# THE NAVAL ARCHITECT

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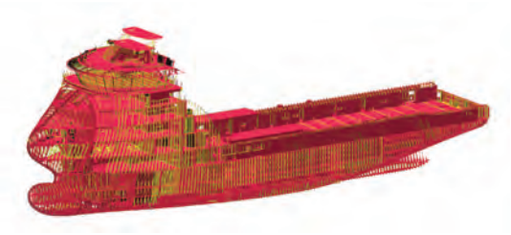

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**Subscriptions & Publications Manager** Jim-Ray Semanhyia
**Publisher** Mark J Staunton-Lambert

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Editorial & Advertisement Office:
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London, WC2N 5DA, UK
Telephone: +44 (0) 20 7235 4622
Telefax: +44 (0) 20 7245 6959
**E-mail editorial** editorial@rina.org.uk
**E-mail advertising** advertising@rina.org.uk
**E-mail production** production@rina.org.uk
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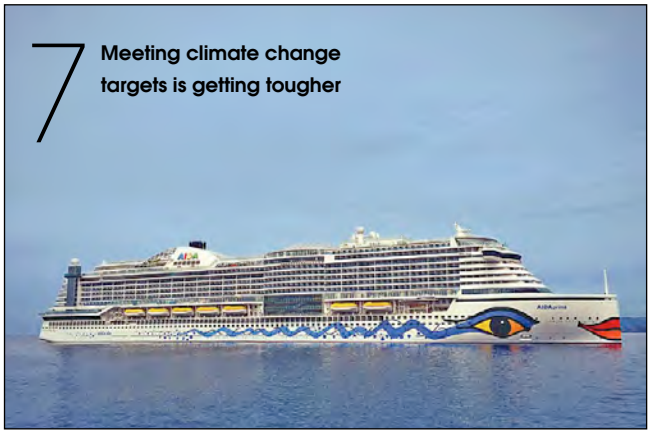



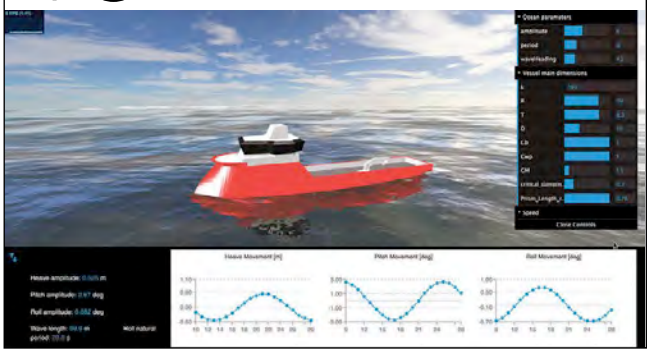




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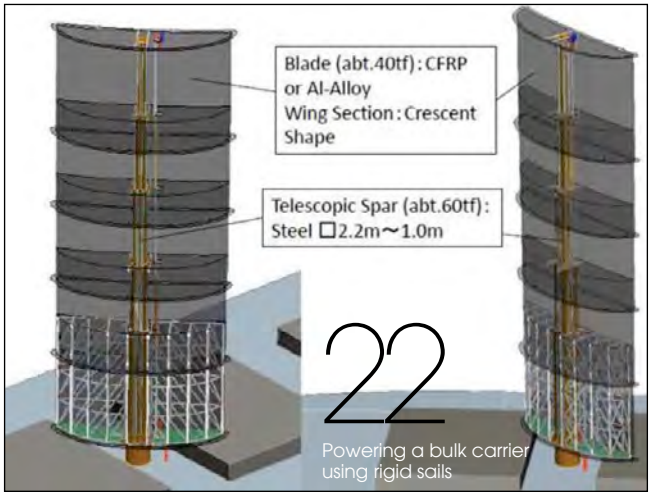


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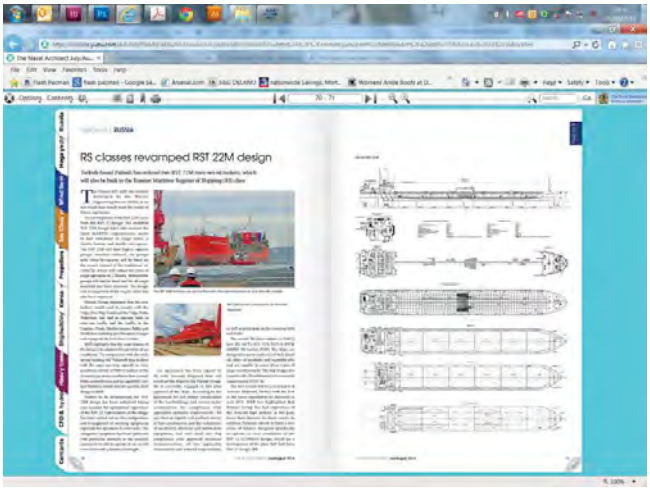

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# The hard technological work starts here

A wave of new green technologies is emerging, as seen onboard *AIDAprima*, but will it be enough?

The current overcapacity in the shipping sector has led to a slump in the number of newbuild vessels, which in turn has led to an overcapacity in the shipbuilding sector. However, the rapid technological development which is taking place in the maritime industry, necessary for it to achieve the climate changes demanded by society and regulation, may well prove to be the salvation of the shipbuilding sector.

New regulations, such as the Energy Efficiency Design Index (EEDI) and the setting of NOx, SOx and particulate emission levels, have led to the introduction of new technology to meet the regulations, but more importantly, in some ways, it has prompted a drive in some regions to bolster research & development budgets in a bid to gain a competitive advantage.

Denmark's Blue InnoShip research projects and Japan's series of 22 high tech projects(completed in 2013) are examples of the technological advances that have been prompted by new regulation. In Denmark, there has been the development of the Trailer Cat, an innovative ro-ro vessel (TNA April 2016), and in Japan, Mitsubishi Heavy Industry's (MHI) MALS, an air lubrication system that is now in use on MHI's latest cruiseship newbuild, *AIDAprima*.

The level of innovation in these projects and their potential is both significant and laudable. Trailer CAT will help the maritime industry compete with road and air services through improved turnaround times. The MALS system, which is the development of an idea that was shelved initially as unworkable some 50 or more years ago, and reinvents a technology with modern materials, techniques and design, has the capability to make significant reductions in the levels of ship pollution.

These projects will have significant benefit for the maritime industry in reducing emissions. MALs will cut up to 5% of $CO_2$ emissions, while in the case of the Trailer CAT, which is LNG powered, NOx is virtually eliminated. There are no SOx emissions, and carbon dioxide emissions are said to be reduced by up to 20%.

Roll back to Paris in December last year and the Conference of the Parties (COP) 21 and a commitment by all the participating countries to limit average temperature increases to 1.5°C. That decision alone is tough for all those involved in transport, but for shipping the move could see a major technological shift.

All projections of the medium to long term future of the industry suggest that there will be a substantial growth in demand for shipping capacity as the rise in the world's population continues and demand for goods increases as a consequence. Some, like Lloyd's Register's Global Trends report, produced in partnership with QinetiQ and the University of Strathclyde in 2013, predict a more than doubling of global trade by 2030 as its most conservative estimate.

According to this view, more ships will be needed as the demand for raw materials and finished goods will increase in line with the growth in population. If this view is correct then the development of technology that can reduce emissions by 5-20% will definitely not be enough; the more likely requirement will be that shipping will need to cut emissions by up to 60% of today's levels. This will require a technological leap of the most dynamic proportions.

And, as MHI found, will a re-examination of past technologies provide the basis for future development? This is the approach taken by the University of Tokyo with its partners, Mitsui OSK Line, NYK Lines and ClassNK, in their research on wind power (see this month's bulk carrier feature).

Wind power is just one of the technologies that is being redeveloped using modern materials and design methods, such as carbon fibre and computerised wind direction finding and weather routing technology.

Other technologies are beginning to surface, such as methanol powered engines, which reduce carbon emissions substantially, and hydrogen power technologies that produce water as an exhaust. Such benign fuel may well be carbon free at the point of use, but its production and source may well prove to have a carbon cost; how much that will be is anyone's guess at this stage. The point, however, is that the industry is now shifting to reduced emission technology to zero emission fuels and that could see LNG's pre-eminence as the fuel of choice short lived. *NA*

Regulation

## MEPC starts EEDI review

A review of the Energy Efficiency Design Index (EEDI) and its application since its inception in 2013 is now under way with the completion of the review expected before MEPC (Marine Environment Protection Committee) 71 next spring at the latest.

The review was a planned evaluation of the regulation; a working group has been established and it is hoped that the group's report will be presented to MEPC 70 in the autumn if possible, but if that proves too soon then at MEPC 71.

EEDI was established initially for tankers, bulk carriers, reefer ships and containerships and later formulae and correction factors were added for vessels that did not fit the EEDI formula directly.

One of the correction factors was for ro-ro and ro-pax vessels and that correction factor was suggested by the Swedish and German delegations and approved by MEPC in May 2013. However, since adoption of this formula doubts have been raised by a number of ship operators, designers and academics as to whether the ro-ro correction factor in its current form offers a workable solution for ro-ro ship designers.

The working group will also look at the ro-ro correction factor and is expected to report on this issue at MEPC 70 also.

In addition, MEPC has developed a three point plan to introduce a Monitoring, Reporting and Verification (MRV) system with an aim to set MEPC's greenhouse gas goals. The first step will be to establish how to collect data on emissions and cargo loading as well as other data such as ship speed. IMO will then set about analysing some two – three years' worth of data in the second phase and then to finally decide how the IMO will move forward.

One of the goals for MEPC is to persuade the EU that its version of the MRV system, which is due to be enforced from 2018, should be aligned with the IMO's system. The EU system is very detailed in some sections, including such data as actual cargo loaded. The IMO believe that some developing countries will not be able to provide such detailed data and will judge cargo carried through the less accurate method of using the deadweight of the ship.

Containerships

## *MOL Comfort* case nears its denouement

Direct discussions within the Tokyo Court between Mitsui OSK Lines (MOL), the owner of the *MOL Comfort*, which broke in two and sank in 2013, and the shipbuilder Mitsubishi Heavy Industries (MHI) are expected to be concluded soon with a ruling following by the end of the year, says MHI.

Senior chief engineer at the Shipbuilding & Ocean Development Division of MHI, Naoki Ueda, told *The Naval Architect* that the dispute is effectively a "production liability issue", which is in practice consumer legislation that "protects consumers against poor production or to protect against life threatening consumer issues".

However, this legislation is not easily applied to the situation between MOL and MHI as the 'product' is a ship which is constructed with the agreement of the owner and a class society, ClassNK in this case. The operating company is a professional organisation, so there is no product user manual as such.

According to Ueda, the root cause of the vessel failure will never be known for certain as all the evidence is lost, so the main issue is the US$800 million claim from cargo owners.

Action in the US and Europe has now been rejected and MOL asked the Tokyo Court to decide whether MHI should be liable for the cargo claims. However, the court decided that cargo owners had a contract with MOL and not with MHI, so the liability remained the ship operator's, explained Ueda.

MOL was asked about the case, but the company would only say that it was uncertain when the court case would come to an end.

Acquisitions

## Palfinger swallows HHH

Austria-based marine equipment supplier Palfinger Group has closed the deal for the entire equity of the Norwegian lifesaving equipment supplier Herkules Harding Holding (HHH) AS for an unspecified amount.

The acquisition is subject to final approval from the authorities which is expected within the next few weeks, says Palfinger.

HHH has offices in 16 countries and its main products include lifeboats, rescue boats and davits. The company says it "has customers all over the world in all the relevant segments such as oil and drilling companies, as well as shipyards for deep-sea vessels, tankers, container ships and passenger ships".

It added: "Today's Harding Group was created through a combination in 2013, when Herkules Capital acquired Schat-Harding and Noreq. Schat-Harding was established in 1945 and had a strong position in high-end markets. Noreq was founded in 2006 and recorded brisk international growth. The two companies were an ideal match in terms of products and markets; under the name Harding, they have since been a leading supplier of lifeboats. With a staff of approx. 800 employees, the company recorded revenue of around €140 million (US$155.88 million) in 2015."


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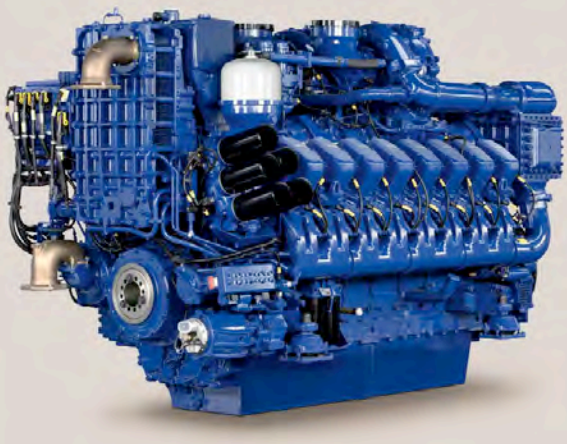

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BWMC

## Ballast water rules edge closer

The fiftieth flag state to accede to the Ballast Water Management Convention (BWMC) has brought the figure representing the world fleet to 34.81%, a tantalising 0.19% from the 35% of the world fleet that would trigger the implementation of the rules a year later.

Tafawa Williams, alternate permanent representative of Saint Lucia at IMO, met IMO's Frederick Kenney, director, legal affairs and external relations division, to deposit the instruments of accession on 26 May.

Ratification of the rules has been exceptionally slow, with the adoption of the convention by IMO in 2004. Since then there have been a number of objections with some claims that a number of flag states were delaying ratification. This view was reinforced at the last MEPC meeting by a move by one flag state to extend the period after ratification, in which owners must fit ballast water treatment systems, from five years to 15 years. The proposal was rejected.

PCTC

## UECC's LNG ships set for October delivery

Two LNG-powered pure car and truck carriers (PCTCs), the first in the world according to the owners, will be delivered from the NACKS shipyard in China this autumn.

NYK Lines, a joint venture partner with Wallenius Lines in United European Car Carriers (UECC), says the Nantong yard will deliver the 181m long, 30m beam ships in October. The ships will be fitted with MAN B&W 8S50ME – C8.2 – GI dual fuel units and they will be the first PCTCs capable of operating on LNG.

The ships will have a capacity of 3,800 cars on ten decks and will reduce carbon dioxide emissions by 23%, NOx by 13%, particulates by 37%, and SOx by 92%, says Kawasaki Heavy Industries, which operates the NACKS (Nantong COSCO KHI Shipyard) yard with COSCO.

Class

## KR develops KR-CON software

Asian class society the Korean Register (KR) released the 14th edition of its KR-CON software in April. The software tool, includes a significantly improved and "increasingly critical, dangerous goods programme", which was developed in-house, as one of the tool's key functions.


China-built *Auto Eco* and its sistership will be the first LNG powered car carriers in the world

The 14th edition of KR-CON has been upgraded through the inclusion of the cargo search programme. Developed in-house, the new programme has enhanced functionality and adds significant value to the latest software. The programme was developed in accordance with the International Maritime Dangerous Goods code (IMDG Code) and enables users to quickly and easily identify critical details for the complicated transport requirements of dangerous goods.

Included in the latest package is a comprehensive electronic database of IMO instruments, providing all of the latest IMO Conventions, Codes, Resolutions and Circulars. "By simply inputting ships' particulars, KR-CON allows the user to find all of the regulations relevant to a specific task and helps to ensure that all of the IMO requirements are applied correctly," said the class society.

The system is currently used by a variety of professionals, including surveyors, port state control inspectors, shipyards and design houses in more than 40 countries around the world today. *NA*

## Clarification:

It has been brought to our attention that the photo of the IMO secretary general, Kitack Lim, at the head of the Editorial Comment in the March issue of *The Naval Architect* may have caused some readers to assume that the words and views expressed in the Editorial Comment were those of the secretary general. We wish to assure readers that this was not the case, and that words and views expressed in the Editorial Comment were those, and only those, of the editor and the institution.

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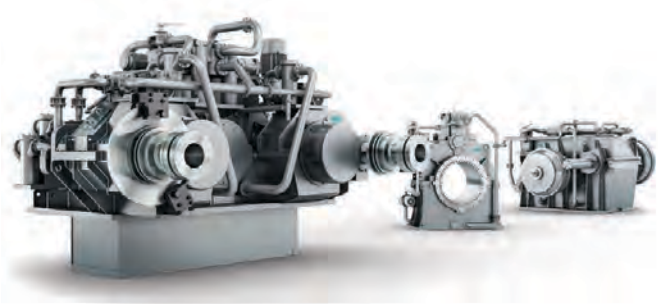

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# IMO and IACS sing from the same song sheet on CSR

Shipping associations have heralded with relief the acceptance by IMO's Maritime Safety Committee (MSC) that regulations put forward by members of the International Association of Classification Societies (IACS), relating to construction of tankers and bulk carriers meet the requirements of goal based standards, *writes Sandra Speares.*

"The philosophy behind goal-based standards for bulk carriers and oil tankers is that ships should be designed and constructed for a specified design life and that, if properly operated and maintained, they should remain safe and environmentally friendly throughout their service life."

The acceptance of IACS-developed rules was highlighted as such by IACS chairman Christopher Wiernicki when he took over the role last year as being a top priority for the association. He said at the time that IACS had been looking again at the structural requirements, digging deeper into what was behind the common structural rules to ensure that they met the 15 functional requirements of goal-based standards.

"IMO's recognition that the IACS Common Structural Rules conform to the goals and functional requirements set down by the Maritime Safety Committee is a powerful endorsement that class rules provide for the design and construction of ships that, in combination with proper operation and maintenance, will meet the mission of safety of life, property and protection of the environment throughout their service life," the association said after the IMO meeting.

Wiernicki added: "This monumental decision is the direct result of collaboration between IACS and the IMO which represents a new era in maritime safety. This IMO recognition, ahead of the entry into force of the relevant SOLAS amendment on 1 July 2016, reinforces IACS' trusted technical advisory role.

"IACS and IMO share a common objective of delivering safer ships on cleaner oceans. IACS anticipates deepening even further its close working relationship with the IMO and believes the organisation's recognition that our members' rules fully comply with the principles of GBS is a positive step for the entire maritime industry which will further enhance the ways in which we collaborate."

According to International Chamber of Shipping technical director Alistair Hull: "ICS welcomes the significant milestone that was reached this week at the IMO MSC. The formal acceptance by IMO of the IACS Common Structural Rules for Bulk Carriers and Oil Tankers will provide even greater confidence in the safety and reliability of these ship types which form the backbone of world trade.

"ICS particularly welcomes the commitment from all parties to further build on the very significant effort made in particular by IACS and the IMO auditors to facilitate ongoing refinement, review and verification of the structural requirements for the design and construction of ships."

Approval was given after MSC 96 had considered the verification audit reports, including the corrective action plans provided by recognised organisations (ROs) - in this case the classification societies that are members of IACS - in response to the non-conformities and observations documented in the verification reports of the audit teams.

MSC 96 also noted that the list of ROs could be expanded pending the outcome of the verification audit of an organisation's rules for the design and construction of bulk carriers and oil tankers that may be submitted to the IMO secretary-general at any time.

Since GBS Standards come into force on 1 July this year, oil tankers and bulk carriers built on and after that date need to be constructed under the building rules of one of the IACS class societies.

IMO secretary-general Kitack Lim said the verification process which has now been completed was a significant step for IMO, since until now there had been no direct oversight by IMO of the classification societies' structural rules.

"The completion of this process of developing goal-based standards for oil tankers and bulk carriers, followed by the detailed verification audit process, means that we now have a much closer alignment between the class societies' rules and the IMO regulatory process. This marks a very significant development in the IMO rule making process," Lim said.

Goal-based standards specify among other requirements that ships are designed and built to be safe and environmentally friendly for a specified design life when properly operated and maintained under the specified operating and environmental conditions, in intact and specified damage conditions, throughout their life.

The ship must have adequate strength, integrity and stability to minimise the risk of losing the ship or pollution to the marine environment due to structural failure, including collapse, resulting in flooding or loss of watertight integrity and it must be constructed of materials acceptable for environment-friendly recycling. The ship's structure, fittings, and arrangements must provide for safe access, escape, inspection, proper maintenance and the facilitating of safe operation. *NA*

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Newbuilds

## Kitting out *Attenborough*

Rolls-Royce will provide the design and equipment for Britain's new £200 million (US$289 million) polar research vessel, RSS *Sir David Attenborough*, which will be constructed by Cammell Laird.

The 128m long vessel will carry out oceanographic and other scientific work in the Arctic and Antarctic, and deliver supplies to Antarctic research stations.

Rolls-Royce will provide the vessel's diesel-electric propulsion system, which features two nine cylinder and two six cylinder Bergen B33:45 engines, as well as two controllable pitch propellers that measure 4.5m in diameter. In addition, the company will deliver its dynamic positioning and Unified Bridge systems.

Design requirements include Polar Code 4 ice class, which will allow the vessel to safely push through one metre thick ice, and the ability to operate self-sufficiently in terms of fuel and supplies on voyages of up to 19,000miles.The list of requirements also includes a high cargo capacity and space for a total of 90 people, and stipulates that the design should keep the level of underwater noise low to prevent both disturbance of marine life and interference with survey equipment. The vessel will also feature a helideck, the capacity to operate two helicopters, as well as a moonpool from which samples can be taken.

*Sir David Attenborough* will enter service in 2019 after the completion of its construction at Cammell Laird's Birkenhead yard, UK.

**www.rolls-royce.com**

Power & propulsion

## Batteries included for hybrid ferry

Scandlines expands its fleet of hybrid ferries with a fifth ferry that will use Corvus Energy's Lithium Ion Energy Storage System (ESS).

The diesel-electric powered *M/V Berlin* will be able to use its ESS for 6,000kW of the vessel's total 15,800kW engine output. It will also be able to use the system to manage onboard consumption; when consumption is lower, excess energy can be stored in the ESS and then later released to cater for higher consumption when generator production is insufficient.

This is one of a number of environmentally friendly technologies that will be deployed on the 169.5m long ferry as it services the crossing between Rostock, Germany, and Gedser, Denmark. Others include an optimised propulsion system and four scrubbers to remove NOx, SOx and fine particles. In addition, particular attention has been paid to the design of the vessel's hull, which has been optimised for the sea depths on its route.

**www.corvusenergy.com**

HVAC

## Shipyard adopts heat power solution

Fincantieri will be the first shipyard to install an innovative heat power system onboard new cruise vessels that can provide up to 0.45MW.

Research vessel *Sir David Attenborough* will have a full complement of Roll-Royce equipment

The shipyard has purchased six Climeon Ocean 450M systems, which generate electricity using waste heat from the ship's engines. Climeon Ocean is based on technology that converts hot water into 100% clean electricity, according to the company, and is powered by the company's C3 technology, which features optimised heat transfer and a turbine efficiency of approximately 85%.

A spokesperson for Climeon says: "each product procured by Fincantieri produces 0,45MW of power but more than one product [is] installed on each vessel, making the total power higher per cruise ship. Our extensive studies on different size ships show that typical power per cruise ship is between 0.6MW and 1MW."

The company believes the Ocean 450M solution can save up to 900tonnes of fuel and 2,700tonnes of $CO_2$ emissions every year through a configuration that optimises energy efficiency and the use of heat onboard.

Johan Larson, head of marine sales, Climeon, says: "Energy and environmental savings are an important factor for the future of the Cruise Ship business, we therefore see a lot of customer interests in our solutions."

**www.climeon.com**

CAD/CAM

## Sustainability gets integrated

Shipbuilder, a Dutch-based ICT company, has taken steps to integrate sustainability requirements for the construction and renovation of a ship within its self-titled software programme. Its aim is to create a "sustainability knowledge base" that provides an overview of contractually agreed sustainability requirements, such as for materials, weight or $CO_2$ emissions.

The company believes a small change, such as the use of a different material, can have a significant impact on the sustainability of a shipbuilding project, and so the new knowledge base is intended to allow clients and designers to immediately see if a particular design choice does not meet the stipulated sustainability requirements.

"The advantage is that the software brings all sustainability requirements together," says Geert Schouten, director, Shipbuilder. "The demands in the knowledge base are a yardstick for the whole project. If a client opts for a cheaper version of an engine with greater emissions, the software will indicate this choice doesn't fit within the sustainability requirements."

**www.shipbuilder.nl**

Shaft generators

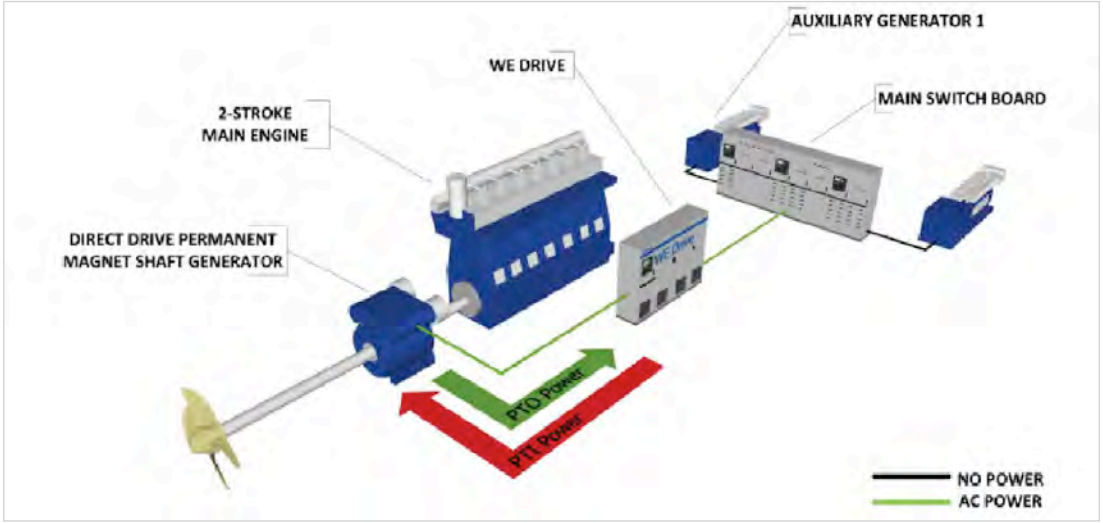
## Handy magnet solution

The world's first LNG fuelled handysize bulk carriers will feature direct-drive permanent magnet shaft generator solutions that produce up to 700kW of power for the vessel's electrical network.

WE Tech will provide the solutions, but a specialist provider of megawatt-class permanent magnet (PM) machines for advanced marine drive trains, fellow Finnish-based company The Switch, will deliver the PM shaft generators for use in the energy efficient solutions.

The solution, WE Drive, features Power Take Out (PTO) and Power Take In (PTI) modes, which allow the vessel to firstly deploy the direct-drive PM shaft generator to produce electrical power for the electrical network and, secondly, to boost the propulsion system during demanding conditions with 1,250kW of mechanical power.

The direct-drive permanent magnet shaft generator solution can provide power for a vessel's electrical networks and its propulsion



PTO enables propulsion machinery to operate in combinatory/variable speed, while PTI sees the conversion of auxiliary generator power to propulsion power, employing the shaft generator as an electrical motor.

The two new 25,600dwt dual-fuelled handysize bulk carriers are to be built for Finnish ship owner ESL Shipping at Qingshan Shipyard of Sinotrans & CSC SBICO, China. Delivery from WE Tech is scheduled for March 2017 and the vessels are set to begin operation in the Baltic Sea in 2018.

Mårten Storbacka, managing director, WE Tech, says: "Our vision is 30% less fuel consumed in the global shipping industry by 2030…This is a perfect example of implementing advanced drive train solutions for green shipping."

**www.wetech.fi**

Paints & coatings

## First carbon credits awarded

Greek tanker and bulker owner, Neda Maritime Agency Co Ltd, is the first shipping company to be awarded carbon credits as part of an environmentally-minded scheme set up by AkzoNobel's marine coatings business.

AkzoNobel's scheme incentivises the conversion of less environmentally friendly hull coatings to greener hull coatings.

Tanker vessel *Argenta* amassed a total of 13,375 carbon credits, which could be worth roughly $60,000, following its conversion from a biocidal antifouling system to a biocide-free hull coating from AkzoNobel's Intersleek range.

Each carbon credit represents the mitigation of one tonne of $CO_2$ emissions according to AkzoNobel, making the overall offset for *Argenta* 13,375tonnes.

Oscar Wezenbeek, managing director of marine coatings, AkzoNobel, says: "This is a landmark moment for AkzoNobel, Neda Maritime and the wider shipping industry. It demonstrates how our carbon credits initiative can incentivise investment in more sustainable practices, accelerating carbon reduction within the shipping industry and enabling owners to gain from operational, environmental and bottom-line benefits from clean technologies."

**www.akzonobel.com**

Scrubbers

## Tech shrinks while innovation grows

Alfa Laval's PureSOx U-design scrubber has been reduced in size through optimisation of flow and pressure.

The company's U-design has a U-shaped configuration that separates the jet and absorber sections with a natural water trap. The updated version optimises the exhaust gas flow through the scrubber, reducing the scrubber's height and weight.

According to the company: "A smaller scrubber facilitates placement and reduces installation costs, while a lighter scrubber reduces the impact on vessel stability."

Alfa Laval also suggests that the smaller design could be placed lower in the ship in some cases, offering further stability benefits.

The minimisation of back pressure was an important factor in the product's development and was carried out without exhaust gas fans or the installation of additional equipment in the system's funnel.

**www.alfalaval.com**

CAD/CAM

## SENER embraces virtual world

ESI Group, a virtual prototyping and testing software developer, has joined forces with marine engineering and CAD/CAM specialist SENER.

The union will integrate IC.IDO, ESI Group's virtual solution, within SENER's FORAN software, allowing movements, collisions, and human models to be simulated. This "makes it possible to verify the entire assembly line and all the manufacturing and maintenance processes," according to a spokesperson from SENER.

Emilio Mencía de Miguel, COO of ESI Group, Hispania & South America, says: "The agreement reached between ESI Group and SENER for shipbuilding is a strategic alliance that will exploit the synergies of both companies."

FORAN's integration with the IC.IDO virtual reality system aims to create "unique opportunities for collaboration and process integration in an immersive 3D environment," according to de Miguel.

It is hoped that the collaboration will benefit the decision-making processes and communication between shipyard teams and those in different design offices.

**www.sener.es**

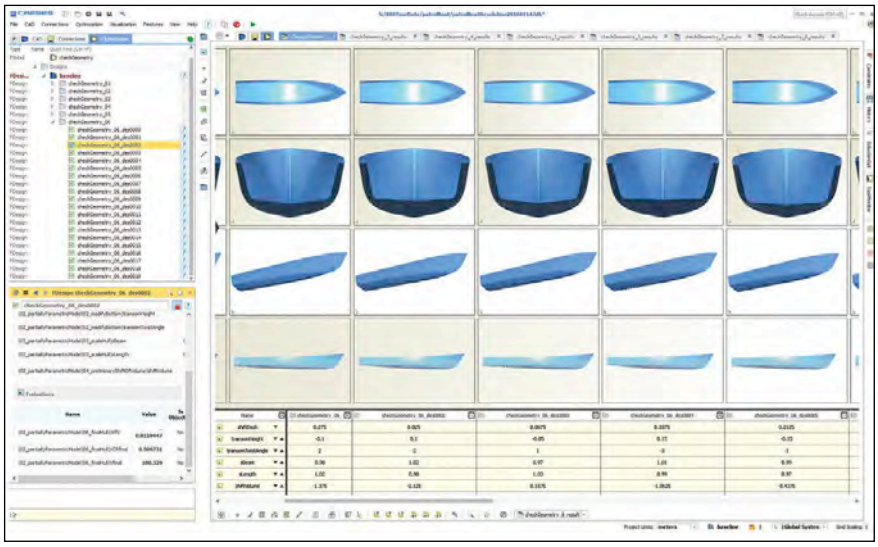
SENER takes the virtual leap with ESI Group

# COMPIT senses paradigm shifting

It has been a long time since a true paradigm shift was sensed in our industry, but the frisson became palpable almost immediately, as the first presentations at COMPIT 2016 clearly illustrated the exciting advent of a new era. Naval architect Nick Danese reports

Those who, like myself, have been Compit regulars since the first edition in 2000 will easily spot the unmistakable signs of industry acceptance and success: big industry sponsorship, international attendance, and a selection of visionary yet practical and directly implementable papers.

At COMPIT 2016, Lecce, the organiser's *leitmotif* and vision that the marine industry should exploit and build upon the wealth of leading commercial technology commonly available today started to take form. It all started to gel, as Big Data becomes a key support of predictive algorithms and real-life operations, open-source keeps its head high, and even generative design and *system-agnostic* software mark (faint) blips on the radar screen. In a nutshell, exploitation of computer power in innovative ways and sharing Big Data were the underlying common denominators of a milestone Compit.



Parametric shape variation coupling design and hydrodynamics software have reached a very mature stage (source: Friendship Systems)

Refreshingly, in *Open Source and Web Based Ship 3D Virtual Simulator*, Olivia Chaves and Henrique Gaspar proposed a forward looking combination of high-performance yet commonly available technology to build a real-time ship motion 3D virtual simulator in a web browser environment, which well deservedly earned them the Compit 2016 DNV GL Award.

As an engineer and avid reader of Waveform, Denis Morais' blog, and of various non-marine technology forums, I treasure out-of-the-box vision, but also like to see research and ensuing technology applied, which in the Big Data context at hand requires sharing the appropriate and relevant data with all concerned stakeholders. This subject was approached by Denis' *Open Architecture Applications: The Key to Best-of-Breed Solutions*, in which "Platformisation" is proposed for efficient data sharing, and *Cloud Computing for CFD Based on Novel CAE Software Containers* [Gentzsch et al.], which made me think of system-agnostic applications, for example Docker technology.

Kjetil Nordby and Snorre Hjelseth also look to the future in *Efficient Use of Mixed Reality in Conceptual Design of Maritime Work Places*. Kjetil and Snorre discuss applying Human-to-Human communications in virtual reality (VR) spaces to designing ship bridges, perhaps a first step towards exploiting augmented multi-player environments in other scenarios, for example remote rescue.

While the surface of how to practically exploit Big Data got scratched, ideas on what to do with Big Data were aplenty. Design, in its various liveries, will benefit vastly from Big Data and VR, particularly by aligning design parameters to field metrics collected during operation and using the underlying framework to optimise for future mission profiles. *Improving Early OSV Design Robustness by Applying Adaptive Distributive Clustering in Ship Lifecycle Big Data* exploits lifecycle data to improve the ship's performance in several, different operational areas. Coraddu et al. develop realistic operating profiles to assess different design solutions and to predict and evaluate performance decay in a statistical fashion. *Applications of Network Science in Ship Design* by Pawling et al discusses the exploitation of networks, another promising piece of the computational puzzle.

Virtual reality also contributes to design, as we read in *A General Arrangement Visualisation Approach to Improve Ship Design and Optimise Operator Performance*, by Lundh et al. The proposed linking of general arrangement drawings to work procedures and task execution in VR allows improving work space for crew operation at the design stage, to generate overall cost savings.

Perhaps comparable to learning from Big Data, it is interesting to see the 'existing ship' or offshore platform side of the same in *Virtual Reality Based Training Improves Mustering Performance* by Scott MacKinnon et al. Many COMPITs ago, a researcher from NavSea presented a Navisworks based application that could be asked using a microphone to show the way from one location to another, which it did (with practical limitations). Scott's VR showed how such VR-based familiarisation may save lives and make evacuation training fun.

Hull shape manipulation was discussed by Ang, Goh and Li, while wind resistance and propulsion assessment using CFD was reviewed in *A Novel Way to Harness Wind Energy on Ships: How CFD Helps Foster Innovation*. Wind propulsion seems to have evolved slowly, from the wing sails first presented at SMM, Hamburg, some eight years ago, to more recently proposed wing-like ships. The related COMPIT 2016 papers might just offer a glimpse of tools soon to be used to produce widely encompassing design concepts that include active and/or passive wind powering.

Contributing to design and operations, simulation fills the room more and more. It was interesting to see good old fuzzy logic and pre-generative design techniques side by side, on the background of the ever present optimisation overlord. *Design Optimisation using Fluid-Structure Interaction and Kinematic Analyses* takes another look at FSI and applies the ANSA (BetaCAE) environment to ensuring the structural integrity of a free-falling life-boat upon impact with water, which must take into account different fall trajectories resulting in different impact dynamics. Fuzzy logic is used by Fireman et al. to determine the operability of the ship from a human performance standpoint.

Surrogate models (or meta-models) represent promising strategies in overcoming unavoidable computational limitations, as discussed by Prebeg et al. in *Evaluation of Surrogate Models of Internal Energy Absorbed by Oil Tanker Structure During Collision*. Essentially a logical representation of the physical model and of its relevant characteristics (crash behaviour in this case), meta-models have long existed in the electronic industry (e.g. to test CPU, boards, etc. by behavioural simulation).

The surrogate model in object here carries the added complexity of there still being little experience in the relative merits of the several models available, the need to tailor the relationship between underlying constraints, model and its training curve, all the while keeping an eye on the ultimate goal, here structural optimisation. The clear conclusion that meta-models are effective in replacing the top-heavy environment of *several design objectives, hundreds of design variables and tens of thousands of design constraints* spawns the question of whether generative design techniques would further alleviate the problem or prove too computationally intensive in the context at hand?

Generative design also comes to mind when reading the very interesting *Multi-Objective Design Study for Future U.S. Coast Guard Icebreakers*, where genetic algorithms are employed. First-hand human experience is used directly as an input parameter to compensate a relatively shallow learning curve due to the somewhat niche nature of icebreaker technology. Another distinctive aspect of the research undertaken is the use of a combinatorial catalogue-based engine selection algorithm. More than 170 objects were used to describe the 2.5 CAD model, subject to a number of non-negotiable constraints, weight, and cost, as driving factors.

Coming closer to everyday considerations, such as cost and ROI, *Learning Curve and Return of Investment in the Implementation of a CAD System in a Generic Shipbuilding Environment*, by Rodrigo Fernandez, discusses a ROI formula based on data collected over the 2007-2015 period by SENER. Morais and Waldie also discuss ROI from a data sharing and best-of-breed system architecture perspective.

Also dealing with data sharing and cost, MacPherson et al. present work carried out using the off-the-shelf NavCad-CAESES coupled solution, to troubleshoot and remedy an endangered design project. CAESES (Friendship Systems) was used as the hull modeller and optimization platform, while NavCad (Hydrocomp) contributed a novel linear wave-theory code for bare-hull resistance prediction of high-speed transom-stern craft. Also on everyday grounds, *Digital Twins for Design, Testing and Verification throughout a Vessel's Life Cycle* suggests a very appealing exploitation of Big Data, and ties in with several other papers on simulation, ship and fleet operation, PLM and cost presented at Compit 2016.

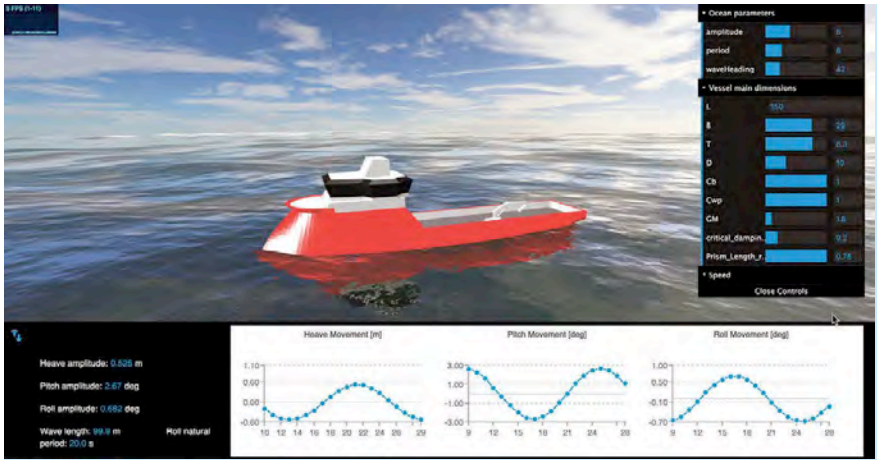
Human-mimicking robotics (CADDY Project) by Marco Bibuli et al. deserves a mention, too, as the work closely relates to multi-presence VR environments and to context sensitive Big Data collection.

Closing the underlying common denominators of a milestone COMPIT loop, I will note the Internet of Things presentation by Mary Etienne and Anthony Sayers, forbearer of more Big Data to come and its corollary exploitation mode requirements.

Neither last nor least, justice is due to all the very valid papers that could not be mentioned in this review, too, all valid, relevant, and well-deserving to be read, as well as to several deserving abstracts that will hopefully be presented during a future COMPIT.

It is always a little triste to leave COMPIT, and the memorable closing dinner at the Masseria Melcarne made it no easier this year, but the stage that has been set for COMPIT 2017 in Cardiff will make short work of a year's wait. *NA*

Virtual Reality visualisation of ship seakeeping in design stage (source: NTNU)




## About the author

Nick Danese, MS NA&ME, 1983, University of Michigan, is the founder and director of NDAR. Applied research in the fields of ship & offshore design and production software is NDAR's principal activity, coupled with an active cooperation with several maritime software houses.

# Tests begin anew

## QinetiQ reflects on the upgrading of its Haslar cavitation tunnel and the future of model testing in an interview with *The Naval Architect*

The cavitation tunnel at QinetiQ's Haslar site, Portsmouth, is set to reopen in July following renovation of its electronics and equipment. Samantha Hill, programme manager, International Maritime Consultancy and Software (IMCS), QinetiQ, explains that the work was undertaken to keep pace with the requirements of commercial customers, as well as to continue to serve military projects, which have formed much of the research undertaken at the Haslar site to date.

IMCS will offer a renewed focus on concept design, naval architecture, propulsion and propellers for the commercial shipping industry, utilising the newly upgraded instruments and capabilities.

The commercially minded shift has necessitated a significant change in ethos for the group, spurring a rethink in the way testing should be carried out in the cavitation tunnel for customers with commercially sensitive deadlines. Hill points out that shipping projects do not offer the same freedom of time taken with military projects, which may run for a decade due to the level of fidelity required. As a result, the group has had to adapt its testing efficiency to reflect the commercial drive for vessels to be in service as soon as possible.

The group also realises that it must offer tailored services that reflect an owner's unique interests, such as conditions across a particular route. This, in comparison to the worldwide applicability needed for military vessels, may lead to more tailored design tests on the basis of meeting more specific operational demands.

### Technical details

The Haslar tunnel uses an impeller to circulate water at speeds of up to eight metres per second and can accommodate models of up to five metres in length with a testing section that measures 2.4m in width by 1.2m in height by 5.35m in length.

The upgrade has involved the incorporation of advanced measuring technologies to keep pace with the latest developments in instrumentation. Laser systems based on Laser Doppler Velocimetry (LDV) or Particle Image Velocimetry (PIV), for example, have replaced pitot tubes for propeller wake surveys. As a result, more data should be able to be generated and the fidelity of results should improve, a factor that is of particular importance when validating CFD, says Hill.

Samantha Hill, programme manager, International Maritime Consultancy and Software (IMCS), QinetiQ

The range of work has also included the replacement of the current 1980s era control system and electronics with a touch pad console from Harland Simon, which provided the original system. This, along with the above changes to instrumentation, should grant greater control of the testing environment, according to Hill, expanding the test facility's capabilities.

QinetiQ plans to re-run tests from the past with the new instrumentation for benchmarking purposes. This is also for training, but could provide interesting results given the raised levels of accuracy the equipment should provide.

A number of potential new customers have expressed interest in the development of QinetiQ's commercially oriented service. Propeller manufacturers and those who have had a relationship with the company through military projects, for example, have been drawn by the commercial shift, according to Hill.

QinetiQ plans to put its military pedigree to good use, leveraging its specialist experience with noise and efficiency work for commercial applications. This crossover is particularly useful considering the noise targets stipulated in the Polar Code.

It also intends to continue research on composite propellers, with a number of ongoing data capture projects onboard vessels equipped with research packages.

3D printing is an additional area of interest for the company. QinetiQ has been 3D printing appendages for some time, but Hill believes there is potential for further use of the manufacturing technique in the model testing world. Presently, however, there is a danger that the surface finish from a 3D printed propeller will not meet the tolerances needed. QinetiQ is, therefore, experimenting with ways to prevent this shortfall, and Hill is confident that the rapid rate of technological development will ensure a bright future for the technology. The company is currently experimenting on propellers of this kind and plans to continue to do so over the next year.

### CFD; the future?

According to some members of the industry CFD could replace the role of model testing (see *The Naval Architect* July/August 2015), but Hill thinks differently. She believes a complex answer is needed to explain how both computational and physical analytical techniques are necessary for the future development of ship design. In terms of how the resources/methods should be used, she continues, it will always depend on the questions you ask and the kind of novel innovations being tested.


QinetiQ's cavitation tunnel upgrade will see the replacement of its current electrical equipment (shown above)

"It is not by accident that the major model testing organisations all have research and consultancy staff engaged in the modelling of the wide range of hydrodynamic problems in CFD. We all recognise the advantages of being able to consider these problems on the computer screen. For some decades we have been seeing papers telling us that physical model testing will be extinct within ten years, but the reality of this still seems to be some way off. Currently, much is being made of our ability to conduct CFD analysis at full scale. The perceived advantage is that there is no need to translate the results to full scale as would be required for physical model tests. Of course the real question remains the same – do the results accurately reflect what is going to happen to the real ship?"

With simple design points, such as in the study of resistance, CFD has clear advantages, adds Hill. For more novel hull forms that push the boundaries of design, there is 100 years' worth of experience to draw on for design correlations. So, for the moment at least, the two technical disciplines should go hand in hand, says Hill.

"The EU 6th Framework 'VIRTUE' project which ran from 2005 to 2009 led by HSVA and involved a number of model testing organisations, academia, classification societies and software companies, made significant steps towards 'virtual tank testing'. However, it concluded by recognising that there was still considerable work to do. The VIRTUE project recognised that CFD modelling of cavitation was an area of difficulty. Comparison of different solvers and software produced significantly different results. The study concluded that meshing and turbulence models were contributing factors to these differences. One of the difficulties highlighted was the computing time needed for this kind of complex analysis. Increased mesh densities and model complexity would serve to exacerbate this. Hence I believe that model testing will be needed for some time to help develop the confidence that the CFD is producing an answer within acceptable and understandable error bands."

She adds that if ship scale CFD is to replace model testing, an important human factor will have to be addressed as owners tend to trust what they can touch and see. The question is, can watertight data offer this tangible reassurance, and can owners make the leap to digital validation when a revenue generating asset is at stake? So while the extent of model testing may change and consolidate in the future, there will always be a case for its place in the design of ships, for Hill, and not every facility in the world will be closed if CFD continues to come to the fore. She says: "I would be disappointed if it was [the case where every facility would be closed] because then we would not be pushing the boundaries anymore."

This being said, the importance of ship scale validation and how it is developing is clear to see, as shown by Lloyd's Register's (LR's) recent collaboration with Anmax Trading (see *The Naval Architect* May 2016), and Hill believes its role will increase, if not to the same extent as advocates of an all-encompassing CFD solution might suggest. There is therefore a place for using data captured through sensor packages onboard trial vessels, she says, but it can be difficult to make sense of this data in hydrodynamic terms due to correlation issues. One way to prevent the skew of test conditions that do not reflect those seen every day, would be to test long term data packages onboard a specific ship or class of ship running on a set route over a year or two years. This should allow a deeper understanding of the route, better monitoring of personnel activity that may affect results, and a long term view. Hill suggests that a relatively set route, as used by a ferry, cruiseship or cargoship would be suitable for this kind of testing, delivering greater insight into a smaller number of variables. *NA*


QinetiQ's cavitation tunnel upgrade will see the replacement of its current electrical equipment (shown above)

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# Sail gets a second wind

Meeting the requirements of an increasingly demanding climate change lobby is unlikely with current technology. But a number of partners, including The University of Tokyo, Class NK, Mitsui OSK Lines and NYK Lines are looking at wind to provide the push towards a carbon free industry

To drastically reduce the fuel oil consumption of a large merchant vessel, the utilisation of ocean wind power should be considered as an option for the main propulsion power of the vessel.

A new concept of sailing ship assisted by a motor called Wind Challenger is proposed as an excellent eco-ship that will contribute to a low-carbon society. The vessel is fitted with rigid sails (50m high, 20m wide with an area of 1,000m$^2$) on the upper deck as a main propulsion system.

The sails are constructed of GFRP composite and the rigid sail has a crescent wing section, with a vertically telescopic reefing mechanism and a self-rotating mechanism to meet the various wind directions and velocities. The four rigid sails (total sail area 4,000m$^2$) are expected to generate enough thrust to drive an 84,000dwt bulk carrier at 14 knots, where a beam wind is blowing at 25kts.

An aerodynamic interaction of the four sail system is carried out with a full scale CFD simulation. Furthermore, a case study on the performance in the real sea was carried out and about 30% of propulsion energy was acquired from ocean wind power on average.

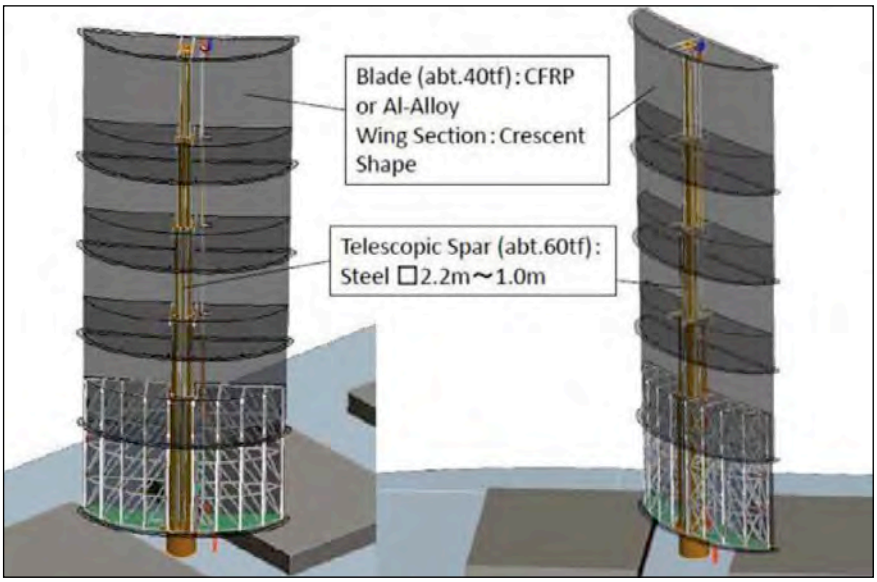


Figure 1: Rigid wing sail

No matter how we adopt various, advanced, energy saving devices, it is impossible to reduce fossil fuel use by more than 50% for vessels operating at the same speed and deadweight. That means a change of energy source for ship propulsion is absolutely necessary for the next generation of merchant vessels.

Possible alternative fuel sources to fossil fuels are wind, nuclear energy, fuel cells, battery power, bio-fuel or to have a carbon capture and storage (CCS) system. From the viewpoint of sustainability and free energy costs, it is clear that ocean wind power is the best solution to drive slow-speed vehicles, such as a very large merchant vessel. For reducing the fuel oil consumption of a ship, it is important to make use of wind power at sea. Sailing ships, whose concept is not only suitable for a low-carbon society, but for punctuality which also meets the requirements of current global logistics requirements, must be considered when developing new ships.

The Wind Challenger project is an attempt to meet the test set by climate change by substantially reducing emissions from bulk carriers. The project, led by Professor Kazuyuki Ouchi of The University of Tokyo, is expected to test a 2m scale model in a tank with wind generating fans this autumn, following which the full scale tests aboard either a Mistsui OSK Lines vessel or a NYK Lines bulker will be carried out next year, according to Ouchi.

The ship will be fitted with an autopilot system which, unlike current autopilot systems which only control the rudder, will control both the sails and the rudder simultaneously. The system is connected to a GPS positioning system and can guide the vessel to its destination; however, the other critical factor in the sailing ship equation is the weather.

"We are currently considering future forecasting," explains Ouchi, "weather reports are 90% accurate up to three

**TECHNICAL PARTICULARS**

***Wind Challenger***

| | |
|---|---|
| Length (OA) | 228.50m |
| Breadth | 36.50m |
| Depth | 19.89m |
| Draught | 13.90m |
| Deadweight | 83,600dwt |
| Cargo Capacity | 102,6000m$^3$ |
| Cargo space | 5Holds, 5Hatches |
| Sail Area (H*B=50m*20mx4Sails | 4,000m$^2$ |
| Main Engine | |
| (B&W 5S60MC-C, MCR) | 9,965kW x 94.0rpm |
| Propeller | 6.6m Dia. x 1 set |
| Service Speed Average | 14.3knots |
| Complement | 25 Paersons |
| Kind of Vessel | Post Panamax Bulker |

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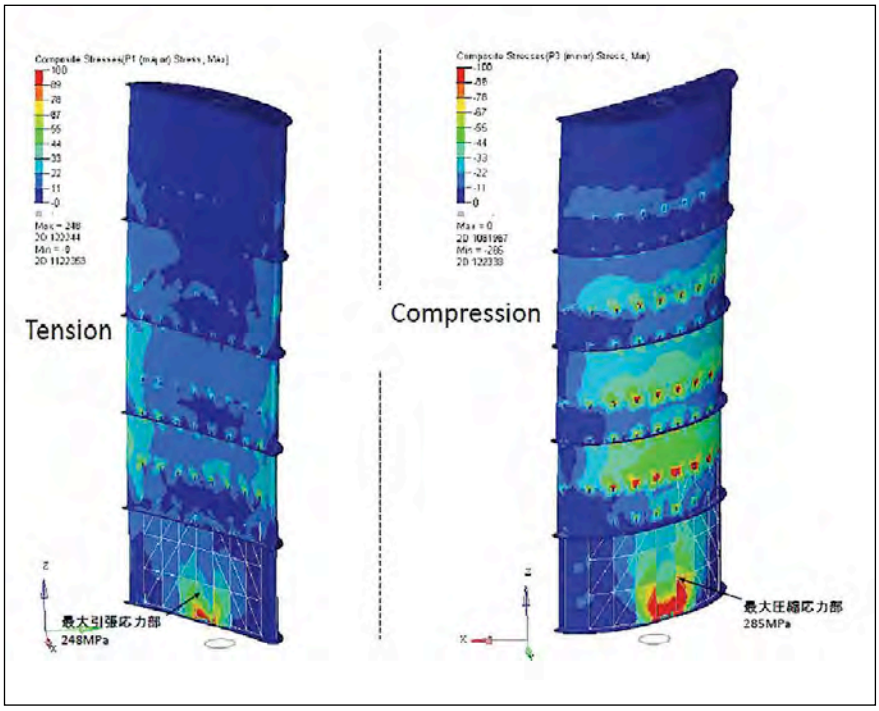


Figure 2: Stress contour of sail panels

days into the future, but after one week they are not so reliable, so we will need to change the data every two to three days," he says.

## Rigid wing sail

Clearly the wind and weather is critical to a sailing vessel such as *Wind Challenger*, which is assisted by an engine, rather than a motor ship assisted by sail, as it needs to have enough thrust to drive the vessel at a specified speed in proper ocean conditions with a wind velocity of 20~25knots. This means that the area of the sails must be extraordinarily large compared to the motor ship assisted by sails listed above. However, large sails have many difficulties for reefing operations, which is a fundamental function of the sailing ship during periods such as rough sea voyages, manoeuvring in port and loading/unloading operations at the berth. It is also important to reduce the sail area reduction ratio between full sail and reef sail, to avoid dangerous wind influence during reefing operations.

In order to resolve these issues an enclosed type rigid wing sail, which can be retracted telescopically as shown in Figure 1, Figure 3 and Figure 4, will be used in the design. The inner telescopic spars are constructed of steel and the outer wing panels are a GFRP composite, and the spars can be rotated 360degs to meet the wind direction and retracted telescopically by a mechanical device inside of the spar together with the panels. Figure 2 shows the stress contour of sail panels calculated with FEM at the condition of right angle wind to the face side panels. The maximum stress is found at the root part of the spar.

In Figure 3 an outline image of an 84,000dwt bulk carrier fitted with four rigid wing sails shows each sail arranged on the centre line between the hatches and the wheel house is arranged on the forecastle deck to secure the forward view.

Figure 4 shows the ship in reef sail condition at port. Sails are stowed at hatch end spaces and the height of the sails is reduced to a similar height to the accommodation block. The principal particulars of the ship are shown in the technical particulars box.

## Performance

The relationship between the wind and a sail force is shown in Figure 5 schematically. The forward thrust generated by the wing sail is expressed as follows:

$$T = 0.5 \cdot \rho a \cdot Va^2 \cdot A \cdot Cx \quad (1)$$

Where, Forward Thrust: T (kgf), density of the air: ρa (kg/m$^3$), apparent wind speed: Va (knots), angle of attack to generate maximum thrust: α, area of wing sail: A (m$^2$), thrust coefficient: Cx (Variable Parameter according to the Apparent Wind Angle (θ) shown in Figure 5. For example, the approximate value of the Cx is shown in the polar diagram of *Shin-Aitoku Maru's* normal rigid cambered sail in Figure 7).

In the case of the 84,000dwt bulker described in the technical particulars box, the following parameters are used for the performance estimation:

ρa = 0.125 (kg/m$^3$)
A = 4,000m$^2$ (1,000m$^2$ x 4 pieces)
Cx = 0.7~1.8 (in the case of an apparent wind angle θ about 315degs — 0degs — 45degs shown in Figure 7).

According to the equation, Table 1 shows the total thrust of four sails (T) acting on the vessel, and also shows the Effective Horsepower (EHP),


Figure 3: *Wind Challenger* at full sail mode

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Figure 4: *Wind Challenger* at reef sail mode

Brake Horsepower (BHP), the vessel's speed (Vs) and Froude Number (Fn) corresponding to the total thrust, considering general propulsion performances of the typical 84,000dwt bulker in the current shipbuilding market. In this estimation, the wave making resistance is not considered because of quite small Froude Number (Fn) and the propulsive efficiency (EHP/BHP) is assumed as 0.72. From this estimation, it is known that abeam wind (θ=75~120degs) of about 25knots can drive the vessel at the speed of more than 14knots without engine.

In the modern transportation industry maintaining a voyage schedule is of key importance, therefore, assistance for engine power is necessary considering the variability of wind conditions. Furthermore, the vessel is obliged to use the engine instead of sails when arriving at port or in narrow channels to maintain the capability of safe manoeuvrability.

That means *Wind Challenger* must be fitted with alternative propulsion and this means a main engine and propeller. This hybrid system of sail, engine and propeller shown in Figure 6 has to be managed properly in each voyage mode such as harbour, narrow channel, and a variety of sea states including calm, windy and extreme conditions for the sake of saving engine power and also safety.

As to the strength of the connection part of the sail and the deck, the moment of 2,000tonf-m is considered to withstand average wind velocity of about 36knots, which gives the aerodynamic force average of 30tonf to the full sail area of 1,000m$^2$. This value is the same as the rotating root of the ordinary marine deck crane fitted on a handy bulker. Where the wind velocity exceeds 36knots the retractable sail can be automatically shortened by an electro-hydraulic cylinder set inside the spar.

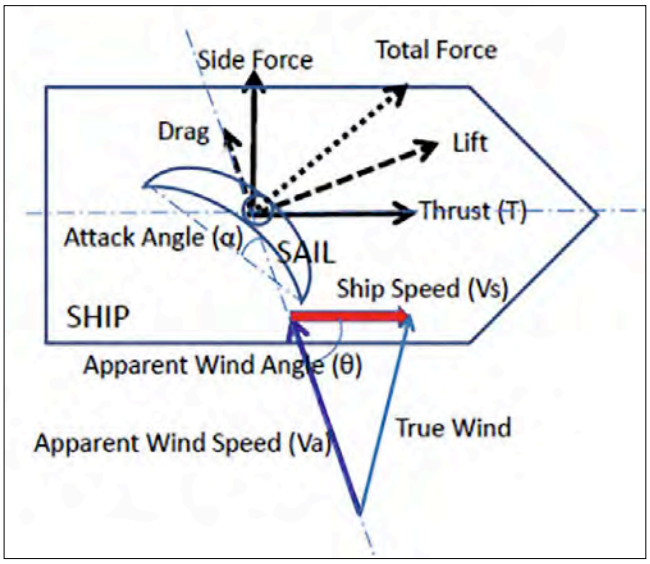


Figure 5: Apparent wind and thrust

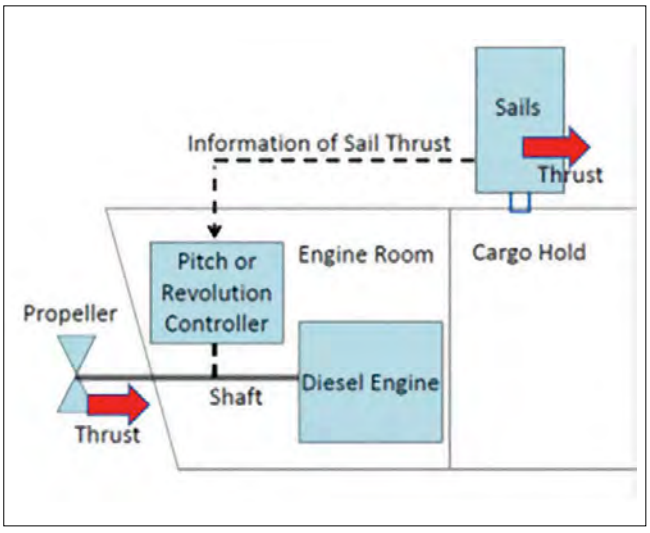


Figure 6: Hybrid propulsion system

## CFD analysis

The objective of the performance study is to find the optimum angle for generating the maximum thrust (Cx) for every wind angle. For the 84,000dwt bulker with four sails, shown in Table 1, the interference among four sails and influence of the ship's hull should be considered to obtain precise propulsion performance for the total ship. This is so that the full scale CFD simulation is

| Va kt | T ton*f | EHP KW | BHP KW | Fn Vs/√g | Va kt |
|---|---|---|---|---|---|
| 5.0 | 2.8 | 40 | 55 | 0.03 | 2.9 |
| 10 | 11.3 | 328 | 456 | 0.07 | 5.8 |
| 15 | 25.2 | 1,097 | 1,523 | 0.10 | 8.6 |
| 20 | 45.1 | 2,625 | 3,646 | 0.14 | 11.5 |
| 25 | 70.2 | 5,097 | 7,079 | 0.17 | 14.4 |
| 30 | 101.4 | 8,859 | 12,304 | 0.21 | 17.3 |

Table 1: Relation of wind velocity, thrust, power and ship speed

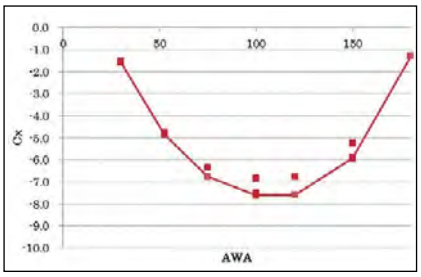


Figure 9: Maximum Cx value of total four sails system apparent wind angle (θ) ratio of Cx

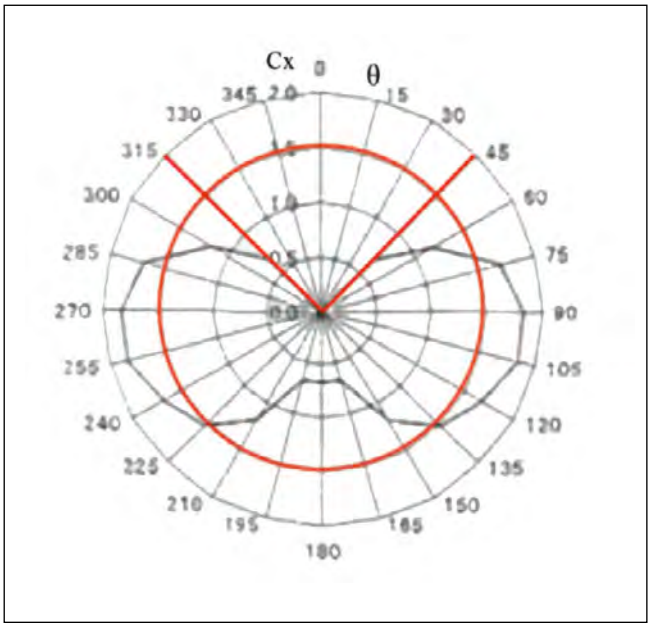


Figure 7: Cx /θ Polar Curve

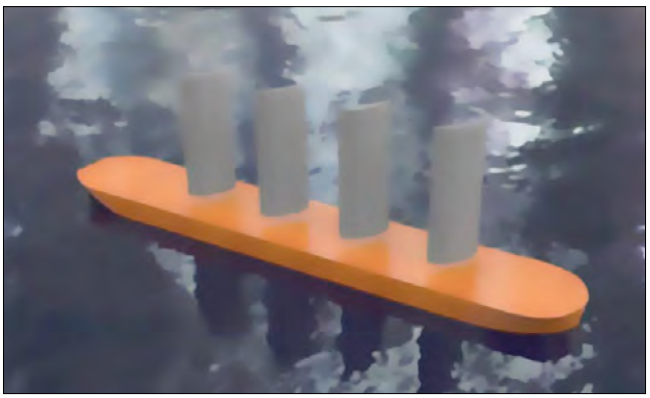

Figure 8: Four sails model for CFD analysis

carried out around the four sail system including the ship's hull.

The CFD code of Fine/Marine (NUMECA) is used for the study. Figure 8 shows the four sails model used in this numerical simulation. Figure 9 shows the maximum Cx value of the four sail system for various wind angles.

Figure 10 shows the ratio of the Cx value between the four sail system and a single sail system. The interference effect in the four sails system is very little when the wind angle is at 52.5degs <θ<150degs, but there is a significant decrease in efficiency when the airflow is upwind or there is a following wind. Figure 11 shows the average attack angle (α) of the four sail system where the maximum Cx value in is achieved at various wind angles (θ) seen in Figure 9. It is known that the lift is useful at a wind angle of 30degs — 120degs, but the drag is useful at 120degs — 180degs.

Using the above Cx data, the energy saving ratio in various true wind angles (TWA) and true wind speeds (TWS) at a ship speed of 14.3knots (with a 15% sea margin) is calculated as shown in Figure 12. The zigzag line shows a step by step change to the reefing sail mode for matching the sail area to the wind speed. If the frequency of the true wind angle (TWA) is even from all 360degs, the energy saving ratio is expressed as the area of inverted triangle made by each true wind speed (TWS) line divided by the rectangular area indicated by the red line in Figure 12.

## Voyage simulation

In order to estimate the reduction of fuel oil consumption on *Wind Challenger* in the real sea, the simulation of wind power acquisition using actual data of wind velocity and direction (six hours average data during the year of 2004) was carried out in case of the voyage of Yokohama to Seattle. Two kinds of voyage strategies were investigated, one was Great Circle Route and the other was Optimum Route using the isochrones method. The simulation voyages of an average speed of 13knots were carried out every six hours throughout the year, so that about 2,800 voyage simulation data sets were collected on both Eastbound and Westbound, and both Full Load and Ballast Condition in total.

From this Big Data (collected in 2011), an average wind velocity and an average energy saving ratio of the voyages have been shown in Figure

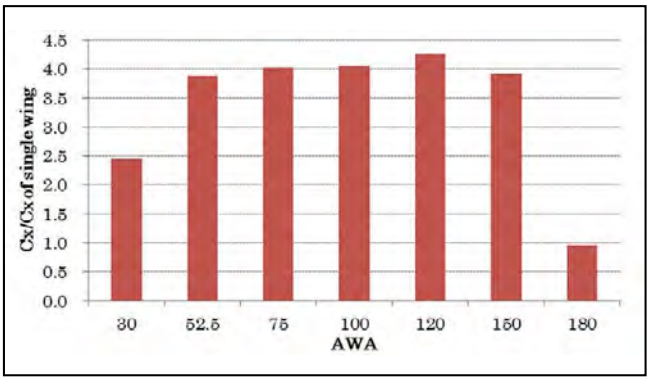


Figure 10: Ratio of Cx value between four sails system and single alone sail

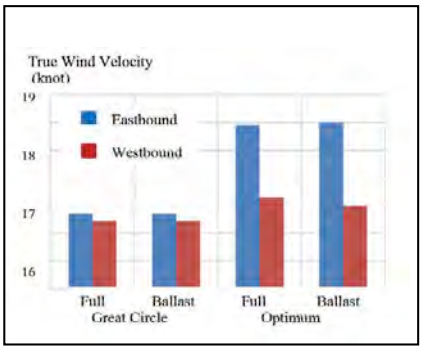


Figure 13: Average true wind speed

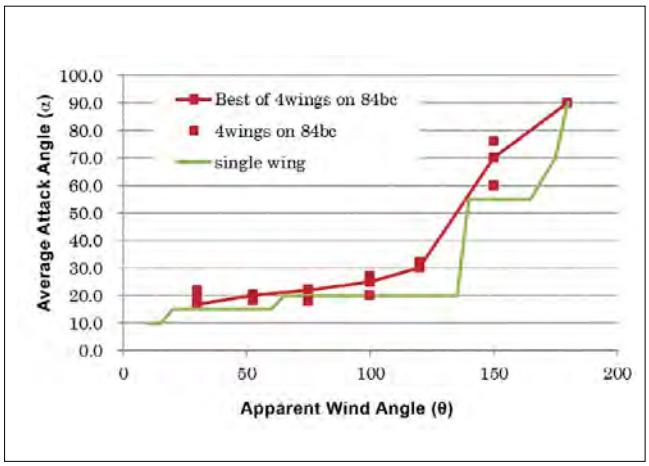


Figure 11: Average attack angle (α) of four sails system

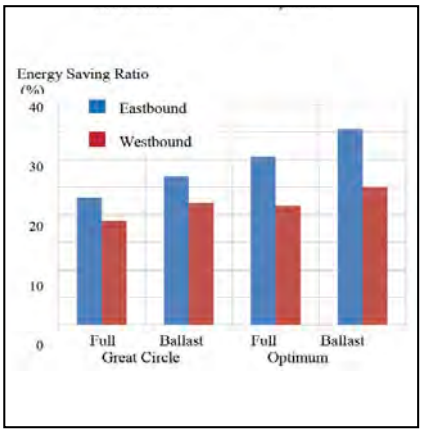


Figure 14: Average energy saving ratio

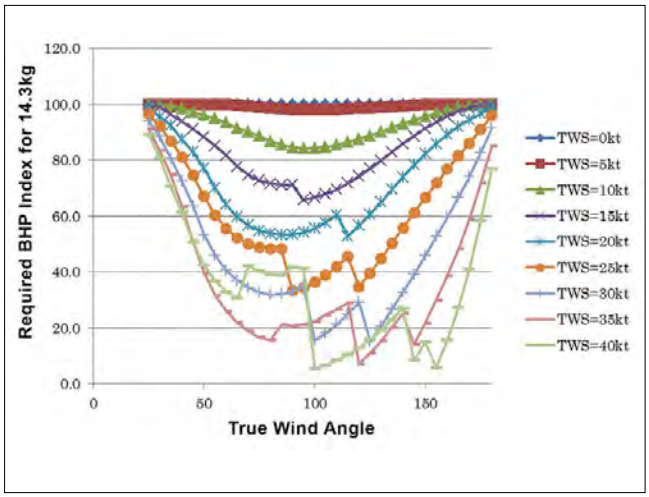


Figure 12: Power saving ratio in TWA and TWS

AA13 and Figure 14 in the cases of Great Circle vs Optimum, Eastbound vs Westbound, and Full Load vs Ballast respectively; it is known that the wind is strong in cases of Optimum Route and Eastbound voyage, and the average wind velocity is nearly 18.5knots. The bigger average energy saving ratio using wind power is achieved in Eastbound voyage, Optimum Route and Ballast Condition, and the value of the energy saving ratio is about 30% of the ship without sails.

The Wind Challenger Project, which aims to utilise the maximum ocean wind power, proposes a new concept of hybrid propulsion system, a sailing ship assisted by a motor. So far research and testing has shown that;

- The extraordinarily large rigid wing sail which rotates and retracts telescopically has been developed and its feasibility is confirmed
- From the study of an 84,000dwt bulk carrier which has four sails (with a total of 4,000m$^2$ sail area), almost 100% of the engine power is saved when there is a cross wind speed of 25kts, allowing a ship speed of 14kts
- The energy saving simulation in the actual voyage (Yokohama/Seattle) was carried out and it was found that the fuel oil saving of 30% is possible
- After land based endurance testing of a 1/2.5 scale prototype, it is planned to fit a full scale rigid wing sail set on the first *Wind Challenger* vessel by next year. *NA*

## Authors

Kazuyuki Ouchi, The University of Tokyo, Japan
Kiyoshi Uzawa, Kanazawa Institute of Technology, Japan
Akihiro Kanai, ACT Inc. Japan
Masanobu Katori, North Sail Japan Inc., Japan

# Class rules, the measure of a company

Judging a class society by its rules is one of the few detached calculations that potential class customers can make. It is little wonder then that the merged DNV GL has heralded its new combined class rules

DNV GL has taken an ambitious step forward with the new class rules launched 1 October 2015. The development of hull rules was not only about transfer of experience from the merged companies, but a strategic investment joining the strong technical organisations of former DNV and GL, building competence of employees, and modernising the technical foundation of class rules. The outcome is a comprehensive set of rules and supporting guidelines which together form a unique toolbox for classification, problem solving, and advanced analysis.

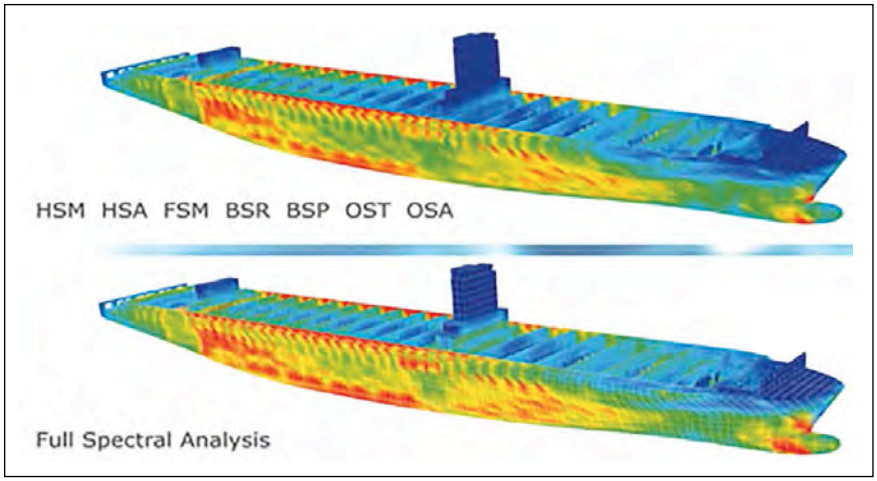


Figure 1: Comparison of equivalent design wave and direct analysis

In September 2013, the two class societies DNV and GL merged and became the world's biggest class society, DNV GL. Class rules are the core of the business for each class society and the launching of DNV GL Class rules in October 2015 was an important milestone for the merged society. The DNV GL rules build on the experience in DNV and GL as well as the achievements made in the development of the International Association of Classification Societies' (IACS) Common Structural Rules for bulk carriers and oil tankers (CSR). Both DNV and GL were among the most technologically oriented class societies and after joining forces a huge effort has been made to consolidate existing knowledge and further develop more advanced standards which may serve as a reference for the industry.

Since the establishment of DNV and GL more than 150 years ago, the rules have been continuously developed. Mostly, in incremental steps, but sometimes through major leaps aiming at renewing the core fundamentals. Around the turn of the last century, 1900, the rules went from being tabular to being more empirical. In the 1950s a major change was introduced; the empirical rules were replaced by scientific rules based on strength mechanics. With the gradual introduction of computers in the 1970-80s, the rules have incorporated more advanced and accurate methods for determining hull strength. Utilising more of the knowledge from inspections and damage records during operations, the rules were made more risk based from about 1990. The most recent development represents a new step, which may later be referred to as digitised rules aligning with the digitised future, and takes advantage of current working environments.

## Rule development

The two rule sets from DNV and GL have been the main foundation for the rule development. The DNV GL rules and procedures are aligned with the previous legacy rules taking into account their strength for different ship types. For instance, for containerships, rules and assessment procedures using global finite element models are similar to the previous GL rules and methods.

The introduction of the harmonised version of CSR (CSRH), has also been a driver because of the technical achievements made in the development and because the remarkable increase in calculation scope introduced with CSR demanded improved software tools. By keeping similarities between CSR and rules for other ship types, synergy effects are obtained in competence building, software development, and production lines.

Both DNV and GL were heavily involved in the development of CSR. Experience from this development and use of these rules has been utilised. Some of the approaches have been selected and developed to cover ship types other than oil tankers and bulk carriers. The use of the more advanced methods in rule development has been in line with the previous development in the two companies.

Assessment of experiences from the fleet in service has been carried out in order to confirm existing requirements as well as to justify necessary changes.

Recent IACS updates, such as the unified requirements for longitudinal strength standard for containerships (UR S11A) and functional requirements on load cases for strength assessment of containerships by finite element analysis (UR S34), were published in the January 2016 version of DNV GL rules.

Furthermore, DNV and GL, and recently DNV GL, have granted a significant amount of funding to research. By this research new discoveries are made, as, for instance within fatigue capacity, there are

many small changes which together make a significant improvement.

## Working with the rules

The ship rules are divided into eight different parts. Main class rules for hull strength, referring to class notation 1A, are covered by Part 3, which forms the generic foundation for all ship types. The ship type related requirements are filed in Part 5 and all other additional class notations can be found in Part 6. Examples of these are class notations CSA, RSD, HMON, PLUS, COLL, HL, HC, OC, COAT-PSPC, Grab and WIV related to hull strength in design and operation.

For a user, Part 5 is the recommended entry point in the DNV GL hull rules, as it covers different ship types in 13 chapters. Containerships are for instance covered by Part 5 Chapter 2, while liquefied gas tankers are in Part 5 Chapter 7.

In addition to the rules, Class Guidelines (CG) are published as supporting documents to the rules. The CGs are divided into ship type class guidelines (e.g. for containerships, passenger ships, ro-ro ships and car carriers) and discipline class guidelines (e.g. for finite element analysis, fatigue, buckling and wave loads). While the rules state the requirements as acceptance criteria, scope and extent, the class guidelines provide methods and approaches which will be accepted by the society. In addition, the CGs provide a comprehensive technical support for users carrying out strength assessments according to DNV GL rules.

## Design principles

The structure of the hull rules is made similar to CSR for the convenience of users using both rule sets. In Chapter 1, the rule systematics are defined and an important element is the systematic for combination of extreme, static, impact or accidental loads with appropriate acceptance criteria. This systematic is used consistently throughout the hull rules.

## Wave loads

The wave loads introduced in the rules are more advanced, with a clear link to direct analysis. This allows the capacity formulas for yield and buckling to account for the phase between the different load components like hull girder bending, hull girder torsion, sea pressure and tank pressure.

The load formulation is following the so-called equivalent design wave (EDW) approach as it was used by GL in direct calculations and in CSR. The EDW in DNV GL rules build on CSR as far as possible, but the EDWs for oil tankers and bulk carriers are not fully applicable for more slender ship types, so further development has occurred. In this work, 3D wave load analysis and rule formulas have been compared for more than 100 ships covering a broad range of ship types and lengths.

For extreme loading, the five most important responses are the vertical bending moment, torsion, vertical acceleration, side shell sea pressure, and transverse acceleration from roll motion. These EDWs cover five headings :

- Head sea
- Bow quartering
- Beam sea
- Stern quartering
- Following sea

These are then symmetric on the other side. A total of 11 pairs of EDWs are defined, and each pair represents a wave crest phase and a wave through phase.

The wave loads are determined at a return period of 25 years, i.e. expected to be exceeded once during an operational design life of 25 years. The basis for these rules is the most harsh wave environment, the North Atlantic.

For any structural detail, one of these EDW's is dimensioning. This has been confirmed by global finite element analyses with direct calculated loads applying full spectral analysis. The stresses in all finite elements have been determined and then compared with stresses from all the EDWs combined. This is illustrated in Figure 1, where one model shows the extreme stress response with direct analysis and the other shows the situation using the EDWs. The stress patterns are close and this confirms the most critical wave loads are represented by the EDWs.

A new Class Guidance CG-0130 Wave Load Analysis describes a procedure for direct wave analysis when needed for consideration of unusual hull forms, consideration of particular wave environments, or marine operations at a given sea state.

## Finite element analysis

The use of finite element analysis (FEA) for evaluation of hull structure has accelerated during the latest decades as the tools become more user-friendly. Finite element analyses are frequently used beyond what is required by the minimum scope of the rules and it has become important that the rules satisfactorily support such application.

A new CG-0127 provides generic procedures for different types of FEA including global models, partial ship modelling and fine mesh. The guideline

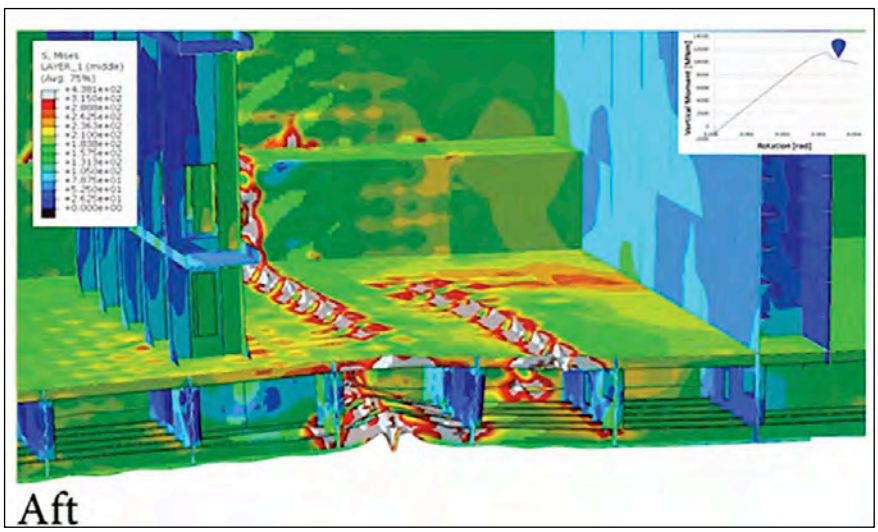


Figure 2: Illustration of structural collapse in the double bottom by nonlinear finite element analysis

defines appropriate loading, boundary conditions, and mesh size for use with acceptance criteria in the rules.

## Buckling

Buckling is typically the most critical failure mode and a new class guideline, CG-0128 Buckling, describes the application of close form methods (CFM) represented by equations, semi-analytical methods (PULS) or nonlinear finite element analysis both for single panels and for hull girder ultimate strength evaluation, see Figure 2.

## Fatigue

Both DNV and GL's long experience in fatigue assessment have now been consolidated in the DNV GL Class Guideline CG-0129 Fatigue assessment of ship structure.

The document support simplifies prescriptive fatigue analysis and provides a way forward for more advanced fine mesh fatigue analysis and components of stochastic fatigue analysis.

For ship structure, the main contribution to the fatigue damage induced by wave loads occurs at moderate stress levels with a corresponding high number of cycles. The most important load level is approximately 25% of the extreme level. So while the extreme sea state may be associated with 15m significant wave height, the important fatigue sea states may be associated with more like 4m significant sea states. The fatigue stress range used in the rules is defined by the stress difference obtained from each pair of the eight EDWs. The highest stress range from these eight pairs defines the EDW which dominates the fatigue damage at that particular location.

Whipping and springing are recognised to contribute to fatigue for all ships, and this is implicitly accounted for as a contribution to the vertical wave bending moment, which increases by 10 to 20% depending on ship size.

## Rules and tools

Modern rules form a necessary partnership with software tools. The increased complexity of loads and capacity formulas in DNV GL rules and CSR allows for better control of safety margins, but it also increases the dependency on efficient design tools. Both Nauticus Hull and Poseidon have been updated to incorporate the new rules, and the tools are enhanced for improved efficiency. *NA*

## References:

DNV GL Rules Part 3 and Part 5
DNV GL CG-0127 FE Analysis
DNV GL CG-0128 Buckling
DNV GL CG-0129 Fatigue assessment of ship structure
DNV GL CG-0130 Wave loads

# Smart ships – smart class: charting the future of planned maintenance programmes

The maritime industry is meeting familiar business and regulatory challenges with new concepts that promote 'smart shipping'. ABS is supporting this evolution with programmes that focus on data-driven reliability-based maintenance, write Domenic Carlucci, Robert Conachey and Christopher Serratella, ABS Corporate Technology

Change is a constant in the shipping industry. Difficult trading conditions, increased regulatory demands and the need for much greater operational efficiency mean owners, designers and shipyards are seeking new approaches to achieving and maintaining optimum vessel efficiency.

Initiatives that support such a process include the collection and more effective use of data from self-diagnosing systems for analysis onboard ship and ashore. Equipment manufacturers and vendors have quickly adopted these technologies, and more and more owners are coming to rely on them.

In response, classification societies and flag administrations are updating their requirements and policies to reflect the latest technologies developed for current and future assets.

Addressing vessel maintenance in the context of smarter shipping is a process that relies on some established precedents – it will still require class verification that the decisions being made as a result are robust, safe and efficient.


Smart operators are using a lifecycle approach to ship maintenance in a shift to condition-driven repairs

## A lifecycle approach

For proactive owners, maintenance is never an afterthought, and it is increasingly being integrated in the design of new shipboard systems. Industry leaders are designing maintenance by accounting for a data-driven, lifecycle approach as a step towards the ships of the future.

By implementing a range of planned and integrated procedures, they are able to achieve a maintenance approach within the context of class recognition and move in the direction of smarter shipping operations.

As maintenance management philosophies shift from calendar-based to more condition-driven intervals, classification surveys must also evolve, leveraging this new source of information in the crediting of machinery toward special survey requirements.

Incorporating performance in operational and maintenance planning is becoming easier at a time when this type of data collection, analysis and monitoring of machinery condition, performance and maintenance data are vital for effective marine asset management.

As vessel operators look for ways to better manage their costs, maintenance planning, execution and continuous improvement programmes are becoming increasingly important to decision-making. Properly leveraging these lifecycle-centred processes requires focusing on maximising uptime, establishing quantitative condition

assessments, and improving overall processes for safety, planning, operations, maintenance and repair.

To achieve the vision of more collaborative, less disruptive and more effective classification, ABS is continuing to integrate its traditional class services with innovative concepts, practices, and enterprise asset management software tools such as ABS Nautical Systems, to better match clients' needs and expectations and also to deliver the most efficient in-service classification process possible.

## Applying new techniques

Developing a robust maintenance plan relies on reliability techniques that align maintenance tasks and monitoring techniques with the potential equipment failure modes and respective causes.

The next step is to establish data streams directly from the vessel's automation and control systems to provide information on machinery condition. This can reduce crew burden and the potential for human error and also help turn an often complex puzzle of qualifying and analysing condition and performance data into an ever-improving, standardised process for decision-making and maintenance planning.

Information gathered from these processes can create a learning loop that, when implemented in an Enterprise Asset Management strategy can improve existing operational execution and influence the next generation of ship systems and processes.

Classification societies are in a position to provide reliability programmes that recognise and provide credit for improved maintenance programme performance. In implementing this type of programme, an operator has the additional benefit of a clearer definition of asset health, which allows unanticipated repairs to be minimised and reduces the likelihood of delays to operations.

Reliability programmes will help to reduce the risk to personnel, vessels or marine structures, cargo and the environment, potentially reducing the economic consequences of machinery failure, which might occur more frequently if a rational maintenance strategy were not in place.


Data streams fed directly from a vessel's control systems will give information on the machinery's condition and reduce the crew's workload

Since not all process automation technologies and protocols are compatible, applying a reliability programme to in-service assets requires analysis of the automation and data collection infrastructure. Many control and automation vendors operate in proprietary data formats, and not all of the machinery control systems are integrated.

In these instances, hardware and software solutions can bridge different device types and protocols, thus enabling different OEM-supplied equipment to communicate. Even modern vessels and offshore structures can be designed and constructed with non-integrated automation and control systems. If this challenge is not addressed during the design and construction phase, it will require in-service retrofits.

It is also important to remember that data collection and electronic systems are vulnerable to security threats. Developing an effective cybersecurity strategy that protects the data and hardware must be considered. Even isolated systems and those disconnected from the internet have been successfully targeted. To combat this threat, the incorporated systems, along with any system interfaces, should be included in a cybersecurity assessment, and active processes must be created to answer these concerns.

## Defining reliability strategies

Engaging in reliability-based design and management processes can result in a maintenance programme that strikes the right balance among performance, risk and costs for each piece of machinery or system.

Improving the inherent reliability of a system or component requires this to be addressed at the design stage, while applying risk and reliability analysis tools throughout the design process provides the information needed by the operator to make more informed decisions.

These design strategies focus on issues including simplifying system and equipment layouts, manufacturing and assembly activities where errors and flaws can be introduced that have a detrimental impact on reliability.

They can also include forecasting anticipated operational, training, maintenance and inspection needs to make sure the design meets these as far as possible. Finally, a testing and evaluation plan can be generated to confirm and validate the changes in design.

Maintenance management consists of assessing the 'what, when, why, who and how'. The end result is to develop

a safe and proven design in which future performance meets reliability expectations.

Owners need to consider some fundamental issues, such as the type of maintenance strategy that will be deployed and when maintenance activity is needed. Why should it be performed (return on assets or cost benefit), who will perform the activity, and how will it be accomplished?

There is always a trigger that creates a decision point on maintenance. Whether this is an interval based on calendar or running hours, or by monitoring results such as condition, performance, or failure finding based on inspection and testing, the trigger determines the need for maintenance. That maintenance may take the form of actions ranging from operational tests, health assessment through examinations and data analysis to restorative repairs or replacement.

## Future maintenance

The engineering and survey classification processes serve as integral pieces of machinery lifecycle management, from design review, construction and assembly, maintenance management verification, to surveys after construction.

ABS already offers several programmes to support and assist operators in minimising disruptions associated with maintenance and classification efforts which can help them achieve greater operational efficiencies.

In particular, as an alternative requirement to Special Survey, clients can enrol their equipment in a Preventative Maintenance Programme (PMP) which allows the operator to execute their planned maintenance and condition monitoring activities via an ABS-approved maintenance plan. Owners and operators can utilise the results of these programmes to seek alternate crediting toward special survey requirements.

Preventative maintenance programmes are not new – ABS has worked with owners since 1978 on their development and implementation. In 1984, ABS issued its first *Guide for Survey Based on Preventative Maintenance Techniques* with subsequent updates in 1985, 1987, 1995 and then inclusion in the Rules for Survey after Construction in mid-2012.

With the evolution of machinery systems that have become larger, more complex, and require skilled operators with specialised knowledge of the machinery and systems, ABS has developed a specific Guide with requirements and Guidance Notes providing supplemental information on this topic. These include the ABS *Guide for Survey Based on Machinery Reliability and Maintenance Techniques, ABS Guidance Notes on Equipment Condition Monitoring Techniques,* and *ABS Guidance Notes on Reliability Centered Maintenance.*

The ABS *Guide for Surveys Based on Machinery Reliability and Maintenance Techniques* offers methodologies for achieving ABS notations applied to machinery reliability and maintenance management programmes. It describes the process and responsibilities for an ABS review of design submittals, analysis processes and resulting maintenance plans as applicable throughout lifecycle stages of the vessel or asset. The methodology relies heavily on risk and reliability assessment techniques as a way of better understanding and anticipating machinery and operational issues related to these concepts.

The Guidance Notes offer best practices for maintenance plan development and list numerous condition monitoring practices for consideration. Vessel operators applying these advanced techniques can allow a surveyor to use the results to achieve less disruptive surveys and to reduce the number of intrusive examinations and inspection actions. The direct result is less disruption and minimised impact to operations.

Additional benefits from employing reliability activities include the following:

- Improved return on asset and improved maintenance cost effectiveness contribute to improved asset availability and safety;
- Continuous improvement through sustainment activities provides improved equipment reliability and asset availability;
- Rationalised maintenance intervals supporting operational goals and the elimination of low value maintenance tasks;
- More intimate knowledge and understanding of system integrity and component interaction;
- Quantitative measurement of equipment and machinery health based on maintenance, condition and performance information;
- Improved co-ordination and alignment of classification activities through collaborative data and information exchange.

## A new mindset

Classification has never been a 'one-size fits all' process because of the need to manage risk on an individual, vessel-by-vessel basis. The emergence of a data-centric approach to maintenance and compliance creates an opportunity to look at processes in the context of maximising efficiency and minimising intrusion.

The industry is moving from a slow, compliance-based approach to adoption of new technologies to a mind-set that embraces new techniques in the cause of efficiency as well as safety. More improvement is needed, not just to demonstrate compliance to regulation and adherence to class requirements, but because greater efficiency can deliver improved margins and play a role in sustaining the viability of an asset.

It is clear that even if the industry has not yet fully adopted these concepts, it has accepted their inevitability. This is evident in the evolution of data capture from the unstructured noon report towards the collection and analysis of ever greater amounts of data being made available to decision-makers.

With this greater volume of sources comes the parallel need for data collected to be useful enough to be utilised. Big Data is a term that has come to have many meanings, but where it can prove most valuable is in meeting the need for better maintenance planning and execution.

Ultimately, this means Class will continue to have a prominent role to play in the evolution of the shipping industry. An understanding of the tools needed to effectively and safely manage performance analysis and what happens when remedial action is needed is a critical step towards development of smarter – even more autonomous – future marine assets. *NA*

## RINA-QinetiQ
# Maritime Innovation Award

Innovation is key to success in all sectors of the maritime industry and such innovation will stem from the development of research carried out by engineers and scientists in universities and industry, pushing forward the boundaries of design, construction and operation of marine vessels and structures

**The Maritime Innovation Award** seeks to encourage such innovation by recognising outstanding scientific or technological research in the areas of hydrodynamics, propulsion, structures and material which has the potential to make a significant improvement in the design, construction and operation of marine vessels and structures

The Award is made annually to either an individual or an organisation, in any country. Nominations for the Award may be made by any member of the global maritime community, and are judged by a panel of members of the Institution and QinetiQ. The award will be announced at the Institution's Annual Dinner.

Nominations are now invited for the 2016 Maritime Innovation Award. Individuals may not nominate themselves, although employees may nominate their company or organisation.

QinetiQ

**Nominations** may be up to 750 words and should describe the research and its potential contribution to improving the design, construction and operation of maritime vessels and structures.

**Nominations** may be forwarded online at
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# KR builds for the future

Looking to kick on from some tough operating conditions in recent years, Asian class society, the Korean Register, is building on its technological knowledge and leveraging its geographical location to expand the services it offers as well as its customer base

The Korean Register (KR) has been examining the economic feasibility of LNG as the main fuel for ships, looking at practical solutions to the necessary engineering challenges. As it is misleading to retrofit or build new LNG fuelled ships merely on the basis of fuel costs, particularly when the oil price is so low, the economic feasibility has been balanced against the cost of countermeasures to meet environmental regulations, particularly those relating to SOx and NOx.

In a further development KR is collaborating with the Korea Gas Corporation (KOGAS) and three major shipyards to develop a new Korean LNG cargo containment system known as KC-1. The KC-1 LNG newbuilding project is scheduled for delivery in 2017. Ordered by KOGAS and built by SHI (Samsung Heavy Industries), the vessel is a 174,000m$^3$ membrane type vessel, and will be fitted with the world's first cargo containment system of this kind. (See TNA October 2009, pages 48-50; TNA May 2011 pages 26-28 and TNA October 2011 pages 32-36).

In addition, KR is leading research into the technological development of Korean type LNG bunkering vessels, having recently conducted an AIP (approval in principle) process on the engineering technology for a new 5,000m$^3$ capacity concept vessel. This vessel has two options: one equipped with bi-lobe LNG storage tanks; the other is the lattice type tank giving an improved storage capacity compared to existing tanks. Demand for new build vessels of this type is expected to see the construction of more than 1,000 ships by 2030.

KR has also worked closely with Singapore based shipowner Navig8 to develop the concept of a wide beam 74,000dwt LR1 tanker that is suitable for river passage and is able to transit the soon-to-be widened Panama Canal.

The tanker was to have similar port accessibility as a standard MR1 tanker, carry as much cargo as possible, be suitably equipped to carry light specific gravity cargo and be optimised for fuel efficiency.

Working with the owner, KR carried out a thorough review of this new concept, conducting a feasibility study to demonstrate that the concept could be used to develop a new vessel type.

With this new design, the owner could achieve:

- Higher payload at river draft
- Larger cargo hold capacity
- Enhanced cargo system flexibility allowing homogeneous or multi-grade cargoes to a maximum of seven grades
- Slow steaming capability with significantly reduced bunker consumption
- Compliance with EEDI requirements.

Another Navig8 vessel, *Madison Orca*, which is managed by the Singapore company was recently converted with KR supervision. The 320,000dwt Ore-Bulk-Oil (OBO) carrier was converted to a VLCC in a significantly reduced time frame, to optimise resources and save costs.

Owned by Monarc and managed by Navig8, the *Madison Orca* was built in 2010 by Hyundai Heavy Industries (HHI) as one of eight OBOs. Confident forecasting of the tanker markets led Monarc and Navig8 to take the step of undertaking the conversion to a VLCC to take advantage of the more promising crude oil markets.

KR was involved throughout the conversion process, from the initial planning stages through to the final performance evaluation. The large scale conversion included the installation of five swash bulkheads located in the centre cargo tank; the removal of the cross deck structure and hatch coamings; and construction of new upper deck structures incorporating an additional 2,300tonnes of steelwork.

The swash bulkheads were constructed to a bespoke KR design. This was not incorporated as part of the original OBO design, but their installation was necessary to enable partial oil loading in the centre tank.

The International Association of Classification Societies' Common Structural Rules were applied to the new VLCC design and KR carried out further, more in depth testing to ensure performance and safety. This involved undertaking sloshing analysis using Computational Fluid Dynamics (CFD) due to the breadth of the centre tank being broader than most conventional VLCCs.

## Ballast water

Late last year the United States Coast Guard (USCG) accepted KR as an Independent Laboratory (IL) that can undertake tests, inspections and evaluations for type approval of ballast water management systems in accordance with the US Code of Federal Regulation. KR is the first in Asia and the second in the world (outside the US) to gain this authorisation.

Since the acceptance, KR has expanded its land-based testing facilities by building four more tanks to save its customers time and money. KR is keen to establish a close communication network with USCG authorities. It endeavours to carry out a close check on items that manufacturers present and, in advance, eliminate items which might be a problem in the future. In this way KR can ensure that its customers avoid rejection and do not need to repeat testing when submitting materials for their audit after testing. *NA*

The Royal Institution of Naval Architects

# International Conference:
# Energy Efficient Ships

23-24 November 2016, London, UK

## Call for Papers

Shipping is one of the most efficient means of transportation for bulk commodities. However, as part of the global effort to reduce greenhouse gases (GHG) the industry must design and operate lower emissions-higher energy efficient ships. IMO introduced mandatory standards on the energy efficiency (EEDI) of the majority of new built vessels and further regulations are expected to be developed for ship types not already covered. The Energy Efficiency Design Index and the Ship Energy Efficiency Management Plan (SEEMP) has been adopted for existing ships in an attempt to monitor (Energy Efficiency Operational Indicators -EEOI) and improve their efficiency.

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www.rina.org.uk/EES_2016

The Royal Institution of Naval Architects

# International Conference:
# Historic Ship 2016

7-8 December 2016, London, UK

## Call for Papers

From the trader junks of China to the battleships of WW2, historic ships are an important link to our seafaring past. And as the skills and techniques used to construct and operate our historic ships fade out of living memory, now is an important time to highlight the struggles of researchers, enthusiasts and engineers as they preserve and restore our maritime heritage.

RINA's Historic Ships conference returns for a fourth instalment that will not only focus on the restoration and preservation of historic vessels, but also the research and investigation into the engineering and efficiency of historic designs through modern naval architecture techniques.

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www.rina.org.uk/Historic_Ships_2016

# "Beyond smoothness"

## A brave new world emerges, combining adhesive coatings, modified coating topographies and robotised application

The EU funded 'eco-friendly Ship Hull film system with fouling Release and fuel saving properties' project, or 'eSHaRk' as it is more manageably known, is in search of the next efficiency paradigm for coating technologies. Its aim is to commercialise a fouling protection technology that combines the best in fouling protection with an application solution that is environmentally friendly, eases the process of application, and aids the industry pursuit of ever greater drag reduction.

The research project establishes two goals. Firstly, to deliver a method of automated application for an adhesive film coating, and secondly, to develop coating textures that open up new efficiency gains. PPG, the project's coordinator, will collaborate with a series of industry partners in eSHaRk, including MACtac (an adhesive specialist), Meyer Werft and ND Coatings, VertiDrive (a robotics specialist), and the Hamburg Ship Model Basin (HSVA) to deliver the project's aims by the end of 2018. Christophe Cheikh, product manager at PPG, says: "The fundamental idea is to develop a siliconised substrate that is industrially engineered to realise optimum fouling release where the surface of the siliconised substrates is textured to have maximum effect on drag reduction."

The undertaking will combine technological innovations from a variety of fields, harnessing PPG's new Sigmaglide prototype – a self-adhesive fouling release film that is being developed in collaboration with MACtac (Figure 1) – and a robotised application technology under development by the Dutch-based automation specialist, VertiDrive.

PPG's global marketing manager for Marine, Sijmen Visser, explains that the fouling release film innovation answers a practical question: how can the variables interfering with the end state of a coating's application be removed? He points out that factors such as temperature, humidity, speed of application and curing time, can cost time and efficiency if the coating is imperfectly applied at shipyard or drydock. And so the new technology was developed with an offsite method in mind, ushering in a prefabricated method that ensures the coating will be applied with factory consistency in a one-coat application.

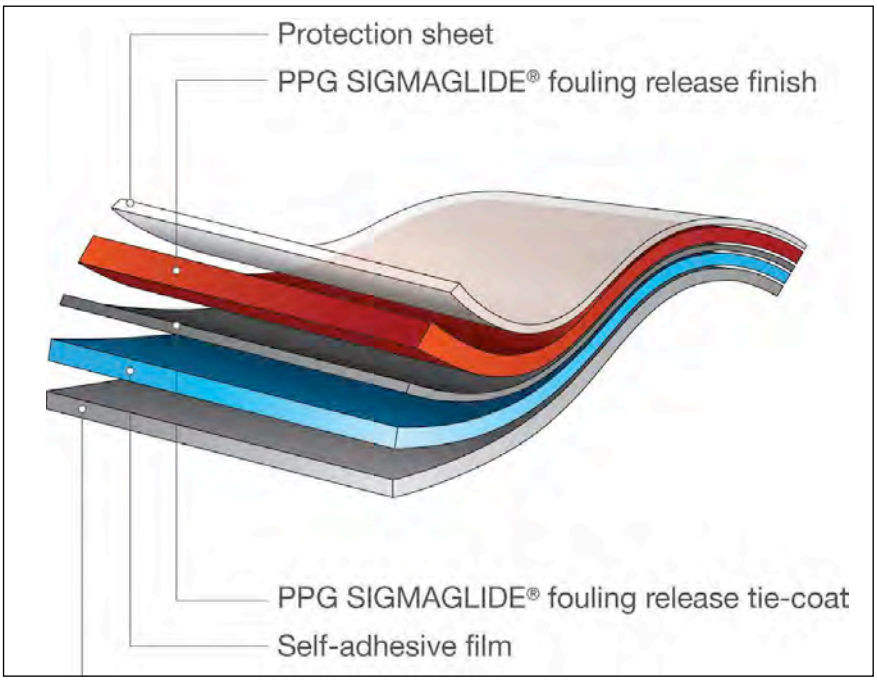


Figure 1: The capabilities of the prototype film adhesive coating could help to double drag reduction, according to PPG

> "The fundamental idea is to develop a siliconised substrate that is industrially engineered to realise optimum fouling release"

PPG says: "The self-adhesive properties [of the film] allow efficient application without release of solvents on site and do not create any problems of silicone spread [around] the surrounding environment."

Its developers believe it will improve the control of dry film thicknesses and management of the surface effect, and will deliver a consistent fouling release when compared with conventional spray applications, which offer less control during application. The added control will also allow further optimisation of the surface's drag reduction capabilities, according to Visser, as the final topography can now be modified to "go beyond smoothness".

Visser explains that the notion of going "beyond smoothness" has long been witnessed in nature and has been bubbling on the mind of innovators for some time. A shark's skin, he posits, will allow it to move extremely rapidly in water and has led to the development of hydro-performing swimsuits in the past; why can't this be applied to commercial ships?

This is reiterated by his colleague, Kees van der Kolk, global technology director of PPG's Protective and Marine Coatings business, who describes the new film technology as effectively "pulling a speedo on a ship",

increasing its hydrodynamic performance by enhancing its drag reduction. Current expectations of the eSHaRk solution suggest a 10% drag reduction, a doubling of the efficiency provided by Sigmaglide without the application method.

At present, the adhesive film is undergoing tests as a prototype, but eSHaRk's goal is to upscale and commercialise the technology. Pilot boats have been used as initial test subjects, but the long term intention is that the film will be appropriate for vessels of any type and size. A particular opportunity has been recognised in the newbuild cruise vessel market, where vessels commonly use fouling release technology on their outside hull. Visser says: "Cruiseships are using mainly fouling release for their outside hull, therefore, this technology is quite established in the cruise market and if you then come in with the next innovation in fouling release it is a more natural process."

Automation technology will therefore be key in the realisation of this goal, as vessels of this size make manual application of the film impractical; manual application of the film occurs at an approximate rate of 100m$^2$ per day, whereas a fully automated, robotised mechanism would allow for the application of roughly 10 times as much per day, says Visser. Progress has been made with an engineered vertical laminator that laminates the foil on the hull with a drying and pre and post heating step. But further mechanisation is still required to ensure the method is fit for shipyard and drydock conditions; the robot now needs to move the laminator from one lane to the next, says Visser.

According to PPG: "Both the number of trials, as well as the size of trial vessels will be increased in order to validate the system thoroughly prior to full scale commercial launch. This validation phase will confirm the benefit for the ship operator in terms of fuel and greenhouse gas."

eSHaRk will run for three years, by which time the industry partners aim to have a working prototype. *NA*

# A polished performance

## AkzoNobel is targeting high-risk fouling routes with its latest deep-sea vessel coating

Vessels sailing through more tropical seas, such as between the Arabian Gulf and South Asia, face more difficult fouling conditions, but AkzoNobel's new coating, Intercept 8500 LPP, will help these deep-sea vessels to shed their bio-shackles, utilising technology that has been ten years in the making to increase efficiency, says Carl Barnes, antifouling business manager at International Paint, AkzoNobel.

Figure 1: A comparative view of Intercept 8500 LPP's performance (right of image) on a 301,000dwt VLCC

The company has combined its in-house polymer system, Lubyon, and a silyl methacrylate self-polishing copolymer in a new high-performance coating for the deep-sea market. The combination provides linear polishing for controlled, consistent polishing and biocide release, and a faster polishing rate compared with other Intercept products. It also features an optimised biocide package that delivers the highest performance fouling control for a biocidal system, according to AkzoNobel, as well as high volume solids (56%) and low volatile organic compounds (378g/l). This make-up reduces waste and makes the coating particularly suitable for vessels operating in areas where reduced solvent emissions are required, says the company.

The ten year development saw a number of step changes. Three years ago Intercept 7000 and 8000 LLP were released and were based on the Lubyon in-house polymer system. This system was developed to replicate the linear polishing behaviour of tributyltin (TBT) polymer systems that were previously banned on environmental grounds.

After the TBT ban the replacement systems were developed typically based on Copper Acrylate or Silyl Acrylate Self Polishing Copolymers. While these provided excellent fouling control, the coatings did not polish in a linear manner like the TBT systems. AkzoNobel's intention, therefore, was to arrive back at the steady release of biocides seen with the TBT self-polishing systems, but without the detrimental environmental impact. The polymer system allowed the company to reach the aforementioned aim, according to Barnes, providing controlled polishing and biocide release through its linear polishing action, which works more predictably. This development consequently facilitated the latest polymer system.

While the internal technology has changed, the application process is no different to any other biocidal antifouling coating, according to Barnes. This means the paint is supplied in the same way and conventional airless spray equipment can be used.

### Raising the bar

AkzoNobel has improved its range of guarantees for Intercept 8500 LPP

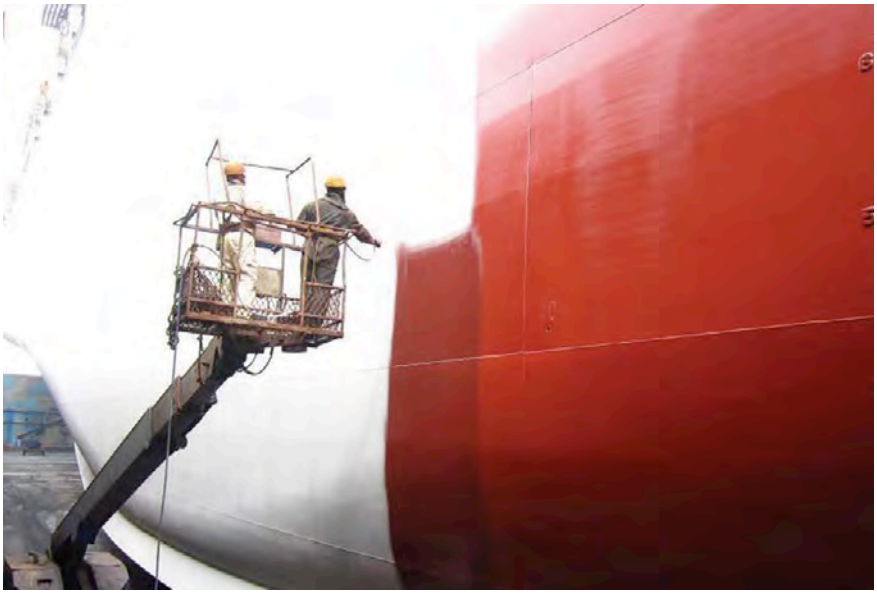

Figure 2: Intercept 8500 LPP's can be applied using established techniques and equipment

customers because of its "step change" in terms of performance. The company now offers a 35 day static guarantee, which marks a substantial increase on its previous guarantee of 21 days, and affirms a new level of confidence in the coating. However, Barnes notes that the operation of the vessel must meet certain conditions to ensure guarantees are fulfilled. These conditions are tailored to individual ships, but one example could be that the vessel must sail at a certain activity and period of time after the static period before it experiences another static period.

A performance maintenance agreement is also in place to assure customers. It stipulates that the average degradation of the coating between the benchmark period and drydocking will not exceed 4% of that measured over the first 12 months after application (the benchmark period). This too is an upgrade on AkzoNobel's previously offered 4.5% for other coatings in the range. Barnes insists that while 0.5% may not seem like a lot, it is a substantial gain. AkzoNobel will clean the vessel if the vessel's coating does not meet the established performance guarantees.

## Market

At present, there is significant interest in the coating at drydock, says Barnes. However, for newbuilds, he continues, it can be difficult to engage with yards involved in these projects because they tend to keep to products they know and those that have a significant track record. As a result, the uptake of new coating innovations is often driven by owners. However, Barnes reveals that despite the challenges faced in the newbuild market, the uptake of new coatings is still promising; there are five 10,500TEU container vessels to be built in Korea for European container owner Hapag-Lloyd that will be coated with Intercept 8500 LPP.

## Testing

Tests began on submerged painted boards in a range of locations with different fouling risks, which allowed developers to identify the most promising formulations. From here AkzoNobel approached owners to secure their participation in patch tests, which would include diver inspection while the vessel was in operation.

The results from one patch test can be seen in Figure 1. It shows the coating's performance on a 301,000dwt VLCC after 22 months in service where 71% of the vessel's activity was at speeds of more than 3knots while trading between the Arabian Gulf and South East Asia; Figure 1 shows Intercept 8500 LPP's performance compared with a fast polishing coastal self-polishing copolymer.

Following the compilation of this data, testing moved to full vessel trials on bulkers, containerships and PCC vessels. Four undisclosed vessels had the coating applied before its official launch: a 27,000dwt PCC trading globally; a 234,000dwt bulker trading between China and Brazil; a 22,000dwt containership trading between South East Asia, Korea and Japan; and a 43,000dwt bulker trading between China and Australia.

Barnes explains that the performance of a vessel is often measured by fuel consumption or degradation of speed at constant fuel. Noon reports or onboard monitoring systems can be used to gather the necessary data, but there are obvious advantages with the latter's use, as an automated monitoring system will offer many more data points for analysis than noon data.

When asked about the impending approval of ISO 19030, which aims to standardise the measurement of hull and propeller performance and will have a direct impact on the paints & coatings industry, he remains positive. Barnes says AkzoNobel is an active member of the ISO working group and the standardisation can only be good for the industry, giving it a "peg in the ground" for comparison and more precise analysis; this is "something everyone can follow" he continues.

The third and final part of the standard should be finalised, and the methodology approved, later this year. For the purposes of transparency, credibility and authenticity, AkzoNobel is advocating the publication of the methodology through an independent third party as opposed to a singular member of the working group. *NA*

The Royal Institution of Naval Architects

# Human Factors 2016

28-29 September 2016, London, UK

## Registration Open

The work of naval architects and marine engineers directly influence the operability and safety of the vessel and the seafarer. Decisions made at the design stage can influence human behaviour and health. And an improved understanding of ergonomics by engineers can 'design out' hazards and prevent incidents, both to the individual and the vessel.

With ever more complex systems and technology, greater improvements in safety can be achieved through a better understanding of human/system dynamics. A greater awareness of the role played by management structures, culture, procedures and regulation in safe and effective operation is also important to the effective running of the vessel and wellbeing of the crew.

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# The Royal Institution of Naval Architects

## CONTRACT MANAGEMENT FOR SHIP CONSTRUCTION, REPAIR & DESIGN

**2-4th November 2016**
**Dr Kenneth W FISHER, FRINA**

This programme is a lessons-learned one, not some theoretical course on contract management. It bears a lot of "scar tissue" from marine contractual disasters. It is designed for; (a) project management who handle day-to-day relations with the other party, (b) persons who form contracts, and (c) senior managers who monitor contract-related resources/cash flow.

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# Cool running?

A new phase out begins for onboard refrigerants. *The Naval Architect* explores the next steps for onboard refrigeration and cooling with Robert Chesters, managing director, and David Lloyd, technical director, of Oceanic Technical Solutions

Production of the most recent mix of refrigerants is set to slow, according to Lloyd, as more recent blends of hydrofluorocarbons (HFCs) will also be subject to the growing demands of environmental regulators. This will change a vessel's eco credentials and may affect the design of onboard cooling systems and their plants.

Currently used HFCs represented a step change in refrigerant development as they do not contain the ozone depleting chlorine found in their predecessors, which were phased out in 2015 by the entry into force of F-Gas rules. However, HFC refrigerants feature a high global warming potential (GWP), producing levels of $CO_2$ that will now also have to be lowered in order to comply with new regulation.

This high potential has driven the further phasing out of the once approved refrigerants so that the next generation will have to feature a GWP of below 2,500 from 2020 – the entry into force date of the new F-Gas regulation (EU) No. 517/2014. This watershed will also involve a service ban for refrigerants that fail to meet the new regulation.

Lloyd and Chesters suggest this shift will lead to new, more energy efficient refrigerants that could in turn reduce the plant size for onboard systems. Chesters cites one refrigerant under development with a $CO_2$ potential of less than 200 – a quantum leap in technological capabilities according to the pair – but cannot give further comment on the product's development.

Other alternative refrigerants exist, but they possess inherent difficulties. According to Lloyd, some people have asked: Why not [use] ammonia [as an alternative refrigerant]? However this chemical, he continues, while environmentally friendly, is toxic to humans and is therefore unattractive. If a halocarbon or ammonia system was used, the plant room would have to be on deck, away from accommodation. Similarly, propane, which Lloyd believes "people are generally staying clear of at the moment", could be an alternative, but its flammability complicates onboard safety in terms of compliance and the areas in which such a system could be used. Such a system, he says, would require its own plant room and air locks, as well as the implementation of a buddy system to ensure crew safety, which will increase costs.

The design of a complete hermetic system could facilitate these alternatives, but such a system is practically impossible, explains Lloyd. This is because the system will still require hand valves and a shaft that has to be sealed with rubber o-rings, for example, creating opportunities for leakage of the more hazardous refrigerants. The advent of 3D printing may reduce the frequency and extent of leaks, but it will not prevent the problem entirely, to Lloyd's mind, as designs will fundamentally remain the same.

In theory, a hermetic system would also answer a relatively new issue for refrigerants, fractionation. This distillation process occurs at saturation point and can take place when a system uses newer refrigerants known as 'blends'. Blends can contain upwards of three components and bring environmental benefits, but the individual characteristics of the chemicals allow for fractionation to occur. This causes the different chemicals in the blend to leak at different rates, fundamentally changing the refrigerant's makeup. As a result, the plant system is no longer functioning with the refrigerant it was designed for, which means that efficiency drops, things take longer to cool, and the plant has longer to run.

## Mind the gap

A further gap between design criteria and operational criteria has emerged for newbuild vessels, says Lloyd. Air-conditioning units onboard new ships meet the SOLAS specification for a standard AC system, but this specification can be at odds with the temperature demands of globally operating vessels.

Lloyd states that this standard does not meet the needs of a vessel that is sailing through areas such as the Persian Gulf, where ambient and sea water temperatures are higher. Consequently, the diversity of a vessel's journey calls for more consideration in the design and specification of an onboard air-conditioning (AC) unit, which is not only responsible for the comfort of those onboard, but also the performance of computer systems and machinery, and the quality and therefore value of temperature sensitive cargo.

Questions of redundancy also remain amongst those in the industry; both cargo control rooms and engine control rooms lack sufficient redundancy on their AC systems, according to Lloyd. This means that electronics may overheat and potentially lead to ship-wide blackouts, which could be particularly costly for refrigerated cargo vessels that transfer perishables like bananas. Lloyd emphasises that this is especially the case for newbuilds, where supplementary units are the first to be ruled out when cutting costs. *NA*

The Royal Institution of Naval Architects

International Conference:

# Design & Construction of LNG Ships

26-27 October 2016, London, UK

## Registration Open

LNG accounts for a significant part of the growth in the global energy supply and despite the recent economic situation the future demand for LNG carriers, floating storage and processing systems is expected to increase. While some companies are building larger vessels to take advantage of economies of scale, others are looking at developing small vessels for shortsea and coastal trades to help create LNG distribution networks. New and improved containment systems are alo offering the designer a diverse range of options. There is also a growing interest in floating production, storage and offloading systems for offshore field development and re-gasification systems and plants designed to avoid the need to construct land based processing and distribution centres.

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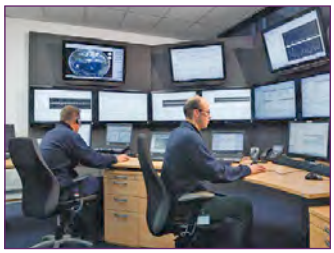
The Royal Institution of Naval Architects

International Conference:

# Smart Ships

24-25 January 2017, London, UK



## Call for Papers

Following on from our successful Smart Ship conference the Royal Institution of Naval Architects is organising a second international conference to further explore some of the key issues and themes raised by the first conference.

Developments in both information and communication technologies (ITC) have had a significant effect on many industries within the last decade. However, it is now just starting to impact the shipping industry. ITC will enable some of the most fundamental changes to the way ships are designed and operated. While there are still technical issues to overcome it's the non-technical hurdles such as economic and legal considerations that will define the rate of this progress.

The concept of Smart Ships covers a whole range of possibilities from predictive maintenance, performance optimisation, decision support tools, increased automation and robotics, unmanned remote or autonomous ship operation.

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www.rina.org.uk/smart_ships2017

# A fair wind

*Dear Sir,*
Your article "Air power; more than just a wind up" published in *The Naval Architect* made reference to comments I made during a panel discussion held last December and paraphrased my views in a way that could mean they are misrepresented.

Your readers may wish to know that during the panel discussion, I gave my view that the current alternative technologies simply do not offer the "power density" provided by a 50MW large 2 stroke marine diesel engine, hence my reference to ships being essentially 'mobile power stations'.

Until such technology exists, it is difficult to foresee adoption of reliable and robust energy sources that can replace the marine diesel engine as the main propulsion power source – especially for some of the more arduous trades, such as a large bulk carrier crossing the North Atlantic in the middle of winter. If your readership can identify such a source – I know there are those who advocate the use of nuclear power for ships but this brings other challenges – then it would be interesting to hear their views.

I also made reference to the mandatory international energy efficiency regulations for ships that entered into force in 2013 that today are driving innovation including the use of new technologies, new materials, alternative fuels, and smarter ships that enable decision making to be supported by real-time data. Indeed, I am pleased to report that over 1,600 ships have been certified as meeting those new energy efficiency requirements.

To enable effective implementation of the requirements IMO is supporting two major technical assistance programmes.

The first is the exciting GloMEEP project, formally designated "Transforming the Global Maritime Transport Industry towards a Low Carbon Future through Improved Energy Efficiency". IMO is executing this Global Environment Facility (GEF)-funded GloMEEP project in partnership with the United Nations Development Programme (UNDP), and delivering the project through ten lead pilot countries.

The second is an innovative, four year €10 million ($11.4 million) EU-funded programme that will see IMO establish a global network of Maritime Technology Cooperation Centres (MTCCs) in developing countries. The aim is to assist beneficiary countries in a region to limit and reduce greenhouse gas (GHG) emissions from their shipping sectors through technical assistance and capacity building. It will encourage the uptake of innovative energy-efficiency technologies and operational practice among a large number of users through the widespread dissemination of technical information and know-how through implementation of pilot projects.

Best regards
*Edmund Hughes*
*Head, Air Pollution and Energy Efficiency*
*Marine Environment Division*

# In response to the Cubic Doughnut Tank System critique

*Dear Sir,*
We appreciate Mr. Clifford Thew's comments and are pleased to respond to them.

**1**. The major benefit for the Cubic Doughnut Tank System (CDTS) is that it offers **either** a smaller length ship for same capacity or a greater capacity for the same length ship as that of the currently used containment tank systems. Length is the major cost dimension and so it should always, within the compromise of design and economic factors, be the minimum possible. In discussions with LNG shipowners and shipbuilders, we were advised that 300m is the preferred maximum length so as to be able to enter existing LNG loading and unloading facilities.

**2**. Regarding why it has "not been done before", it should be noted that the original idea was actually patented in 1973. The SPB and membrane containment systems are somewhat rectangular cuboid in shape and many of the new tank systems are trending to that shape to maximise capacity to gross tonnage.

The CDTS is unique because the gross cube shape is constructed predominantly of 12 intersecting cylinders rather than flat plate structures, thus requiring minimal stiffening to mitigate the hydrostatic loads. Additionally, this system does not require cofferdams nor double hulled deck structures. These features as well as the CDTS being self-standing, allow for the tank to extend above the deck, thus utilising hold space and above-deck space far more effectively than competitive designs.

These innovative design ideas in aggregate all contribute to the high capacity to gross tonnage rather than just merely filling void spaces inherent in other designs. The CDTS has been awarded Approval-In-Principle (AIP) from ABS and we are currently working on General Design Approval (GDA). The detailed structural analysis, sloshing analysis and initial stability evaluation all show the

**Table 1: FOR SHIPS OF SAME LNG 83,400CM CAPACITY**

| | Membrane | Spherical | SPB | CDTS |
|---|---|---|---|---|
| Gross Tonnage | 112434 | 144159 | 108192 | 102959 |
| Capacity/Gross Tonnage | 1.542 | 1.203 | 1.603 | 1.684 |
| Comparison V Membrane | 1.000 | 0.780 | 1.039 | 1.092 |

design to be safe and suitable for all the operational conditions.

**3**. Mr. Thew's approximate gross tonnages are too low by a factor of 2. For the same Capacity LNG Carrier, the carrier using the CDTS containment system will have lower gross tonnage than Membrane, Spherical and SPB ships as shown in the Table 1.

For the same length carrier, the CDTS gross tonnage will be larger than the other systems. However, it can be seen from the table below that the capacity benefits more than the increase in gross tonnage and the CDTS Maximum Length Carrier still wins out over all the other containment systems except the SPB. It should be noted that with the ongoing design development, the capacity for the maximum length CDTS Carrier is now 234,000CM and that the capacity/gross tonnage ratio improves to 1.694, a 13% improvement over the Membrane design as shown in Table 2 as Improved CDTS.

**4**. Mr Thew is correct that the 49m beam was selected as it is the maximum allowed by the new Panama Canal.

We believe we have compared "like for like", namely the same cargo capacity in the first case and the maximum 300m length overall in the second.

Mr. Thew's comment that there is a big difference between academia and the professional world can be excused by there being an inadequate author description at the end of the paper. For clarification:

**Table 2: FOR SHIPS OF SAME 300M LENGTH OVERALL**

| | Mem-brane | Spheri-cal | SPB | CDTS ORIGINAL ARTICLE | 234000CM IMPROVED CDTS |
|---|---|---|---|---|---|
| Gross Tonnage | 124237 | 130627 | 125770 | 138458 | 138458 |
| Capacity/Gross Tonnage | 1.502 | 1.275 | 1.574 | 1.517 | 1.694 |
| Comparison V Membrane | 1.000 | 0.O.848 | 1.048 | 1.010 | 1.128 |

**Mr. Lamb** has over 60 years' experience in the design and construction of many ships of different types and only spent his last 11 active years teaching and performing research. He served a five-year apprenticeship at HM Dockyard Rosyth and graduated from Durham University in 1958 with his B.Sc. in Naval Architecture. He has worked in shipyard design offices in Scotland, England, Denmark and the USA. He is a Fellow of RINA, SNAME and ImarEst, and was the Editor of and five-chapter contributor to the 2003 edition of the SNAME SHIP DESIGN AND CONSTRUCTION Book as well as being the SNAME Ship Design Committee Chairman for many years. He is also a Professional Engineer in the US, Chartered Engineer in UK and Eur Ing.

**Mr. Ramoo**, Vice President of Engineering at Altair Product Design has over 30 years' experience in the use of computational methods for design ideation and Advanced Structural Analysis. He has broad experience in using advanced CAE methods in structural design of land vehicles and marine structures. He encourages Mr. Thew to visit their website at www.altairproductdesign.com to see some of the "not been done before" innovative design solutions that we have brought to a multitude of industries including the marine, aerospace and automotive industries.

Both have had extensive discussions with shipowners and shipbuilders regarding the use of the CDTS in LNG Carriers and FLNG.

# Door A, plan B

*Dear Sir,*

The steel cabin door in a cruiseship my wife and I were on was a tight fit in its steel frame. Opening and closing it required quite a hard push. There was no other way of exiting the cabin.

Collision, fire, explosion or structural failure could distort a door frame and jam the door. In the absence of other ways to get out, passengers would be trapped in their cabins. A secondary means of escape from cabins should be mandatory for all ships. A possible remedy would be the inclusion of manhole-size kick-through panels in the cabin doors.

*Terry Bryant BSc(Hons)*
*C.Eng. MIMechE.*

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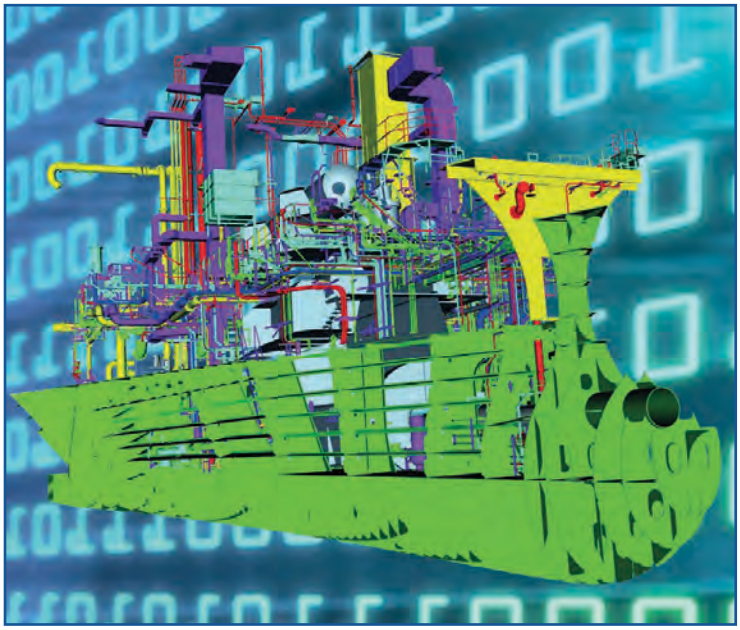

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