havariekommando

> completely. Furthermore the electrical system was replaced, and many parts of the superstructures were renewed.

NSB Vice President Bozidar Petrovic is more than satisfied with the results. A new, redesigned bulbous bow and a new propeller will drive down "MSC Flaminia's" fuel consumption far below the original levels. "Analyses by our departments TOM (Technical Operating Materials) and EOD (Engine Operation Department) show that under ideal conditions these two modifications alone could save up to twelve per cent of fuel," says Petrovic.

Time will tell what real-life savings can be achieved, but the story of "MSC Flaminia" demonstrates the opportunities of eco-modification: it enables older ships to fully compete with current designs in terms of efficiency. "Of course we are willing to make our know-how available to other shipowners. Some of the retrofits we did on 'Flaminia' have already been replicated on other vessels of our fleet," says Petrovic.

For example, a modified bulbous bow was installed on "CMA CGM Hugo" recently, a vessel managed by NSB. Another efficiency-enhancing measure is a so-called turbo charger cut-out, which lowers fuel consumption during part-load operation. Turbo charger cut-out devices were installed on many of NSB's ships in 2013.

But not all modifications made to "MSC Flaminia" were motivated by purely economic considerations. Some retrofits were simply implemented to make her a true "eco-ship for the future", without reaping an immediate financial benefit. "To us retrofitting is not exclusively a question of economics. We also find it important to help protect the environment. The ballast water treatment is one example," says Petrovic.

23 July 2014 was thus a great day not just for NSB but for "greener shipping" as well.

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At the Daewoo-Mangalia shipyard in Romania, "MSC Flaminia" was converted into a state-of-the-art vessel and given a high polish as well.

REPAIR AND RETROFIT

Owner Reederei NSB seized the opportunity of "MSC Flaminia's" repair to turn the 12-year-old container vessel into a modern eco-ship capable of competing with today's newbuilds. Repairs and modifications included:

- Complete refit of the midsections weakened by the fire
- Bulbous bow refit to improve fuel efficiency
- New, optimised propeller
- Turbo charger cut-out devices for part-load operation
- Replacement of certain parts of the superstructure
- Completely new electrical system
- Advanced ballast water treatment plant
- Various detail upgrades and improvements

Photo: Reederei NSB

Bulbous bow redesigns are a common approach to improving fuel efficiency.

Experts from DNV GL were on site to monitor the implementation of the eco-design package on "MSC Flaminia".

SMART SHIPS FOR SMART OWNERS

In the fiercely competitive shipping business, ship maintenance is a constant challenge for owners. Technological advances can help them stay one step ahead of asset failure and the resulting financial risks.

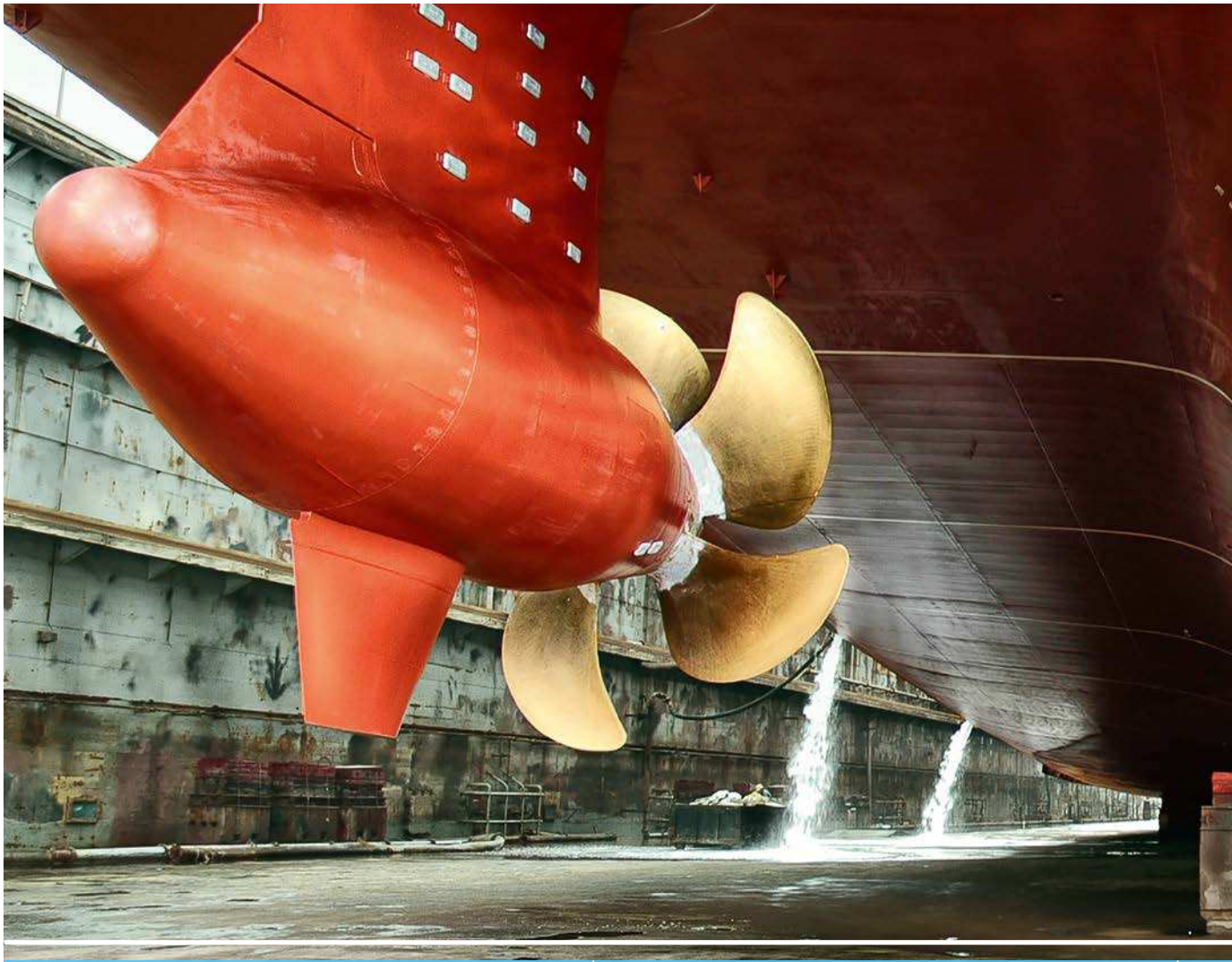


Photo: Ivelin Ivanov - Fotolia

THE TECHNOLOGY REVOLUTION

New technologies hold great promise for shipping. In particular, on-board, sensor-based, integrated condition monitoring systems linked with on-shore systems via satellite communication could revolutionise asset management.

Smart sensors with pre-processing capabilities will deliver digitised information, boosting confidence in measured event characteristics while reducing the volume of data transmitted.

Avoiding the costly consequences of unexpected asset failure is a major concern for shipowners. Over the past 70 years maintenance has evolved from a reactive process performed after a functional failure to scheduled, rule-based preventive maintenance regimes.

This was an important achievement, but the pressure to cut costs continues, and the evolution of sensor hardware and information technology has opened up new possibilities to optimise maintenance. A data-driven, risk-based maintenance regime can improve failure prediction accuracy and maintenance planning, ultimately helping owners lower their costs and increase the safety and availability of ships and systems.

Validating the data

Condition monitoring is the basis of advanced maintenance concepts. Monitoring a set of parameters relating to the condition of a system component allows the operator to identify any significant change that might indicate a developing fault. To derive >

Equipment sensors supplying a steady stream of condition data are indispensable for predictive maintenance.

Advanced, highly reliable ship-to-shore connectivity links will enable on-board sensor systems to transmit information at a flexible rate depending on the criticality of equipment conditions and the complexity of the systems on board.

Cloud computing, big data and increased computing power are driving the development of architectures and methods for collecting, transmitting and handling big data, including distributed data storage, advanced computing infrastructures and powerful information management systems.

> meaningful information, the sensor output must be pre-processed by validating the data and extracting relevant features such as temperature gradients and vibration modes. This information is diagnosed to determine the health status of the system and estimate its remaining useful life (RUL). A variety of methods are employed in condition monitoring, including model-based, data-driven and combined approaches.

The use of condition monitoring varies widely in the shipping industry, depending on the type and age of the vessel and the installed components. Monitoring mostly takes place at the component level and its sophistication depends on the component maker. A ship with components from a variety of manufacturers may have several separate monitoring systems. But such a complex system environment ignores component interdependencies and fails to capture the big picture.

In most cases the sensor data and the associated alarms and trends are monitored on board, sometimes undergoing some simple automated diagnostic routines. The data is then commonly transferred to shore for further processing. State-of-the-art systems are capable of automating these processes.

Predictive maintenance and risk management

As technology progresses, smart sensors, satellite communication and powerful computers and software will combine on-board monitoring equipment and on-shore systems into integrated networks, allowing large volumes of condition data to be evaluated in real time as a basis for proactive maintenance management (refer to box insert). Next-generation condition monitoring systems are expected to deliver an accurate picture of an entire vessel's current and future status as a basis for preventive action to increase the reliability and safety of the vessel and ensure continued operation.

Future ships will be equipped with holistic monitoring solutions looking at the ship as one integrated system. In a hierarchical framework which aggregates the health condition or reliability of individual components into an overview of entire sub-systems, crews and shore-based staff will be alerted in real time about potential failures and their effects on ship reliability and performance.

Photo: Wärtsilä

THE STAGES OF IMPLEMENTATION

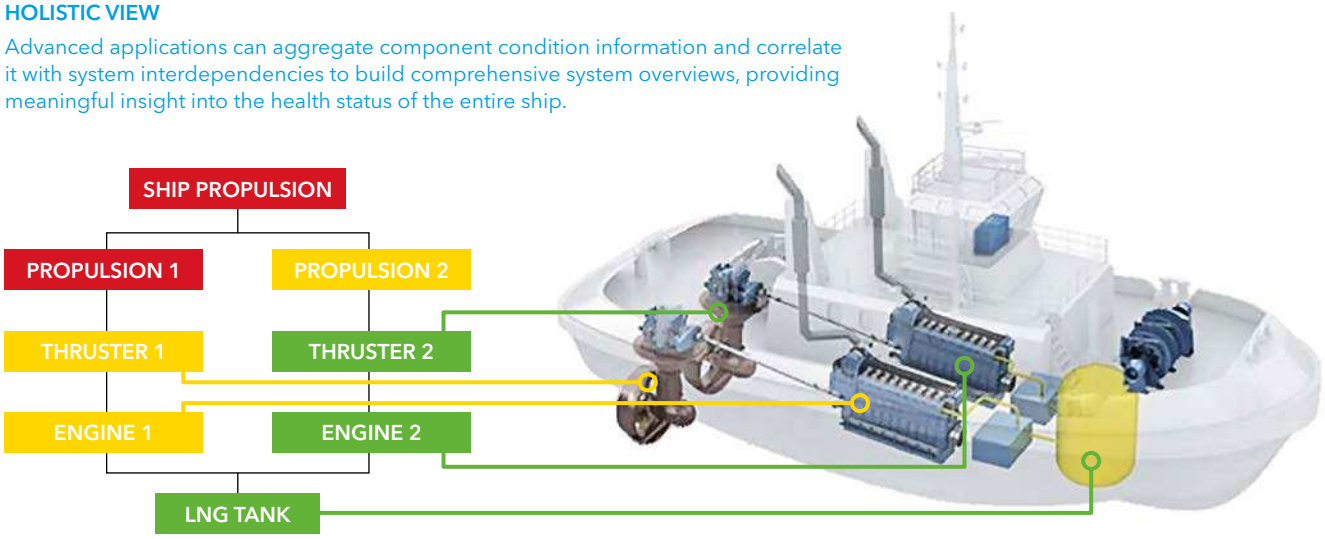
Defining an effective diagnostic system
- Determine the most critical failure modes
- Equip relevant components with sensors that can detect related physical parameters
- Install on-board and on-shore computers to perform diagnostics

Moving towards an effective prognostic system
- Use of prognostics to determine the remaining useful life (RUL) of components
- Maintenance and spare planning based on RUL

Migrating to real-time risk-based maintenance
- Maintain or reduce the system risk level cost-effectively
- Focus on relative criticality between components as a function of time
- Consider maintainability from the design phase

HOLISTIC VIEW

Advanced applications can aggregate component condition information and correlate it with system interdependencies to build comprehensive system overviews, providing meaningful insight into the health status of the entire ship.



When condition monitoring output is combined with risk management, it provides valuable decision support for maintenance planning. Risk management incorporates cost, reliability, safety and environmental considerations. Risk analysis-based maintenance interprets the condition of components at the system level, evaluating reliability and risk indicators in real time to prioritise maintenance measures on individual components. Risk-based maintenance planning minimises the probability of system failure and its consequences for safety, profitability and the environment, providing a sound basis for business decisions.

Business benefits

An integrated, predictive maintenance management system reduces the need for inspections and prophylactic repairs and the occurrence of unexpected failures, downtime and unplanned maintenance. It improves equipment performance and potentially even fuel efficiency, and may lower insurance costs. All of this boils down to significant cost savings.

What is more, an advanced, data-centric maintenance regime reduces uncertainty and allows the shipowner to negotiate charter rates with greater confidence. By enhancing the reliability and value of a vessel, it delivers a competitive advantage.

There are organisational benefits as well. Advanced networking technology allows ship crews and their on-shore colleagues to collaborate much more directly. Certain tasks may be delegated to specialised shore-based personnel and systems. Powerful hardware and business intelligence software deployed at a central location can provide fleet-wide equipment performance and risk tracking services and allow decision makers to view aggregated, up-to-the-minute equipment data and forecasts at any time. On board, the availability of meaningful diagnostic data supports a continuous learning process among the crew. All this will greatly improve the effectiveness of ship maintenance while keeping the crew well informed at all times. Furthermore, component manufacturers can use the same equipment data to improve components and minimise losses and failures.

Of course, these benefits cannot be reaped without a willingness to embrace change and adopt new ways of thinking about maintenance. An expanded use of sensor technology will necessitate equipment design changes, and a complex monitoring and forecasting system will require additional training for crew members to understand interdependencies, interfaces and changing operating conditions. Much can be learned from the air transportation industry, which has pioneered modern maintenance concepts. Ultimately, a more data-centric approach encompassing the extended value chain will help shipowners remain competitive and operate efficient, reliable fleets at the lowest possible cost.

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Vessels
Companies
Users
Voyage
Vessel
Engines & systems
Fuel
Consumption
Speed
Profile
Trim
'Emissions'
Explore single vessel timelines
Operational profile - Insight
Percent
Sailing
Maneuvering
Loading/Unloading
Waiting
Wind force per vessel
Insight
Insail
Plan
Weather and sea
Beaufort/Douglas
Sea state

GATEWAY TO A TRANS-PARENT FLEET

In response to market demand, DNV GL has created a new ship and fleet performance monitoring solution. Featuring a Web-based portal with data analytics and benchmarking functionality, it provides operators with the insight they need to make well-informed management decisions.

DNV GL's new solution puts crucial operating data at the operator's fingertips.

Photo: DNV GL

Operators face the challenge of knowing exactly how their fleet performs. Where can they find further potential for improvement? Can they trust the data collected, and is it stored and aggregated effectively, and presented in a way that enables sound analysis of ship operation to support the right management decisions?

In numerous conversations with ship operators, DNV GL discovered a frequent lack of a practical method for gathering, sorting and presenting ship operation data. There are two basic approaches to this problem: either choose a fully automated system, which may be technically sound but turn out to be a disproportionate investment, or purchase a professional data collection and reporting software product requiring manual data entry but offering valuable features such as correction and plausibility checks.

Operators of smaller and medium-sized fleets may not have the infrastructure or the financial padding required for a customised hardware and software solution. Staff constraints may also be an issue where information must be consolidated >

ECO INSIGHT SOLUTION

- All major fleet performance measures organised in a logical structure.
- Customisable dashboards along with ship and fleet benchmarking features readily available in a Web-based portal.
- Hull, propeller and trim performance based on the detailed and ship-specific model from ECO Assistant.
- Best-practice approach for voyage reporting, including data plausibility checks using the state-of-the-art, ship-to-shore reporting software Navigator Insight or an MS Excel spreadsheet.
- Additional advice, issue awareness and trouble-shooting options available for decision support.

Efficient ship operation requires a structured approach to data collection and analysis.

Photo: Hasenpusch

BENEFITS OF ECO INSIGHT

- Cost savings – realise fuel consumption reductions through optimised ship operation and reduce operational expenditure (OPEX) through efficient engine and system usage.
- Competitive advantage – make your vessel more attractive in the market through continuous performance management and proven energy efficiency.
- Transparency – get insight into all energy efficiency-related operational parameters.

> and analysed. To provide a feasible solution to these customers, DNV GL combined its ship-to-shore reporting software Navigator Insight with its Web-based performance management portal ECO Insight. Together these applications allow ship operators to access the information they need in an aggregated format, presented on an appealing user interface via pre-defined dashboards for further analysis.

Once reliable data about the vessel, each voyage as well as engine and system performance has been collected in one central location, ECO Insight can be used to aggregate and display the data and perform data analytics. This provides the operator with easy access to comprehensive fleet performance information which may be sorted and used to compare similar vessels. The data can be grouped by any category, and various timelines or operational modes may be investigated. An owner may draw conclusions about fleet performance based on user-defined KPIs, or use the unique benchmarking capability to display anonymised performance data provided by other users of the portal in comparable vessel categories for market-wide evaluation.

Focus on ease of use

Installation of the solution is straightforward both on board and, as a Web-based hosted solution, in the shoreside office. There is no dedicated hardware, and the on-board procedures are not duplicated. The application is fully scalable, flexible and easy to adapt to any fleet size thanks to its user-friendly layout. For example, it allows a chartered-in fleet to be added to or removed from the portal with ease.

Accessible from anywhere through the Internet, the ECO Insight portal delivers a holistic view of fleet operation data. Should a client require further support for drill-down, root cause analysis, DNV GL's technical staff can assist with tailored commentary for decision support.

DNV GL will continue to develop this solution, eventually connecting additional data sources to the ECO Insight portal to deliver comprehensive insights across an evolving range of parameters.

Provided by DNV GL's Maritime Advisory, ECO Insight is designed to help shipowners and operators globally improve fuel efficiency and increase profitability. Ten pilot customers who have been using the solution for more than 50 ships have confirmed the effectiveness of the solution. The new ECO Insight service will be launched officially at SMM Hamburg.

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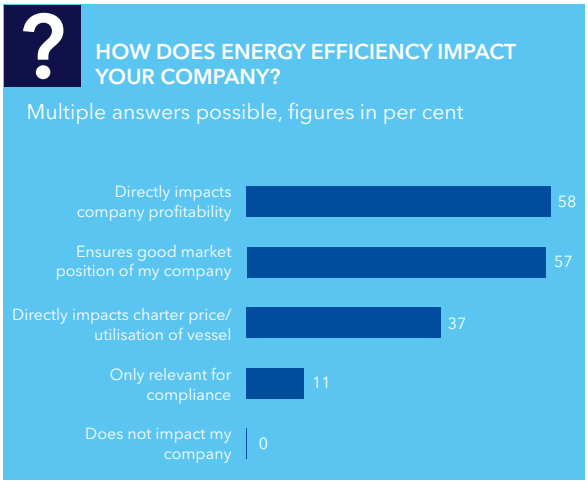

MANAGING ENERGY

Rising fuel prices and new emission limits put pressure on the market to optimise energy management in ship design and operation.

DNV GL's Shipping Advisory conducted a global study to better understand how the industry has handled the need to increase efficiency in a challenging market environment with little available funding. The results reflect the answers of ship managers, operators and owners globally, representing more than 2,000 vessels in all major shipping segments with an estimated annual fuel bill amounting to more than 40 million tonnes or almost 25 billion US dollars.

The report by DNV GL reveals the driving forces for implementing energy management measures and reviews the popularity and success of their implementation. It also provides an overview of hurdles companies are facing and of the savings and progress achieved so far. The results can help participants improve energy usage and assess their own performance vis-à-vis the industry. Three major facts were revealed.

Determination makes the difference

Energy efficiency is a competitive advantage. It affects the companies' profitability by lowering operational costs, improving their market position and boosting charter rates and ship utilisation. An increasing demand for sustainable shipping supports this development.

Considerable savings potential remains untapped. Yet, a few companies have managed to position themselves as true experts in energy management, reaping energy savings of 10 per cent and more. Some even enjoy better fleet utilisation and charter rates. But most respondents achieved energy savings between one and three per cent, often missing the defined targets. To realise meaningful savings, many shipping companies will need to implement more ambitious measures, motivate changes in employee behaviour, monitor performance to assess the success of their energy saving measures, and encourage cooperation between all parties involved.

Companies practising successful energy management attest to the effort required. The industry needs to comprehend that energy management provides benefits beyond compliance but involves major efforts that must become part of the company's culture and strategy with long-term goals.

In the future, only high performers will be able to reap the full benefits of efficient energy management. It takes true determination to master this challenge, turn it into a competitive advantage, and persist under mounting market pressures.

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NEW DIMENSIONS

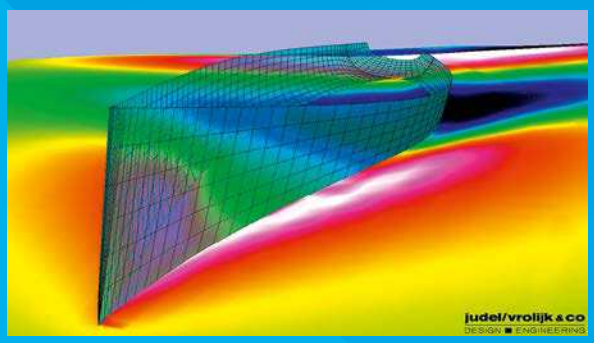
The world's largest carbon fibre sloop is currently being built at Baltic Yachts. 24,000 square metres of bonded carbon fibre are required to form the impressive 53.9-metre hull.

The launch of the new "Pink Gin" is still two years away, but the responsibility weighs heavy on Patric Brännbacka, project manager at Baltic Yachts in Pietarsaari, Finland. At nearly 54 metres, the carbon fibre sloop will be the world's largest boat of its type and a reference project for the shipyard. Specialising in lightweight construction, Baltic Yachts often collaborates with the Bremerhaven yacht design firm judel/vrolijk & co and the interior design professionals at Design Unlimited in Southern England. Fortunately for Brännbacka the owner is not in a hurry, an extremely unusual situation, says Brännbacka.

Uncompromising craftsmanship

The owner is no stranger to Baltic Yachts. "The new 'Pink Gin' will be his sixth yacht from our facility," explains dockyard head Henry Hawkins, who worked for the owner as captain of the last "Pink Gin" for many years and was promoted to the executive position when Baltic was taken over by the owner's Duderstadt-based company, Ottobock, in 2013.

Hawkins was familiar with the shipyard from the long planning and construction phase of the last "Pink Gin" which made quite a stir when it was



Preparing the hull bottom mould for lay-up (l.); computer simulation for hull shape optimisation (pressure map).

"PINK GIN VI" DIMENSIONS

LOA	53.90 m
LWL	45.10 m
Beam	9.55 m
Draft	4.50/7.00 m
Light displacement	240 t
Ballast	approx. 75 t

launched eight years ago. The boat had a displacement of 180 tonnes, at a length of 46.2 metres. Perfect workmanship was a must for the traditionally styled blue water cruiser with the fast underwater hull. No other shipyard was considered for the job, says Hawkins.

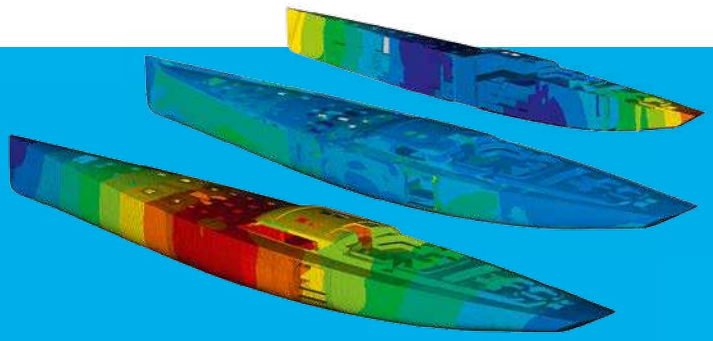
Ambitious design

But after many years and many thousands of miles sailed, the owner began dreaming again – of more space on board, for example, or faster sailing even in low winds. He contacted his design friends in Bremerhaven, and now a new "Pink Gin" is taking shape: a more lightweight design, with a 240-tonne displacement, 75 of which will be in the keel. Baltic and, in particular, Patric Brännbacka will be working hard until the launch in 2017.

To implement the ambitious design, the shipyard once again relies on prepreg carbon for the hull and deck. "We ordered roughly 24,000 square metres of carbon fibre roving," explains Brännbacka. In a SPRINT vacuum process, the sandwich hull, consisting of carbon fibre, aramid and e-glass roving, is laminated over a foam core. Once cured, the >

Photos: Baltic Yachts, judel/vrolijk

From hull fabrication to the design of features, such as hinged tilt-out balconies, perfect craftsmanship is required.



FE models are used for structural-strength calculations.

An elegant home in an ultrafast sailing yacht? It can be done, as the Baltic 175 "Pink Gin" demonstrates.

"DNV GL have highly talented engineers – always willing to help and give us guidance with the difficulties we might have within the project."

Patric Brännbacka, project manager at Baltic Yachts

The SPRINT vacuum process ensures resin saturation.

> hull will be hauled to the state-of-the-art facility in Pietarsaari where it will be finished and equipped.

Increasing demands

"Because of its enormous dimensions the hull is built in three individual sections in a negative form, whereas the box for the seven-metre keel is built on a positive form applying many layers of prepreg carbon," says Patric Brännbacka. The structural longitudinal beams and crossbeams crucial for hull strength and torsional stiffness are in the works as well, as is the carbon fibre transverse bulkhead, which absorbs a major share of the forces occurring in the hull.

For the complex structural calculations, Baltic relies on the composite pros from Gurit who monitor the load distribution on the hull structure with extensive finite element calculations, then adjust the laminate thickness accordingly.

"The demands on the shipyard and the engineers performing structural calculations are mounting," observes yacht design expert Rolf Vrolijk. The forces acting on the hull structure are significantly higher than on motorised yachts because of the rigging. "The forestay has a breaking load of 145 tonnes and affects the foreship with a load of 63 tonnes; the mast compression is 300 tonnes," adds Patric Brännbacka. According to judel/vrolijk calculations, hull deflection can range from 35 up to 70 millimetres.

Ultimate sophistication

These peak loads are critical, especially for the area between the two balconies, which can be hydraulically tilted out of the hull just above the waterline. Located on the port side near the salon gangway, one of the hull flaps can be used as a landing and loading platform. The second tilting platform is linked with the owner's cabin, which stretches across the entire width of the vessel in the forecastle.

"The portholes must be absolutely resistant to deformation, even under heavy loads," explains Rolf Vrolijk. In sailing mode, the portholes are closed and secured with solid stainless steel load pins in all corners. "All hull forces go directly to the pins," says the designer. Hydraulic pistons press against the porthole covers from inside to form a watertight seal. "The portholes in the hull are among the most technically sophisticated elements on board," Brännbacka points out. "Since we build according to legacy GL and LY3 rules, everything has to be designed to perform flawlessly from the start. Nothing can be changed later." To make sure the planned clearances

FROM CONCEPT TO COMPLETION AND BEYOND

Privately owned and operated yachts do not necessarily require full classification but frequently opt for compliance with flag state safety codes to ensure an appropriate level of safety or fulfil the requirements for commercial operation later on. DNV GL Maritime Hamburg has developed and successfully sold various services for owners and operators of such craft. The DNV GL straight structural plan review and the certification of carbon fibre rigs for sailing yachts have been adopted by authorities such as MCA as mandatory requirements for commercially operated yachts.

DNV GL Maritime has acquired significant experience in the field of composite yachts and carbon fibre rigs and rigging. Rig certification has been offered for nearly two decades, and type approvals of carbon fibre rigging are performed on the basis of current standards.

Years of experience designing America's Cup yachts, combined with comprehensive expertise from the day-to-day business of certifying top-flight racing yachts, have earned the DNV GL team an excellent reputation.

Ingenious design details make life on board a dream.

By going beyond strict adherence to rule-book wording and keeping an open mind for new approaches, DNV GL Maritime Hamburg encourages innovative thinking. When Baltic Yachts asked DNV GL to put its Baltic 175 concept to the test, the team accepted. The two large balcony doors in the hull contribute to the hull's global and local strength when closed during sailing operation but do not when opened in sheltered waters.

Lead Senior Approval Engineer Hasso Hoffmeister decided to support the structural engineers of Baltic Yachts and the experts from Gurit in the complex development of the doors, the locking system and the surrounding structures. Many design loops were necessary and the development work continues. DNV GL Maritime Hamburg supervises the development and implementation of the yacht and its components, scrutinising the performance and integrity of materials, features and the ship's structure in lab and sea trials as well as load tests.

will be sufficient to move about comfortably, the owner ordered mock-ups of both the cockpit set-up and the owner's quarters. These proved to be very helpful in ensuring an ergonomically designed onboard environment.

As with the construction of his last Baltic yacht, the owner has been enjoying his new "Pink Gin's" construction and planning process. "He is very involved in all processes and comes to Finland several times a year to follow the construction progress," reports Patric Brännbacka. Countless decisions have to be made and meetings held to move the project along as efficiently as possible. An entire team consisting of the interior designers, yacht designers, the captain and the ship's engineer are there to give advice to the owner and make various decisions on his behalf.

"That's the only way to handle a project like this," says Brännbacka who is in charge of coordinating the work of all the teams involved. "Thanks to the extensive experience of all participants, the owner places enormous trust in his advisors." An estimated 1000 days will pass before the new "Pink Gin" will finally touch water for the first time. Until then, a staggering number of decisions must be made and as many calculations be performed. The interior design will soon be finalised, and contracts with the suppliers of the rigging and sails will be signed. Surely project manager Patric Brännbacka won't have any reason to complain about boredom anytime soon!

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Photos: Baltic Yachts, judel/vrolijk

GREENER SHIPPING

In the face of dwindling fossil fuel reserves and tightening environmental restrictions, the shipping world is turning to low-carbon propulsion technologies. Future ships will rely on a combination of power sources and power-saving technologies.

In terms of noxious emissions per tonne of cargo carried, ocean shipping is still the least polluting mode of transport. Nevertheless, conventional fuel oils are a threat to the environment and to world climate. They are not sustainable and will eventually be simply too expensive. Since no single, universal alternative source of propulsion energy is available, future ships will likely be powered by a variety of sources.

With tighter emission limits coming into force in Emission Control Areas (ECA), the next logical step towards low-emission propulsion systems is liquefied natural gas (LNG), which is much cleaner than heavy fuel oil. Provided that the necessary supply infrastructure is established, LNG could be the ship fuel of choice for decades to come. Using LNG would eliminate SO_X emissions and significantly reduce NO_X, particle and greenhouse gas emissions. The worldwide fleet of LNG-powered ships

ECA ZONES – EMISSION CONTROL AREAS

Sea areas in which stricter controls were established to minimise ships' airborne emissions (SO_X, NO_X, ODS, VOC). ECAs existing since 2011 include the Baltic Sea and the North Sea, the North American ECA, which includes most of US and Canadian coast, and the US Caribbean ECA, which includes Puerto Rico and the US Virgin Islands.

is increasing rapidly. But while LNG is still available in vast quantities, it is a fossil fuel nevertheless and does emit CO_2. Achieving full independence from fossil fuels in the long term will be inevitable.

Technical challenge

Efforts continue to explore other alternative energy sources and develop technology for their economical use. In ports, ships can practice "cold ironing", powering their on-board systems with electricity from the grid. This can even be carbon-neutral if renewable energy is used. Fuel cells and battery systems can power smaller craft and some on-board systems but may not be practical for larger propulsion machines. However, new on-board electricity management concepts, such as DC grids, can help reduce overall energy consumption.

While storing major volumes of electricity directly remains an unsolved technical challenge, many experts recommend using excess offshore wind energy or photovoltaic electricity to produce hydrogen by electrolysis. Hydrogen can power fuel cells or be combined with trapped CO_2 to produce methane (synthetic natural gas, SNG) for use as a natural gas substitute. SNG avoids the problems associated with transporting and storing hydrogen, which is extremely volatile. Furthermore, SNG can be distributed using the existing natural-gas supply infrastructure.

Biofuels produced from agricultural waste, high-energy crops or algae could contribute significantly to low-carbon shipping. Biofuels can be mixed with conventional fuels to compensate for dwindling supplies. While expected to play a significant role in the future energy mix, they have drawn criticism for driving up the cost of food and animal feed crops and competing with food crops for the available cultivable acreage.

Carbon capture systems (CCS) allow continued, climate-neutral use of fossil fuels by trapping the carbon emissions and storing them or converting them into an ecologically neutral form. CCS are an established technology and may prove useful on board ships, provided the costs can be brought down and the trapped carbon can be recycled economically.

New power sources require new propulsion machinery. Advanced gas-only and dual-fuel engines or hybrid systems have been developed and installed in some commercial vessels. Research continues to develop cost-efficient, eco-friendly on-board energy systems.

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Photo: Armin Lehnhoff – Fotolia

Germany's "Wattenmeer" National Park with its unique tidelands is an extremely vulnerable ecosystem.

TRIM THE FUEL BILL – AND PROVE YOU DID!

DNV GL has released version 4.1 of its trim optimisation software ECO Assistant with many new features, including fuel efficiency monitoring under specific operating conditions, report charts, e-learning and better language support.

Trim optimisation ranks highly in all standard publications on ship energy efficiency – and for good reasons: it is easily implemented on ships in service, typically pays for itself within a few months and delivers significant savings, as sea trials have shown.

In short, trim optimisation tools have gained a reputation for being a great, low-risk investment. But DNV GL's ECO Solutions portfolio can do more to enhance energy efficiency. For example, ECO Assistant, winner of the Lloyd's List Asia Award in 2012, is now available in an upgraded version 4.1 which addresses human-factor aspects and specific market needs in response to new IMO regulations (e.g. SEEMP).

The crew makes the difference

When ship operators fail to achieve the fuel savings they had hoped for, this can often be attributed to human factors. Whatever good intentions the management office at home may have, it is ultimately the crew on board that must take the necessary action. This requires awareness and commitment.

DNV GL's ECO Assistant 4.1 addresses the human factor at various levels by drawing on experience gained with close to 800 installations. User feedback has yielded detailed insight into practical aspects afflicting fuel-saving measures, in particular, human nature and cultural differences across all professions and nationalities. Besides obvious aspects such as user interfaces, the developers of ECO Assistant recognised a need to address office work and training. A user-friendly, intuitive interface has been a key feature of ECO Assistant from the very beginning. A new language package now makes it even easier for internationally mixed crews to work with the application.

While ECO Assistant is easy to use, experience shows that users appreciate a guided introduction to a new application. Faced with the diversity of users in international shipping, the challenge was to provide cost-effective training with enough flexibility to adapt to the needs of individual crew members. The solution is an e-learning tool allowing users to familiarise themselves with ECO Assistant or brush up

VERIFYING TRIM PREDICTION IN SEA TRIALS

Sea trials pursuant to ISO 15016 are a widely accepted method of establishing the speed/power performance of a ship. The standard procedure combines trials with minimum ambient disturbances (wind, sea, etc.), and semi-empirical corrections for the remaining differences to target conditions (load conditions, temperatures, etc.).

Trim trials are a variation of classical sea trials. Typically two conditions are tested:

- One trim with relatively high fuel consumption
- Another trim with lower fuel consumption

Sea trials on opposite course and for various main engine rpm's yield speed/power curves for both trim conditions. Trim-related fuel savings are identified through comparisons.

China Shipping completed successful trials for a 14,000 TEU containership recently, confirming fuel savings in excess of 10 per cent for a 1.8-m trim change in line with ECO Assistant's prediction. While trim adjustments of this magnitude are not always possible in actual operation, China Shipping's long-term performance monitoring confirmed fuel savings of up to 8.2 per cent.

Speed/power curves for three different trims with fuel savings of more than 10 per cent

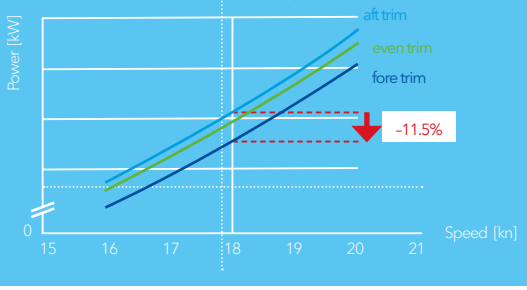

Photo: Marco2811 - Fotolia

In container shipping as in other segments, energy efficiency is influenced by human behaviour. DNV GL's new ECO Assistant 4.1 accounts for this fact.

on certain features at their own pace whenever they choose to. Initial feedback indicates that the tool is very popular with ship operators whose frequently changing crews are in constant need of training.

Easy reporting keeps all stakeholders happy

To verify the fuel-saving potential of ECO Assistant, DNV GL performed several dedicated sea trials with ECO Assistant. The predictions based on full-scale CFD (computational fluid dynamics) were confirmed in all instances.

But since dedicated sea trials are usually not feasible for operators, they prefer to look at data from daily routine operation. ECO Assistant has added enhanced reporting features indicating tool usage and fuel savings achieved for time periods or voyages. The generated PDF reports serve as proof of energy-efficient operation for SEEMP documentation vis-à-vis national and port authorities as well as for charterers, ship or cargo owners and other stakeholders. In addition, the process presents on-shore and on-board staff with a common view of the usage and benefits of the system, effectively encouraging its consistent use.

Fuel efficiency made transparent

Many shipowners require fuel consumption figures as part of a ship's description within a charter party or as a baseline for performance monitoring. But experience shows that these can quickly lead to frustration and fruitless discussions. The standard defence for allegedly poor performance is to cite varying load conditions, speeds or ambient conditions. Such comparisons are hardly helpful in establishing better practices in fleet operation.

In response to market demand, DNV GL developed the "Fuel Calculator" feature, which takes advantage of the hydrodynamics database used by ECO Assistant's trim optimisation functionality. It allows the fuel consumption for any sailing condition to be assessed at the click of a button. Upon request noon reports along with ECO Assistant's performance data and advanced mathematics can be used to display and compare actual consumption against performance at delivery. While this calibration needs to be done every few months to account for marine growth, DNV GL's new performance portal ECO Insight visualises hull degradation on a continuous basis.

Together or as stand-alone tools ECO Solutions contribute to a more equitable performance comparisons. On a level playing field, good practice will be recognised and rewarded.

Positive market response

By listening closely to its customers, DNV GL has been able to continue the success story of ECO Assistant. Clients have specifically praised the on-board e-learning features for continuous trim optimisation and the ready availability of current fuel consumption data in real time.

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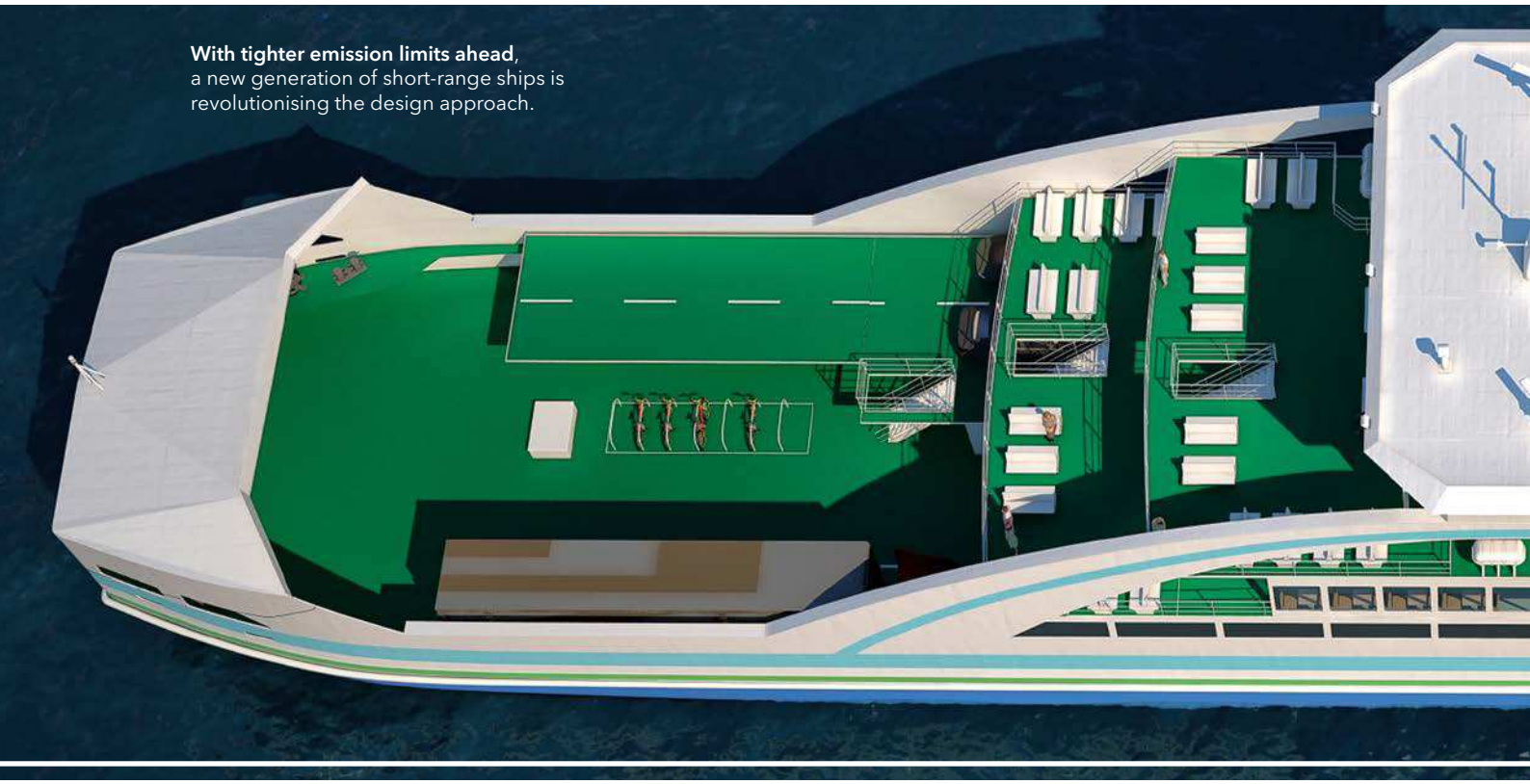


With tighter emission limits ahead, a new generation of short-range ships is revolutionising the design approach.

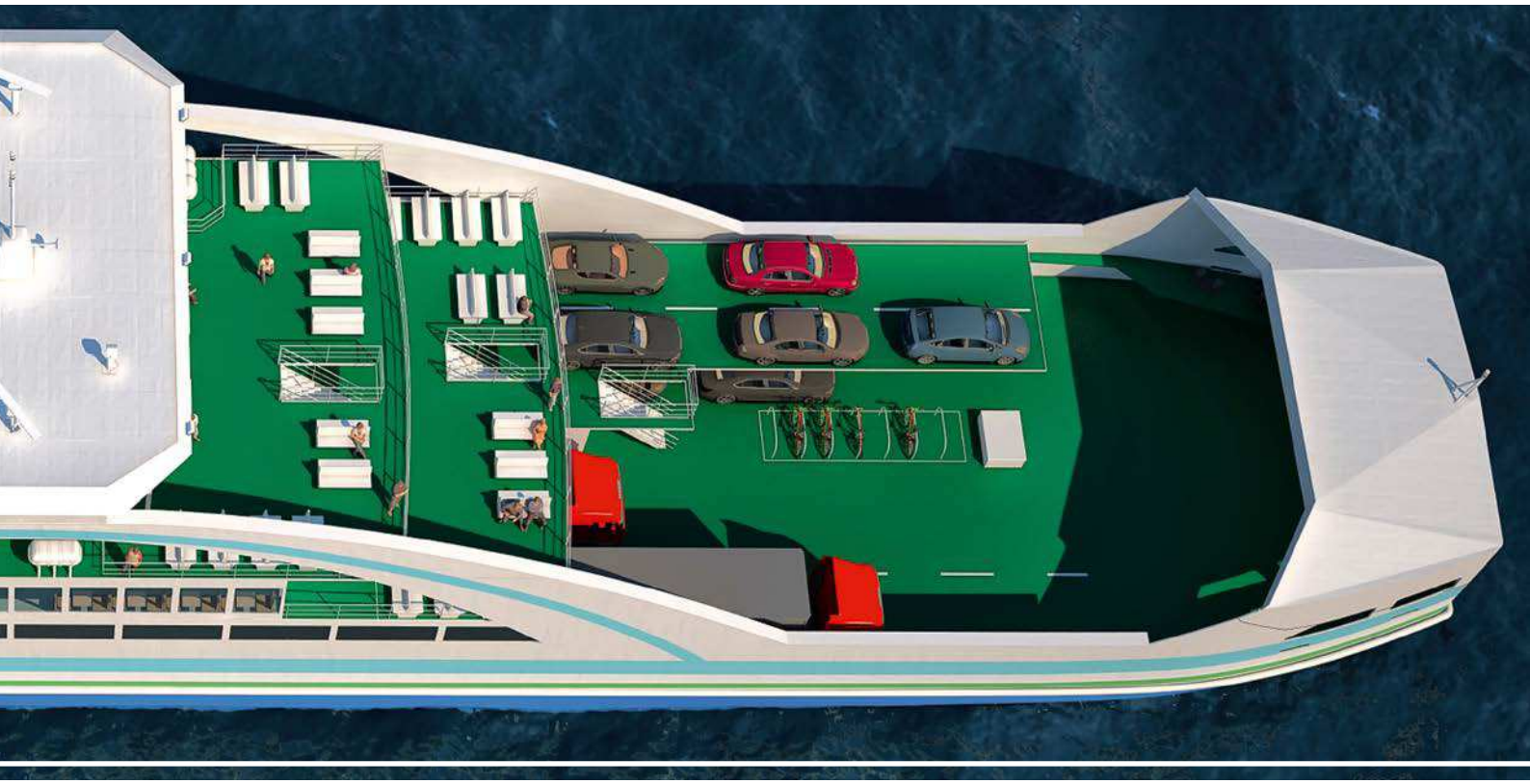
ZERO EMISSIONS FOR THE RIVER ELBE

State-of-the-art technology enables ultra-efficient operation of an innovative ferry type for the lower River Elbe. DNV GL has verified the feasibility.

Clean air is a scarce commodity in congested urban areas. Global warming caused by CO_2 from burning fossil fuels makes sea levels rise – and shipping bears part of the responsibility. While waterborne transport is approximately ten times more efficient than land transport, typical marine fuels contain more pollutants. But this will change soon. The magic word is ECA – Emission Control Area. The North and Baltic Sea are the first ECAs to adopt stricter emission limits in 2015. The sulphur content will be cut from 1 per cent to 0.1 per cent. The purity of marine diesel fuel will then be close to diesel fuel for cars. Good for the environment but difficult for ship operators.

For many older ships a conversion to cleaner fuels does not make economic sense. Since cleaner fuel is more expensive, the extra costs need to be compensated by designing a new generation of ultra-efficient, energy-conserving vessels. DNV GL has demonstrated the feasibility of such a concept with a pioneering ferry for the lower River Elbe.

"Each design starts with the mission requirements," explains ship designer Fridtjof Rohde of DNV GL. The "Cux-Bru" ferry has to cover 16 nautical miles between Cuxhaven and Brunsbüttel, with departures every hour. Traffic volume is estimated at 300,000 cars, 50,000 lorries and 650,000 passengers per year. The average utilisation should not exceed 40 per cent to avoid bottlenecks during high season. The ferry terminal must be easily accessible from the nearby motorways to avoid transit traffic through the cities.



It is therefore recommended to relocate the Cuxhaven terminal to a nearby industrial site, saving two nautical miles of ferry distance in the bargain. The ferry is designed for a 15-minute maximal turnaround time in terminal. Furthermore, the double-ended concept avoids time-consuming turning manoeuvres on the River Elbe with its strong tidal currents of up to four knots.

Flexible design options

Even small changes in the design speed of a ship can have a significant impact on the required power and fuel consumption. Taking a closer look at schedules, the fleet size and the design speed is well worth the while. Three "Cux-Bru" ferries should be built to offer hourly departures with a design speed of 15 knots. This will ensure arrivals within 75 minutes even under adverse current and wave conditions.

Flexibility wins the day. The ferry design features four permanent car lanes plus two lorry or three car lanes. In the car/lorry variant, the capacity is 140 cars, 25 lorries and 400 passengers. A light salon and a big sun deck offer passengers a "mini cruise experience".

The DNV GL designers go for flexibility. The most conventional propulsion option is a diesel-electric plant running on marine gas oil to meet the 2015 emission criteria. But the customer may as well consider LNG, which is even cleaner and, for the time being, cheaper. A third variant goes all the way to zero emissions: excess energy from nearby wind power plants could be converted locally to liquid hydrogen for on-board fuel cells emitting nothing but water. Batteries would supplement the fuel cells for short-term energy boosts, e.g. during manoeuvring. The technology has proven successful in German submarines. Guidelines for safe arrangement and operation are also available from DNV GL. "The technology is there, commercially off the shelf. We just need the price for liquid hydrogen to drop in Germany. Then the zero-emission option will become attractive for Cuxhaven as well," summarises Rohde.

The double-ended design avoids time-consuming turnarounds amid tidal currents.

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Photos: DNV GL

AMBITION DRIVES EXCELLENCE

COSL Innovator, one of the three COSL series semisubmersible drilling rig units currently operating in the North Sea, was again declared "Rig of the Month" by Statoil in July. This is the fifth time a CIMC Raffles-built North Sea rig has received such an accolade.

"We are really very happy to learn that the CIMC Raffles-built rigs in the North Sea are operating well with above-average performance and, in particular, that they have received this top award five times already," says CIMC Raffles President Yu Ya. "It shows that the CIMC Raffles-built offshore units are increasingly gaining recognition from owners and operators around the world."

CIMC Raffles is one of the leading offshore shipyards in China, specialising in the construction of semisubmersible drilling units, jack-ups and multi-purpose offshore projects. With its main production base located in Yantai and two others in Longkou and Haiyang, CIMC Raffles has established significant capabilities and capacities for series production of offshore units such as semisubmersible drilling rigs and jack-ups.

Prospecting for success

Since 2010, CIMC Raffles has delivered eight semisubmersible rigs including the three COSL drilling units operating in the North Sea. Another six are on order, and nine options are pending. In the jack-up segment the company has delivered nine units with seven more on order and four options. The offshore units delivered to date are operating in some the world's major offshore oil producing regions, including the North Sea, the Gulf of Mexico, Brazil, West Africa, the South China Sea and the China Bohai Sea.

Mr Yu explains that the company's strategy is to be the best in selected offshore sectors. The yard is poised to accumulate experience and learn from past projects to improve continuously. Yu cites the semisubmersible drilling units as an example: CIMC Raffles has delivered three COSL series drilling units and gathered a great deal of experience for North Sea units. The company then applied all of the lessons learned when building its fourth rig, "COSL Prospector", which is currently in the final commissioning stage at the yard and scheduled for delivery in the fourth quarter this year.

The other four semisubmersible drilling units under construction are called North Dragon, Beacon Atlantic, D-90 No. 1 and D-90 No. 2. North Dragon and Beacon Atlantic are both GM4-D design units co-developed by Global Maritime and CIMC Raffles for operation in severe sea states like the North Sea and Barents Sea, as per CAT-D requirements. Both parties own the intellectual property rights for this design jointly. D-90 No.1 and D-90 No. 2 are the world's first seventh-generation, ultra-deepwater semisubmersible drilling rigs.

Common values

Most of CIMC Raffles' deep-water drilling rigs are classed by DNV GL, whose Yantai Station Manager Sun Guang has been working with the yard on many projects. "I am deeply impressed by the yard's perseverance in pursuit of the offshore arena," says Sun Guang. "The yard has a very clear strategic goal and has been seriously focusing on the relevant areas, such as quality, technology, HSE, project management and on-time delivery. These are core aspects for an offshore shipyard. CIMC Raffles has shown >

COSL Prospector, sitting under CIMC's 20,000-tonne "Taisun" crane after the completed mating procedure.

Photos: CIMC Raffles

Yantai on the Shandong peninsula, China, is the site of CIMC Raffles' company headquarters and one of its three shipyards.

> a great willingness and ability to learn new technologies, class rules and shelf state regimes to meet its customers' requirements for offshore units."

Mr Yu expresses his appreciation of DNV GL, the world's leading offshore class society. The company is determined to position itself as the best offshore shipyard, he stresses. Strict adherence to DNV GL's offshore rules and class requirements has been a good learning experience for the company and its employees. "We are truly grateful to DNV GL. We share these same values: quality and technology. We are strategic partners," he says. This determination to be the best and to improve continuously has made CIMC Raffles China's leading offshore yard and is earning the company recognition from the world's rig owners and operators, says Mr Yu. He further attributes CIMC Raffles' success to three aspects: state-of-the-art facilities, a strong focus on research and development, and unwavering support from the parent company CIMC Group.

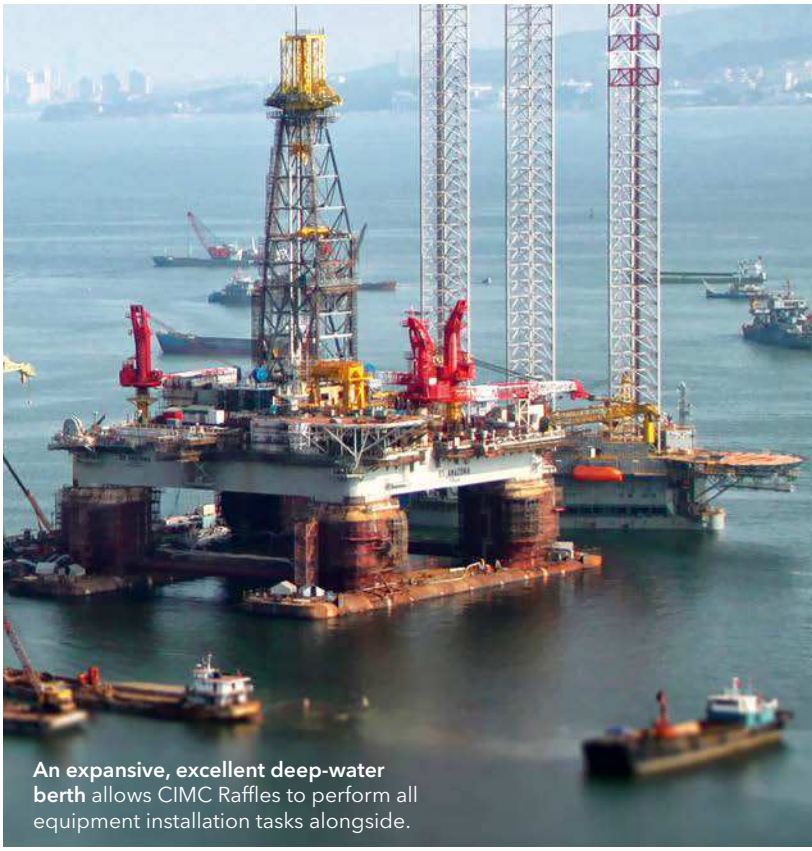
Located on the shore of Bohai Bay in Shandong Province, CIMC Raffles owns an enviable deep-water berth 1,327 metres in length and 18 metres in depth. This allows the yard to dock nine rigs simultaneously and install underwater thrusters alongside, which enables a more convenient and efficient commissioning process.

State-of-the-art facilities

Over the years CIMC Raffles has developed innovative technologies to improve efficiency and quality, such as the world's largest 20,000-tonne "Taisun" crane, which provides unrivalled capacity and flexibility for challenging lifting tasks, such as installing deck boxes on semisubmersibles or fully outfitted accommodation modules, etc. It takes about ten days to complete the global mating between deck box (upper hull) and lower hull, so the occupation period of the dry dock will be controlled to less than two weeks, which plays a critical role in significantly improving the production capacity of the yard and theoretically enables the yard to construct more than ten semi units simultaneously. CIMC Raffles also built China's first jack-up leg fabrication workshop, making it the only shipyard in

"With DNV GL we share the same values: quality and technology. We are strategic partners."

Yu Ya, President CIMC Raffles



An expansive, excellent deep-water berth allows CIMC Raffles to perform all equipment installation tasks alongside.

China capable of complete jack-up leg fabrication. What is more, the company can handle the entire production cycle from basic design, detail design, fabrication, mechanical completion, commissioning, sea trial and delivery of semisubmersible drilling platforms at its own yard.

Focus on research and development

CIMC Raffles has made huge investments in research and development. In 2010, the CIMC Offshore Research & Design Institutes were established in Shanghai and Yantai simultaneously. Later on CIMC bought the Swedish offshore design specialist Bassoe Technology (BT), which has strong R&D capacity in offshore projects. CIMC Raffles has thus acquired a comprehensive design capability covering all stages from concept and basic design to detail and output design.

CIMC Raffles currently employs over 1,000 engineers from China, Singapore, South Korea, Europe and the US with extensive offshore design experience. Together with the Norwegian consultancy Global Maritime, CIMC Raffles has developed the new GM4-D design, with currently two projects under construction and two more options. "I should mention that we have established a strong, capable, young technical team over the years and through multiple projects. This is our core competitive strength," says Mr Yu.

Support from the CIMC Group

CIMC Raffles is a subsidiary of the CIMC Group. Established in 1980, the parent company has adopted proven enterprise management practices including vigorous support of research and innovation as well as international cooperation, all of which benefits CIMC Raffles. "Backed by the group's strength and vast resources, I am confident CIMC Raffles will continue to thrive and become one of the world's premier offshore shipyards," says Mr Yu Ya.

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Photos: CIMC Raffles

OPTIMISING LNG PROPULSION SYSTEMS

On-board LNG fuel systems are basically a mature technology, but Wärtsilä continues to refine the concepts to conserve space, cut costs and simplify installation.

Most industry experts agree that LNG is currently the best, most feasible approach to overcoming the ship propulsion challenge in the face of environmental restrictions and rising fuel prices. With LNG technology progressing, acceptance of LNG as a ship fuel is increasing steadily. Wärtsilä continues to develop technical solutions in support of this trend. Wärtsilä's unique role as a full-systems integrator benefits from comprehensive in-house knowledge of all key components of ship machinery, fuel gas handling systems and ship design. This has enabled the company to develop more efficient and elegant solutions, including an upgraded version of the Wärtsilä LNGPac, an integrated fuel gas handling system, and the Wärtsilä gas valve unit (GVU).

Wärtsilä introduced the LNGPac in 2010 and the first LNG project, the conversion of the chemical tanker Bit Viking from conventional HFO to LNG, was completed as early as 2011. The LNGPac is a complete LNG fuel handling system including the bunkering station, the LNG tank and Tank Connection Space with the necessary process equipment, the heating media skid, and the control and monitoring system. With more than 20 LNGPac systems in operation or under construction, this unique system has proven to be a valuable enabler of LNG fuel for marine applications.

Since the system's introduction in 2010, Wärtsilä has further optimised its design, removing unnecessary interfaces and equipment and making the complete package as compact and simple as possible. Besides reducing the physical dimensions, a significant reduction in the capital expenditure (CAPEX) as well as operational expenditure (OPEX) has been achieved. This has resulted in a much improved LNGPac. By involving all stakeholders in the development process, end customers are reaping huge economic benefits from the optimised operational performance and interface integration, while the shipyard profits from a streamlined installation process.

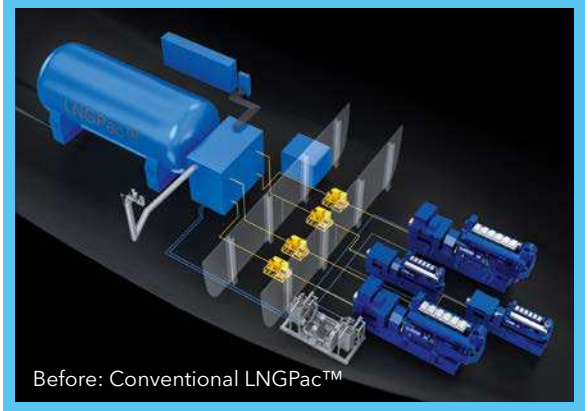
Smart improvements

The airlock, previously a separate room for passage into the tank hold space, was taking up valuable space and turned the entire tank hold into a hazardous area when accessing the tank connection space.

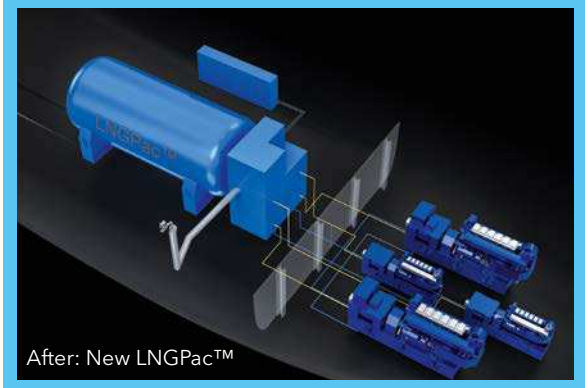
Precious on-board space is saved by simplifying and integrating the fuel system design.

As LNG as a ship fuel picks up speed, experts are fine-tuning the technology.

By integrating the airlock into the tank connection space, its footprint has been reduced, safety increased and installation at the yard made much easier. In addition, relocating the control cabinet to the tank connection space has dramatically reduced the amount of electrical cabling required to connect the external switchboards while minimising the number of interfaces.



Before: Conventional LNGPac™



After: New LNGPac™

COMPACT IS BEAUTIFUL

- Maximised LNG storage volume
- Efficient space utilisation
- Fewer interfaces
- Reduced installation and operating costs
- Increased reliability

The Wärtsilä GVU, a module located between the LNG storage system and the dual-fuel (DF) engine, ensures a safe and reliable gas supply to the engines and allows the gas system to be shut-off safely if necessary. In the new LNGPac design the GVUs are contained in an enclosed unit allowing them to be placed inside the engine room rather than requiring a separate compartment. Going one step further, Wärtsilä has integrated the functional components of the GVUs into the tank connection space. By combining the LNGPac and the GVU into a single, fully integrated "plug and play" unit, the solution saves considerable amounts of space while reducing installation time and costs for the yard.

The list of neat system design enhancements continues: the heat needed for LNG evaporation, previously provided by a separate heating media skid including the pumps, has been replaced by natural circulation of an intermediate heating media inside the tank connection space. The new heating circuit requires no pumps and directly utilises heat from the engine cooling water. The result is once again a reduction of interfaces, installation effort and electrical loads – all of which benefits the customer, the shipyard and the environment.

Leading the way in LNG technology

A similar modification has been made to Wärtsilä's cold recovery solution, which enables the "cold energy" of the LNG to be utilised by the ship's HVAC-system. In the new cold-recovery system, the ship's HVAC or other refrigeration systems are connected directly to the tank connection space, thereby removing an entire circuit of heat exchangers, valves and pumps.

Today Wärtsilä is recognised as a leader in propulsion solutions for gas-fuelled vessels and has advanced the technology by developing a complete value chain of systems, solutions and bunkering arrangements – both on-board and shore-based – to accelerate the use of environmentally sustainable and economically competitive LNG fuel. These latest developments are fully in line with Wärtsilä's commitment to ensuring better economic and environmental performance of ships and on-board systems.

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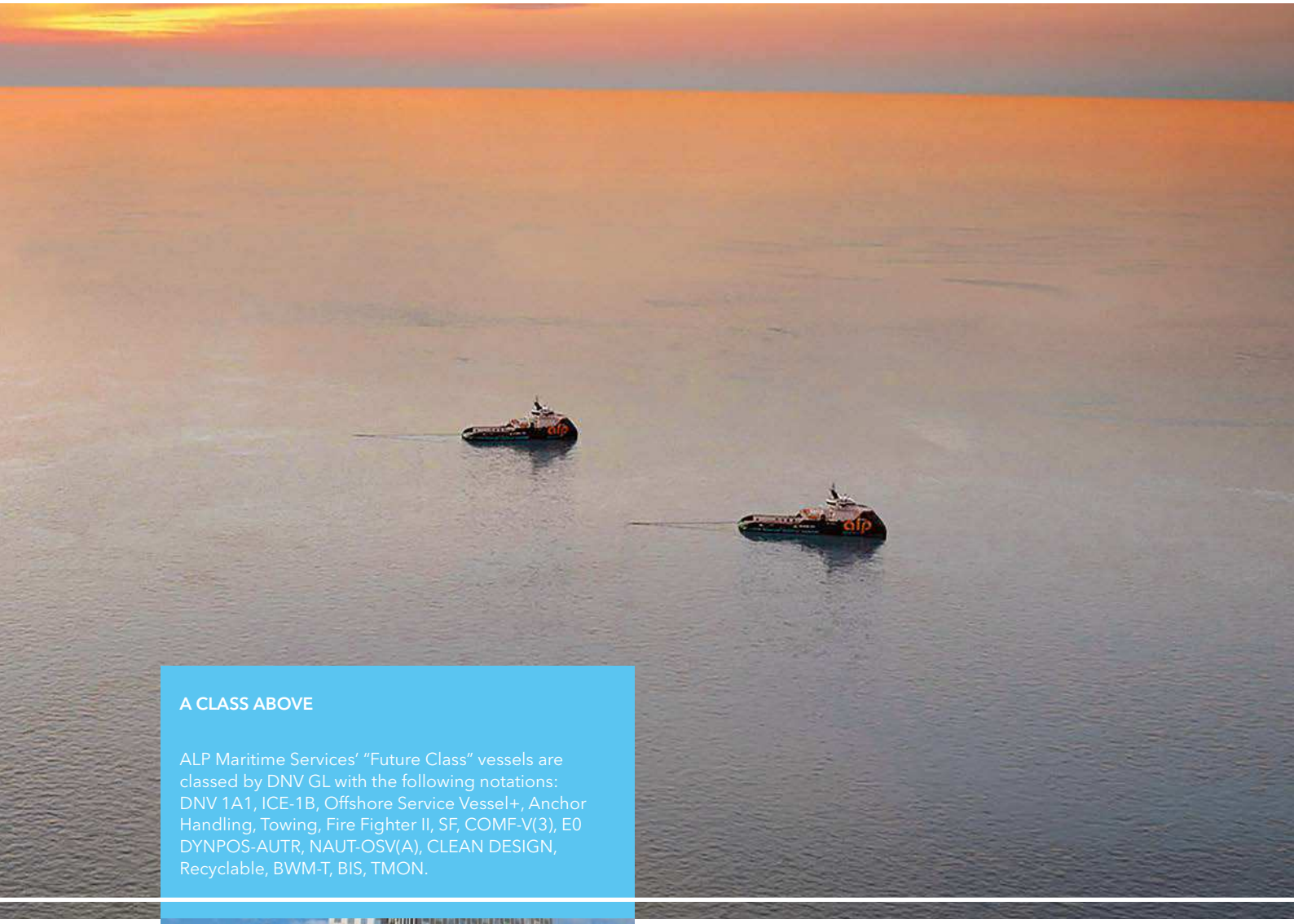
THE FUTURE IS (ALMOST) HERE

Founded in 2009 as a consultancy for ocean towage, heavy transport and non-conventional marine contracting, ALP Maritime Services has recently ordered four high-spec ocean-going tugs designed to meet the evolving demands of this highly specialised shipping segment.

The SX157-design vessels, developed by Ulstein Design & Solutions in close cooperation with ALP Maritime Services, have a 300-tonne bollard pull and are capable of operating at full load for 45 days without refuelling. ALP, recently acquired by Teekay Offshore, contracted Niigata Shipbuilding & Repair to build the four ships. The first vessel is scheduled for delivery in the first quarter of 2016.

Paul Mulder, CEO of ALP, says that the 4,250 dwt ocean-going tugs have been designed to manage



A CLASS ABOVE

ALP Maritime Services' "Future Class" vessels are classed by DNV GL with the following notations: DNV 1A1, ICE-1B, Offshore Service Vessel+, Anchor Handling, Towing, Fire Fighter II, SF, COMF-V(3), E0 DYNPOS-AUTR, NAUT-OSV(A), CLEAN DESIGN, Recyclable, BWM-T, BIS, TMON.

Photos: ALP Maritime Services

For CFO Arjen de Geus, COO Leo Leusink and CEO Paul Mulder, founders of ALP Maritime Services, the new vessels will be a big step towards fulfilling a long-held dream.

a growing number of ultra-large floating production units which are currently on order. "The growing size of these new units has created a demand for increasingly large and powerful vessels to perform mooring leg survey, maintenance, repositioning, refurbishment and/or decommissioning services, often in remote locations," he says. "Our goal is to provide the market with highly reliable, flexible and safe vessels that will minimise risk to crew and avoid damage to offshore installations."

Minimising risk

Mulder says that unlike many existing ocean-going tugs, the "ALP Future Class" vessels are equipped with DP II and redundant systems to avoid collisions, engine failure or blackouts – all genuine risks when towing large units in rough seas. "We started from scratch to develop a design that would >

> meet – and exceed – the expectations of energy majors," he says. "In many ways, the vessels reflect our 'customer first' business philosophy."

ALP Maritime Services takes its name from the first names of its three founding partners: CFO Arjen de Geus, COO Leo Leusink and Paul Mulder, CEO. The three met while working for Fairmount Marine, a leading contractor for ocean towage, salvage and heavy-lift transport based in the Netherlands. "We enjoyed our time with Fairmount, but in 2009 we recognised an opportunity to offer support to clients seeking the best solution to manage transport and towage."

Starting out

Over the next two years, ALP Maritime Services worked with clients such as Harms Bergung Transport und Heavylift, Fukada Salvage & Marine Works and ZPMC Shanghai Zhenhua Shipping, providing operational, consultancy and commercial services. "We valued these contracts but soon realised that without tonnage of our own our business would be limited," says Mulder. "Over the years we had all dreamed of owning our own fleet of high-spec tugs, and the time seemed right to make our move."

After consulting with a number of designers, ALP selected Ulstein Design & Solutions and the detailed engineering work began. Mulder explains that the vessel design for the "ALP Future Class" tugs meets both existing and future market requirements, with a focus on customer needs and emerging emissions regulations. "These vessels have been designed to minimise a number of concerns identified by energy majors transporting large structures over long distances," he says. "Take for example the redundant cooling and propulsion systems or the DP II and anchor-handling capabilities which will eliminate the need for extra anchor-handling tugs usually required for mooring and installation work."

Mulder adds that with 300 tonnes of bollard pull, towing some structures may require fewer tugs, reducing complexity, transport costs and collision risks. "We have also taken steps to ensure the ocean tugs are compliant with the Tier III emissions regulations scheduled to go into effect in 2016."

Financing a dream

With robust design and a solid business plan, the ALP team set out to raise capital for the newbuilding project, meeting with a number of banks and investors in Europe and North America. In the process ALP Maritime Services met with Teekay Offshore, who showed an interest in the project – enough to acquire ALP Maritime Services in early 2014. In a company statement Peter Evensen, Chief Executive Officer of Teekay Offshore, noted: "We believe ALP's

TOWING

- Towing winch: ROLLS ROYCE mod. SL400-3T
- 1° speed: 402 t @ 0-13 m/min
- Brake holding load: 675 t towing drum's layer
- 675 t on AH drum's 1 layer
- Drums: 3 x 86 m x 2,510m steel wire
- Control: Remote-controlled from bridge
- Cable lifters: 2 for 76 m rig chains
- Tow wire: 1 x 2,000 m x 86 mm on main tow winch
- Storage reels: 1 x 2 compartments 2,630 & 620 m 86 mm wire
- 1 x 3 compartments 1,115 m 86 mm wire each
- Fibre rope storage drum: Dismountable, max. capacity 7,200 m x Ø 203 mm
- Stern roller: 1 dimension Ø 4,000 mm x 5,500 mm, SWL 650 t
- Gog winch: 2 x RR, 30 t pull at 0 - 12 m/min
- Capstans: 2 hydraulic, 13,2t pull at 0-10 m/min
- Tugger winches: 1 x RR, 15 t pull at 0-30 m/min
- Tow pins: 2 sets of towing pins designed for horizontal locking of wire, SWL 300 t
- Pop up pins: Hydraulic raised/lowered vertical towing, guide pin sets (pop-up), SWL 300 t.
- Karmforks: 2 x 600 t variable inserts up to 120 mm chain

Photos: ALP Maritime Services

The ALP Future class is designed for the long-distance towage of the world's largest floating objects.

operational capabilities and customer relationships in the growing long-haul ocean towage and offshore unit installation segment is a natural complement to Teekay Offshore's existing offshore project offering."

With financing secure, ALP, working closely with Ulstein Design & Solutions, finalised the design. Suppliers include Pon Power (propulsion), Kongsberg (dynamic positioning) and DNV GL, among others. According to Bas Veerman, DNV GL Customer Service Manager (Benelux), the "ALP Future Class" vessels have several special notations. "It was clear from the beginning of the project that ALP was committed to developing a very unique, high-spec design," he says. "In terms of operational performance and flexibility these vessels are 'best in class'. They also include features to reduce emissions, enhance safety and robustness, and ensure crew comfort over long distances."

People, not steel

Indeed, Mulder says that while the company has committed significant resources to the project, successful operation has more to do with people than steel. "Long-haul towage is a highly specialised segment requiring experienced, highly skilled crews," he says. "Our focus now is to attract, train and develop officers and crews, and we feel the quality and comfort of these vessels will serve as a powerful recruiting tool."

Mulder acknowledges that the company still has a long way to go, but with a four-vessel newbuilding programme now underway, ALP Maritime Services has a bright future. "Arjen, Leo and myself have spent a lifetime to get to this point. Now, the time has come to execute our business plan."

DNV GL Expert
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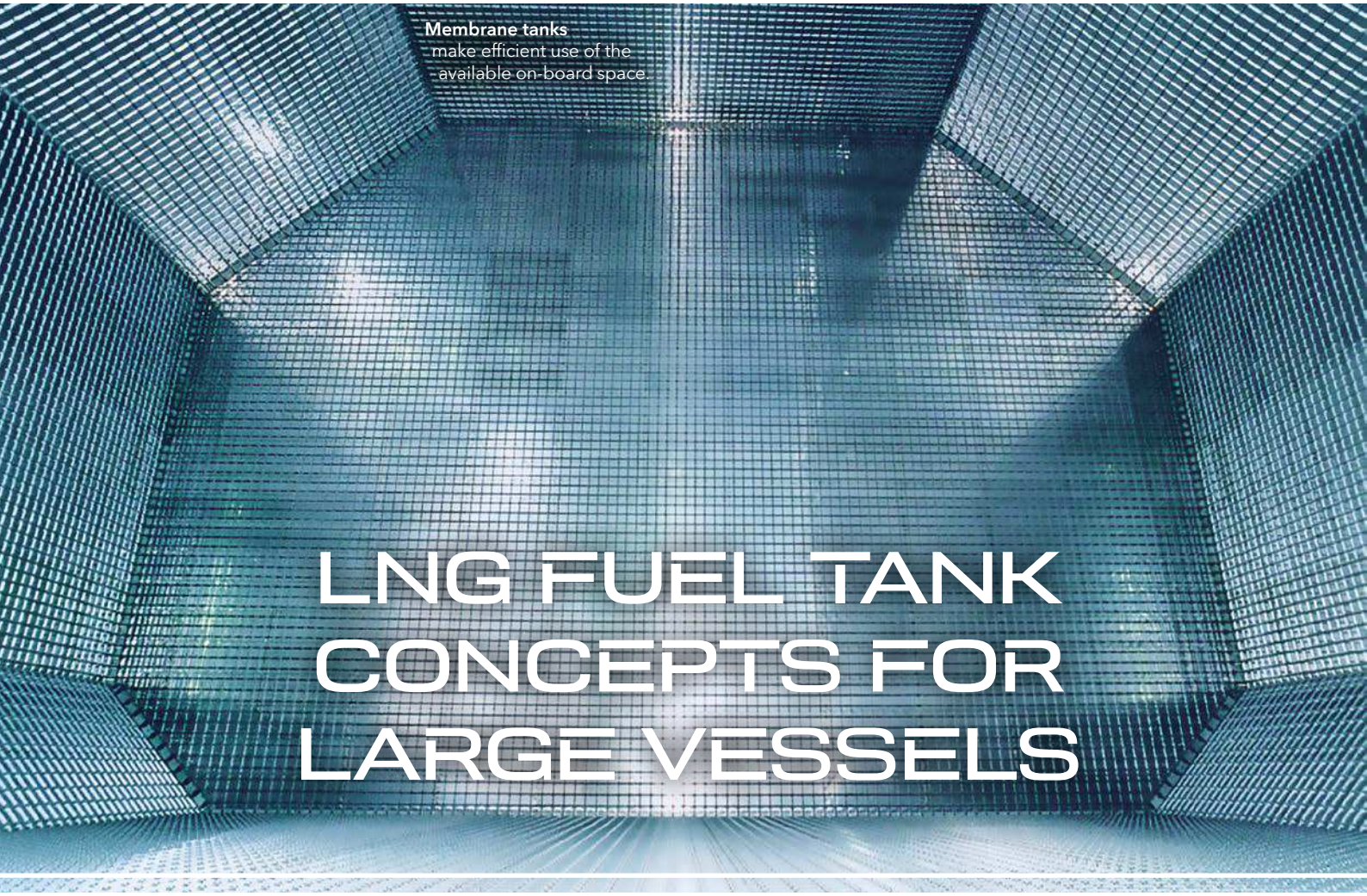

Membrane tanks make efficient use of the available on-board space.

LNG FUEL TANK CONCEPTS FOR LARGE VESSELS

Large ship types are the next frontier for LNG propulsion technology. Proven fuel tank concepts can be adapted for long-range LNG operation of container vessels.

The advent of LNG as a low-emission, comparatively cost-efficient future fuel for merchant ships has prompted a surge of development activities across the shipbuilding industry. Hanjin, GTT and DNV GL have signed an agreement to jointly investigate and develop a gas-fuelled large container vessel concept equipped with membrane fuel tanks. Based on current fuel price forecasts the joint development project focusses on long-distance endurance of an LNG propulsion system. The concept relies on well-proven (containment of LNG as cargo) or market-ready technologies (dual-fuel, low-speed two-stroke engines).

The study envisions a 16,300 TEU container vessel equipped with two membrane tanks capable of bunkering up to 11,000 cubic metres , enough for approximately 15,000 nautical miles. Designed by Hanjin Shipyard, the ship is intended to travel between Asia and Europe. It will have to cross at least one Emission Control Area (SECA) in European waters where the new, strict sulphur emission limits will be in effect. The tank size can be adjusted to the given operational profile, in particular, the expected sailing time or distance in ECA areas.

Efficient LNG storage

The project focuses on the LNG fuel system, consisting of the bunker station, LNG fuel tanks, gas preparation and fuel supply systems. Hanjin is designing the key components for the LNG supply system, GTT is responsible for the integration of the fuel containment system, and DNV GL is handling the design review, hazard identification and, upon successful completion of the project, the Approval in Principle (AiP) of the design. The safety performance assessment for the gas supply system and the tank system integration will be key aspects of DNV GL's contribu-

tion. Apart from the technical aspects, the project will also investigate economic feasibility criteria based on the LNG-Ready Step 1 procedure. This includes evaluation of the LNG tank location and range in gas mode based on the ship's operational profile, outlining the requirements for an LNG-ready or LNG-fuelled design, and an assessment of prospective LNG availability at relevant locations.

The GTT tank system uses proven technology which has been in use for many years on board LNG carriers. The biggest advantage of membrane tanks is that they make efficient use of the space available on board, requiring little more than half the hold space occupied by spherical or cylindrical tanks. The Mark III membrane system chosen for this large container vessel concept consists of a cryogenic liner directly supported by the ship's inner hull. The liner is composed of a primary metallic membrane with an insulation layer and a secondary membrane underneath.

The boil-off challenge

One key issue has been the treatment of boil-oil gas from the LNG tanks. The pressure increase inside the membrane tank system, which is designed for a maximum of 700 mbarg, must be limited without releasing gas to the atmosphere. This can be achieved by using the boil-off gas to power the auxiliary engines and the boiler. Most of the time the power demand by far exceeds the natural boil-off from the tanks, so the system must actually vaporise additional volumes of LNG to meet the fuel demand while maintaining a low operating pressure inside the tanks (typically between 50 and 300 mbarg). However, when the ship is idle (at anchorage for instance) and the power demand is very low, gas pressure will build up inside the tank. As long as some gas is drawn to power the minimum hotel load, the pressure will increase relatively slowly. Should the pressure inside the tanks exceed a preset value (around 600 mbarg) – a case not foreseen in the operating profile envisioned for the ship – the excess boil-off will be directed to the boiler (as a gas combusting unit) for incineration. For operating profiles including longer idle periods, a Mark III Flex membrane system could be used, which would provide 50 per cent more time for the pressure to reach the GCU threshold. A Mark III Flex membrane has 400 millimetres of PU foam insulation versus 270 millimetres in a standard Mark III system.

Today 50 LNG-fuelled ships are in service and the milestone of 100 confirmed LNG projects worldwide was achieved this year. There is no longer any doubt that LNG will be a major ship fuel in the future. Yards and component manufacturers have developed fuel-efficient and eco-friendly LNG propulsion systems for all types of vessel. The joint project of Hanjin, GTT and DNV GL demonstrates that efficient concepts for large ships are feasible and available to meet the needs of tomorrow's maritime industry.

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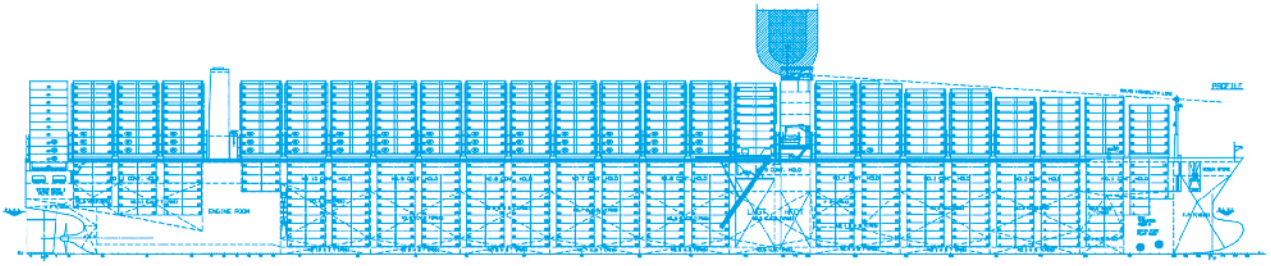

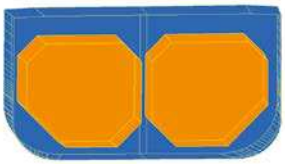

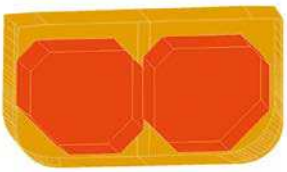

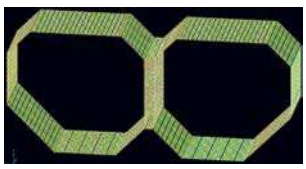

No space is wasted by membrane tanks as the cross-sectional CAD images show (left and below). The 16,300 TEU vessel (above) could travel 15,000 nautical miles on LNG alone.

Photos: Hanjin – GTT – DNV GL

MAIN PARTICULARS OF THE SHIP CONCEPT

Length overall:	approx. 397 m
Breadth:	56.1 m
Design draught (MLD):	14.5 m
Fuel tanks (LNG):	2×5,500 m^3 (symmetric with centreline)
Tank lenghth:	approx. 12 m
Tank height	approx. 22 m
Tank breadth	approx. 24 m
Engine:	dual-fuel MEGI engine

TRAINING AT DNV GL

For the complete range of training courses offered by DNV GL Maritime Academy please visit www.gl-academy.com.

10.09.14
Damages to Machinery and Repairs
Hamburg, DE

11.09.14
Asbestos – A Hidden Hazard on Board Ships
Hamburg, DE

11.09.14
How Lean is Your Safety Management System (SMS)?
Hamburg, DE

12.09.14
New EU Regulation on Ship Recycling
Hamburg, DE

16. – 18.09.14
Bulk Carrier Hull Inspection – Survey Simulator Workshop
Gdynia, PL

17.09.14
Introduction to the System of Maritime Regulations
Hamburg, DE

17. – 18.09.14
OHSAS 18001 for Shipping Companies
Istanbul, TR

22. – 23.09.14
ISM Compact Course
Rotterdam, NL

22. – 23.09.14
Marine Environmental Awareness Course
Mumbai, IN

23. – 26.09.14
Approved HazMat Expert
Istanbul, TR

23. – 23.09.14
Introduction to the Offshore Industry and Dynamic Positioning
Gdynia, PL

23. – 25.09.14
Train the Trainer for Shipping Companies
Dubai, AE

24. – 26.09.14
ISM Advanced Course
Rotterdam, NL

25. – 26.09.14
Accident Investigation in Shipping – Analysis and Root Cause
Hamburg, DE

29. – 30.09.14
TMSA and Vetting Inspection Workshop – Understanding and implementing TMSA guidelines and Improving SIRE-VIQ Inspection Performance
Singapore, SG

01. – 02.10.14
Internal Auditor ISM-ISPS-MLC for Shipping Companies
Copenhagen, DK

01. – 03.10.14
HAZOP Leader Course
Rotterdam, NL

03. – 04.10.14
TMSA Workshop – Efficient Tanker Operation
Mumbai, IN

07. – 08.10.14
TMSA Workshop – Efficient Tanker Operation
Rome, IT

08. – 09.10.14
Implementation of an Environmental Management System according to ISO 14001 for Shipping Companies
Hamburg, DE

08. – 09.10.14
Risk Management, Incident Investigation and Change Management
Singapore, SG

09.10.14
Personnel Performance Evaluation
Piraeus, GR

13. – 14.10.14
Security Awareness Training for Seafarers with Designated Security Duties
Hamburg, DE

13. – 14.10.14
Energy Efficient Operation of Ships – Masterclass
Genoa, IT

13. – 16.10.14
Approved HazMat Expert
Valencia, ES

13. – 16.10.14
Approved HazMat Expert
Shanghai, CN

16.10.14
The IMO Convention on Ship Recycling
Genoa, IT

16. – 17.10.14
Designated Person Ashore (DPA) Training Course
Makati City, PH

21. – 23.10.14
Modern Safety Management Course
Rotterdam, NL

21.10.14
Complying with the MLC 2006
Makati City, PH

22. – 24.10.14
Internal Auditor of an Integrated Management System acc. to ISO 9001, ISO 14001 and OHSAS 18001 for Shipping Companies
Istanbul, TR

28. – 29.10.14
Effective Leadership in a Maritime Environment
Dubai, AE

28. – 30.10.14
Machinery Course
Høvik, NO

28.10.14
HSE Leadership for Managers Course
Rotterdam, NL

28. – 29.10.14
Energy Efficient Operation of Ships – Masterclass
Copenhagen, DK

EVENTS & EXHIBITIONS

Please visit www.dnvgl.com/news-events for a constantly updated list of events, conferences and exhibitions.

15. – 18.09.14
Rio Oil & Gas 2014
Rio de Janeiro, BR

21. – 23.09.14
Dry Bulk Europe
Amsterdam, NL

22. – 25.09.14
3rd Annual Offshore Support Vessels Middle East
Dubai, AE

24. – 27.09.14
Monaco Yacht Show
Monte Carlo, MC

28. – 30.09.14
NuTTS
Marstad, SE

10. – 11.09.14
Global Liner Shipping Asia Conference
Singapore, SG

25. – 26.09.14
Ballast Water Management Technology
Miami, USA

08. – 09.10.14
Asian Offshore Support Journal Conference
Singapore, SG

10.10.14
Asian Dynamic Positioning Conference
Singapore, SG

14.10.14
2nd GreenPort Cruise
Barcelona, ES

15. – 17.10.14
2nd International Conference on Maritime Technology and Engineering MARTECH 2014
Lisbon, PT

15. – 17.10.14
9th GreenPort Congress
Barcelona, ES

Live LNG bunkering of MS Stavangerfjord at the Risavika terminal is part of this years' Gas Fuelled Ships Conference programme in Stavanger from 25. to 27. November.

21. – 24.10.14
Shiptec China 2014
Dalian, CN

22. – 24.10.14
SNAME
Houston, USA

23. – 24.10.14
2nd INTNAM Symp.
Istanbul, TR

28. – 30.10.14
Seatrade Middle East Maritime 2014
Dubai, AE

October 2014
2nd Shipping Emissions Conference
London, GB

October 2014
LNG World Shipping Conference: Ship-Shore Interface
London, GB

20. – 21.10.14
7th Annual Arctic Shipping North America Forum 2014
St. John's, CA

15.10.14
Brazil Offshore Finance Forum
Rio de Janeiro, BR

14. – 15.11.14
Hiroshima Workshop
Hiroshima, JP

17.11.14
IBJ Awards 2014
Rotterdam, NL

19. – 20.11.14
Tanker Shipping & Trade Conference
London, GB

25. – 26.11.14
5th Ship Propulsion Systems Conference
London, GB

25. – 27.11.14
Gas Fuelled Ships Conference 2014
Stavanger, NO

02. – 05.12.14
Exponaval
Valparaiso, CL

07.11.14
Eisbeinessen
Hamburg, DE

19. – 20.11.14
2nd Offshore Oil and Gas Engineering Conference
Houston, USA

19. – 20.11.14
Hellenic Institute of Marine Technology – Annual Meeting of Marine Technology: Technological Conference and Exhibition, ELINT 2014
Athens, GR

03. – 05.12.14
The International WorkBoat Show 2014
New Orleans, USA

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100
Countries

16,000
Employees

300
Offices

13,000
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